2018

A Macromorphological Analysis of End Scrapers from Sites Associated with Two Phases of the Oneota Tradition, the Blue Earth and Spring Creek, in Southern Minnesota

Joshua Bradley Anderson
Minnesota State University, Mankato

A Macromorphological Analysis of End Scrapers from Sites Associated with Two Phases of the Oneota Tradition, the Blue Earth and Spring Creek, in Southern Minnesota

By

Joshua Bradley Anderson

A Thesis Submitted in Partial Fulfillment of the

Requirements for the Degree of

Masters of Science

In

Applied Anthropology

Minnesota State University, Mankato

Mankato, Minnesota

July 2018

06/06/2018

A Macromorphological Analysis of End Scrapers from Sites Associated with Two Phases of the Oneota Tradition, the Blue Earth and Spring Creek, in Southern Minnesota

Joshua B. Anderson

This thesis has been examined and approved by the following members of the student's committee.

Dr. Ronald C. Schirmer (Advisor)

Dr. Kathleen T. Blue (Committee Member)

Dr. Stephen J. Stoynoff (Committee Member)

Mr. Dan Wendt (Consultant)

Abstract

The relationships and distinctions between Oneota tradition groups in southern Minnesota are not well understood. Two contemporaneous phases of the Oneota tradition in southern Minnesota, the Blue Earth and Spring Creek, which date, minimally, to the 14^{th} and early 15^{th} centuries, are represented by clusters of sites along the Blue Earth River Valley (the Center and Willow Creek localities) and near the junction of the Mississippi and Cannon rivers (the Red Wing region). This thesis attempts to address some basic questions with regards to the differences and similarities between Spring Creek and Blue Earth phase groups in terms of end scraper and lithic raw material use. Macromorphological end scraper attributes that relate to material choice, core reduction, tool modification, maintenance, use, and discard are measured and compared. Experimental, ethnographic, and theoretical sources, as well as corollary measurements of end scrapers from two Woodland tradition sites, are used to identify and interpret relevant similarities and differences between end scrapers from Blue Earth and Spring Creek phase sites.

Acknowledgments

Many people aided me throughout this work. To all of you, I am grateful for the help given and, still more, for the giving of help. The truth of a deed is not in the thing done but in the small moments around it, and, in sharing those with all of you, I am fortunate. Foremost, I want to thank my mom, dad, brother, and sister. Your support and love has sustained me. My appreciation for this cannot be adequately symbolized—just know that the value I have found in this life stems from you. I would also like to thank the rest of my family—grandparents, aunts, uncles, and cousins. I am lucky to have so many people that care about me. Without the foundation of love and meaning you have provided, this work would be but a golem.

To my friends and peers, learning and practicing archaeology with you has been a joy. Our experiences together in the lab, field, classroom, and places in between are treasures to me that are worth far more than the knowledge gained. We have had fun, and I bask in the expectation of future merry-making. Travis Hager, Josh Anderson, Andy Brown, Cory Nowak, Ty Warmka, David Briese, Jasmine Koncur, Duncan Widman, Jason Reichel, Michelle Neumann, Caleb Kalinowski, Jaclyn Skinner, Kelli Damlo, Adam Peterson, Emily Evenson, Jared Langseth, Kelly Harvey, Kyle Harvey, Glenn Ojard, and Michael Bergervoet, I thank you all.

To Ron Schirmer, my advisor, mentor, and friend, thank you for everything. You provided me with balanced measures of guidance and freedom, allowing me to drift on my own creative current without ever losing site of the lighthouse. I will ever be grateful to you for the skills, knowledge, opportunities, and experiences that you have shared with me. I would also like to thank the rest of my committee, Kathleen Blue, Dan Wendt, and Stephen Stoynoff. You abetted me freely and graciously when I most needed it. I will not soon forget these kindnesses.

I want to especially thank Dan Wendt. Without your timely assistance and counsel, I would have been lost.

Lastly, I want to thank all the students and staff of the Anthropology Department at Minnesota State University, Mankato; the staff of the Minnesota Historical Society; the assistant to the state archaeologist, Bruce Koenen, who was always helpful when called upon; and the staff of the Science Museum of Minnesota, most especially Edward Fleming, who facilitated my access to the Willow Creek collection.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

Questions and Approach

The Center Creek locality, Willow Creek locality, and Red Wing region are clusters of archeological sites in southern Minnesota (see Dobbs 1988 for an overview of Minnesota prehistory). In terms of population densities and settlement sizes, the most intense prehistoric occupations of all three site-clusters occurred, broadly, in the Late Prehistoric period, between about 1,100 and 500 years ago (Dobbs 1988:183-186, 198-213). The artifactual assemblages associated with the three site-clusters are primarily composed of Oneota tradition materials. While the occupations of the Oneota tradition site-clusters along the Blue Earth River Valley (i.e., the Center Creek and Willow Creek localities) occurred within a single phase, the Blue Earth, and are recognized as closely related, the relationships between Blue Earth phase groups and other Oneota tradition groups (e.g., those in the Red Wing region) are not well understood (see Dobbs 1984). However, recently analyzed carbon remains demonstrate that the Blue Earth phase was contemporaneous with at least one Oneota tradition phase (i.e., the Spring Creek phase) within the Red Wing region (see Schirmer 2016). This thesis is an attempt to address the differences and similarities, as well as the relationships, between Blue Earth and Spring Creek phase groups through an analysis of end scrapers from the Red Wing region, Center Creek locality, and Willow Creek locality. End scrapers from two Woodland tradition sites are included in the analysis as controls.

End scrapers are chipped stone tools that have at least one beveled, outwardly curved edge oriented perpendicular to the artifacts length and formed through intentional modification or use (Crabtree 1972:60). End scrapers, although the name implies otherwise, are thus primarily defined by morphological, rather than functional, characteristics (Odell 1981:319).

Macro-morphological end scraper attributes that relate to material choice, core reduction, tool modification, maintenance, use, and discard are quantified in this thesis. Experimental, ethnographical, and theoretical insights are utilized to identify and interpret the variations amongst end scrapers from the Red Wing region, Center Creek locality, Willow Creek locality, and Woodland sites. In general terms, this research focuses on stylistic variations that relate to the use and manufacture of end scrapers, as well as differences and similarities that relate more to the economic factors involved in the use of specific lithic raw materials for the manufacture of this tool type.

Specifically, this thesis aims to address three basic questions. The first question is centered around the economics of lithic raw material use: how does the use of Grand Meadow Chert vary between the Blue Earth and Spring Creek phase sites with regards to the stages of reduction represented by various end scraper attributes? Put more simply, how reduced are the pieces of Grand Meadow Chert cores from which end scrapers are made, and does this vary consistently between the Blue Earth and Spring Creek phases? Grand Meadow Chert is a high quality lithic raw material, the nearest known source of which is around 100 kilometers away (see Figure) from all three site-complexes (see Bakken 2011; Trow 1981), and previous research has demonstrated that over 90 percent of the end scrapers from the Center Creek and Willow Creek localities are made from Grand Meadow Chert (Dobbs 1984:87). As such, Grand Meadow Chert lends itself to questions involved with stone-tool economics and group movements in southern Minnesota. The next question addressed through this thesis involves the ways in which cores are reduced to manufacture end scrapers: do the techniques of core reduction involved with the production of end scrapers vary significantly by phase or lithic raw material? To address this question, attributes that relate to core reduction are compared between end scrapers made of Prairie du Chien Chert and Grand Meadow Chert from the Spring Creek phase sites, as well as between Grand Meadow Chert end scrapers from the Blue Earth and Spring Creek phase sites. The comparison of Prairie du Chien Chert and Grand Meadow Chert end scrapers from Spring Creek phase sites is also used to address how differences in lithic raw materials impact end scraper morphology more generally. The final question involves how end scrapers are used: are there significant similarities or differences between the Blue Earth and Spring Creek phases with regards to how end scrapers are hafted? The final question is approached through a comparison of the Blue Earth and Spring Creek phase end scrapers to those from two Woodland tradition sites.

In order to address these questions, a total of 145 end scrapers are analyzed in this thesis. Sixty-nine of the analyzed end scrapers are from the Red Wing region sites, nine of which are from 21GD96, 24 of which are from 21GD204, and 36 of which are from 21GD258. The end scrapers from the Red Wing region that are analyzed in this thesis were recovered by Minnesota State University, Mankato in 2006, 2010, 2014, and 2015 and are curated by the same. Twenty-four of the end scrapers included in this thesis are from the Center Creek locality, two of which are from 21FA93, six of which are from 21FA69, and 16 of which are from 21FA2. The end scrapers associated with the Center Creek locality that are here studied were discovered by Minnesota State University, Mankato, the current curator of the artifacts, in 2012 and 2013. Thirty-seven of the end scrapers studied in this work are associated with the Willow Creek locality, all of which were found at 21BE14 by the Science Museum of Minnesota, the current curator of the artifacts, in the early 1980s.

Attributes of 15 end scrapers, seven from 21NL30 and eight from 21NLw/x, associated with Woodland tradition sites were also measured as a part of this research. The primary reason for the inclusion of end scrapers from 21NL30 and 21NLw/x is that these sites were occupied at least several hundred years before the most intensive occupations of the Center Creek locality, Willow Creek locality, and Red Wing region: it is unlikely that the occupants of Wills (21NLw/x) and Eleanor (21NL30) interacted with Willow Creek, Center Creek, and Red Wing occupants. As such, the end scraper data from the two Woodland tradition sites will serve as a control through which the degree of the similarities and differences between Blue Earth phase and Spring Creek phase end scarpers can be accessed. The Wills (21NLw/x) and Eleanor (21NL30) sites were also selected because of accessibility (both are curated by Minnesota State University, Mankato), as well as because the assemblages from both sites contain a large number of end scrapers relative to many other Woodland tradition collections.

Chapter Overview

Chapter two provides background information that relates to the archaeological study of end scrapers, especially within Late Prehistoric contexts of the midwestern United States, as well as definitions of some of the archaeological constructs that are central to this thesis. Chapter three presents the end scraper attributes measured and the methods employed in this research. Chapter four contains descriptions of the sites and site-complexes from which end scrapers are analyzed in this thesis. The descriptions of the sites and site-complexes are organized by associated archaeological phase and/or tradition into three sections— the Woodland tradition sites (i.e. 21NL30 and 21NLw/x), the Blue Earth phase Oneota tradition sites (i.e. the Center Creek and Willow Creek localities), and the Spring Creek phase Oneota tradition sites (i.e. the Red Wing region). The amount of field work that has been conducted, as well as the number and level of related analyses, varies considerably amongst the sites and site-complexes, and, as such, the descriptions vary considerably in terms of detail. Also provided in chapter four are overviews of the major watersheds that surround the analyzed sites and site-complexes. Chapter five presents the results of the analysis, and chapter seven contains the conclusions. The approximate locations of the sites and site-complexes from which end scrapers are analyzed, as well as the Grand Meadow quarry (21MW8), are depicted in Figure 1.

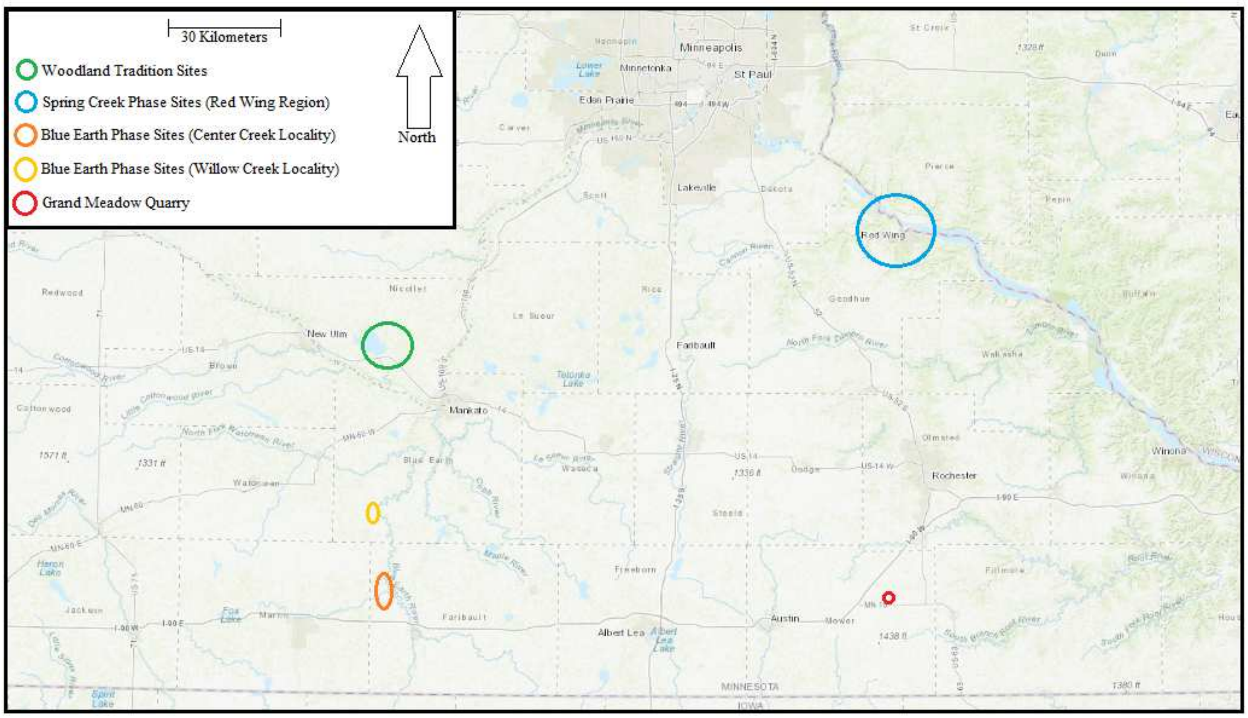

Figure 1: Approximate locations of the Center and Willow Creek localities, Red Wing region, Grand Meadow Quarry, and included Woodland tradition sites (source: Office of the Minnesota State Archaeologist Portal)

Chapter 2: Background

End Scrapers in the Archaeological Record of the Late Prehistoric Midwest

Despite the wide distribution and frequent occurrence of end scrapers in archaeological assemblages from Minnesota sites, end scrapers are not thoroughly discussed in syntheses of Minnesota prehistory (see Anfinson 1997; Dobbs 1988). In part, this could be due to disagreements regarding the nature (see Sackett 1982 and 2008) and visibility (see Barton 1990; Odell 2001) of style within stone-tool assemblages. However, some researchers (e.g., Weedman 2006; Wendt 1985) have observed that there are patterns in the morphology and distribution of end scrapers that may make these tools significant in interpretations of cultural history and patterning. Thus, end scrapers may be a largely untapped resource in terms of the tools which have the potential to help us better understand the behaviors of prehistoric people.

End scrapers may especially be useful for investigations into the relationships amongst the Late Prehistoric inhabitants of southern Minnesota because of the tools association with the processing of bison hides: Dobbs (1984) hypothesized that Red Wing region and Willow/Center Creek locality inhabitants may have been linked through the exchange of hides and other bison products (e.g., bone tools and marrow/grease). Although end scrapers were likely employed in a variety of tasks (Odell 1981; Siegel 1984), some ethnoarchaeological (e.g., McCall 2012; Weedman 2006) and use-wear (e.g., Boszhardt and McCarthy 1999; Schultz 1992) studies support the idea that some groups of people commonly use or used end scrapers to work hides. Of more specific relevance to this research, Late Prehistoric sites throughout much of the Midwest typically contain more end scrapers than earlier sites (Boszhardt and McCarthy 1999:179), and some argue (e.g., Boszhardt and McCarthy 1999; Johnson 1997) that this is, in part, due to an increase in the utilization of bison. Experimental studies (e.g., Shultz 1992;

Boszhardt and McCarthy 1999) that demonstrate bison hides dull/wear end scrapers much more quickly than other hides, such as deer and elk, support the idea that increases in end scraper frequencies are linked to increases in the production of bison hide products. When used to work hides, end scrapers were commonly employed to remove flesh and hair, as well as to soften and thin.

The association of end scrapers with hide-working links the tool to other, more perishable aspects of material culture (e.g., shelters, containers, and clothing). End scrapers are thus imbedded in a complex of relationships that connect the acquisition of lithic raw materials and animal hides to the creation, presentation, and exchange of those incidents of material culture that are amongst the most intimate, visible, and ever present (i.e., clothing). Within Late Prehistoric period contexts of southern Minnesota, knowledge and skills related to hide-working and the creation of hide products, such as clothing, were likely possessed mostly by women and passed from mothers to daughters (see Ruth 2013; Spector 1993; Sundstrom 2002).

There are steps involved in the processing of bison hides (e.g., stretching, fleshing, dehairing, and softening) which are necessary irrespective of the sociocultural differences amongst the groups of people who utilize this animal (see Shultz 1992). However, although the general procedure remains fairly consistent cross-culturally, the individual tasks themselves can be accomplished in a variety of ways. For instance, how hides are stabilized, the angles at which tools are used, the orientation of the hide relative to the hide worker, and how tools are hafted are all interrelated and can vary cross-culturally while the goals of each step in the hide-working process remain relatively constant. Differences in how end scrapers were specifically used with regards to hide-processing are sometimes reflected in the morphology of end scrapers (see Beyries and Rots 2008). Variations in functionally equivalent tasks, such as those discussed above, are seen by some researchers (e.g., Sackett 1982) as stylistically and ethnically significant. Thus, variations in end scraper morphology between Blue Earth and Spring Creek phases that can be linked to similarities or differences in the performance of the above-mentioned tasks may shed light on the ethnic relationships amongst the inhabitants of these site-clusters. Further, some end scraper attributes, such as retouch angles and amounts, also relate to the degree to which a tool is curated, or 'used up' (Dibble 1995; Morrow 1997).

Indicators of tool manufacture (i.e., initial reduction), as well as use, are evident on some recovered end scrapers. End scrapers can retain platforms and other features, such as dorsal surface facets, that relate to the initial detachment of the flake or blade from a larger piece of lithic material (Blades 2003; Collins 1999; Marwik 2007; Shott 1994). This is significant because the concept of style as described in the preceding paragraph can be applied to the process of making end scrapers as well: similar tool forms can be achieved through different core reduction strategies (Callahan 1979). For example, lithic tools that overlap a great deal in form can be made using different reduction techniques (e.g., direct or indirect), percussion instruments (e.g., antler, stone, or wood), stabilization techniques (i.e., how the stone is held or otherwise steadied), and angles of force application. Variations in core-reduction strategies may also shed light on the ethnic relationships between the inhabitants of the Center/Willow Creek localities and Red Wing region.

Variations in attributes that relate to tool creation can also indicate the stages of core reduction associated with end scrapers and raw materials (see Callahan 1979; Rozen and Sullivan 1989; Shott 1994 for perspectives on core reduction stages). The stages of core reduction that are represented for the lithic raw materials in an assemblage partially depend on the particulars of the procurement, transportation, quality, and availability of raw materials. As such, reduction stages and lithic material types can aid in the understanding of the movements and geographical focuses of groups of people.

Archaeological Units of Classification

A number of constructs that relate to the spatial and temporal organization of archaeological information, as well as the integration of the associated units, are relied upon in this research. The classificatory system thus comprised was first explicated by Willey and Phillips (1958) and has been, with few modifications, widely used by midwestern archaeologists since. In terms of spatial units defined by Willey and Phillips, three are central to this thesis—site, locality, and region. A “site”, the smallest of the spatial units within the Willey-Phillips system, is marked by a continuous spread of artifacts that is bound by an area throughout which no evidence of similar human activity exists. Put differently, a site relates to a “single unit of settlement, which may be anything from a small camp to a large city” (1958:18). The next spatial unit, a “locality”, is larger than a site (i.e., contains multiple sites) but small enough to start with the assumption that the people living in a locality at any given time were very closely related culturally. Further, sites within a locality may be functionally, as well as culturally, integrated. A “region”, the last spatial unit here defined, is an area larger than a site (i.e. contains multiple sites) within which culturally distinct groups interact. The borders of a region often relate to environmental and/or geographical distinctions (e.g., ecotones or physical barriers). At various points in this thesis the Center Creek locality, Willow Creek locality, and Red Wing region are refereed to, generically, as site-complexes (i.e., clusters of related sites).

A “phase” is the basic unit of organization with regards to archaeological manifestations, individual examples of which are meant to possess “traits sufficiently characteristic to distinguish it from all other units similarly conceived”, while being “spatially limited to the order of magnitude of a locality or region and chronologically limited to a relatively brief interval of time" (1958:22). In practice, the traits by which phases have been defined in the Midwest are, most often, related to pottery manufacture and decoration. Applied as a means to integrate phases in meaningful way, the archaeological "tradition" is a "temporal continuity represented by persistent configurations in single technologies or other systems of related forms" (1958:37). In other words, the tradition concept is meant to capture socio-technological patterns that, although they may evolve, persist through time and crosscut ethnic differences. The etherealness of the tradition concept, although sometimes resulting in somewhat inconsistent usages, is viewed as a strength by Willey and Phillips because it lends the flexibility required of a broad, integrative unit.

End scrapers from two archaeological traditions, the "Woodland" and "Oneota", are analyzed in this thesis. Sites ascribed to the Woodland tradition in Minnesota are up to about 3,000 years old (see Arzigian 2008). The Woodland tradition persisted at some places in the northern portion of the state until the early contact period, while in the southern portion of the state Woodland tradition materials cease to appear around 1,000 years ago and are replaced by Oneota and Plains Village tradition materials. Importantly, within southern Minnesota, the replacement of the Woodland tradition by the Oneota and Plains Village traditions appears to be related to the transformation of local populations as well as large-scale population movements (see Schirmer n.d.). Technological indicators of the Woodland tradition include pottery, earthworks, and storage features. Relative to the traditions that preceded it, the Woodland tradition is also marked by a region-wide increase in population, increases in the population densities of individual settlements, less mobile populations, and predominantly lacustrine-focused settlements (Anfinson 1997). It is important to note, however, that the changes associated with the Woodland tradition did not occur in a linear fashion (e.g., populations fluctuated throughout the Woodland tradition) or homogenously throughout the state.

The Oneota tradition refers to portions of the material record that were created by some of the people who lived throughout the prairie peninsula and in nearby areas of North America from the 11th through 17th centuries (Dobbs 1988). Some researchers (e.g., Dobbs 1988) use the term to acknowledge broad similarities in pottery manufacture and subsistence patterns. Others (e.g., Benn 1989; Gibbon 1972; Theler and Boszhardt 2006) argue that the commonalities captured by the category "Oneota tradition" extend to political institutions and the relations of production. Yet other researchers (e.g., Berres 2001) contend that Oneota tradition groups shared a common worldview. There is much disagreement over what is common to all of the people whose material history is categorized as "Oneota" (see Schirmer 2002). Regardless of the exact definition, globular, shell-tempered pottery vessels, large storage/refuse pits, and a riverine settlement orientation, as well as a reliance on bison, aquatic resources (e.g., fish and freshwater mussels), and cultigens (e.g., maize, sunflowers, beans, and squashes), are seen as hallmarks of the Oneota tradition. Not all of these traits, however, are equally present at all Oneota tradition settlements. In terms of historical connections, descendants of the people associated with the Oneota tradition are thought to include the Oto, Ioway, Missouri, and HoChunk tribes (see Dobbs 1984)

Two phases of the Oneota tradition, the Blue Earth and the Spring Creek, are the focus of this research. Blue Earth phase materials are found at two locations, the Willow Creek and Center Creek localities. The Willow and Center Creek localities are, at least partially, contemporaneous, dating, conservatively, to the 14th and 15th centuries (Schirmer 2016). The localities, however, may have been occupied as early as the 11th century and as late as the 17th

century (Dobbs 1984). The presence of Blue Earth phase materials at the Willow Creek and Center Creek localities, as well as the spatial and temporal proximity of the site-complexes to one another, suggests that the people who lived within the localities were closely related and, if the localities were occupied simultaneously, which appears to have been the case in at least the 14th and 15th centuries, regularly interacting; however, the precise nature of the relationships amongst the inhabitants of the localities is not known.

Spring Creek phase materials are found at, minimally, three sites within the Red Wing region (i.e., 21GD96, 21GD204, and 21GD258). The Spring Creek phase is distinguished from the Bartron and Silvernale phases, the two other major phases present in the Red Wing region, by a few factors (Schirmer 2017). Spring Creek materials, dating to the 14th and 15th centuries, are slightly later than Bartron and Silvernale phase materials. Further, Spring Creek phase sites are restricted to the small, interior creek valleys within the region, while Bartron and Silvernale phase sites are focused around the large valleys of the Cannon and Mississippi rivers. In terms of associated assemblages, sites with Silvernale and Bartron phase components contain artifactual materials indicative of aggregative social behaviors (discussed in more detail in chapter 4), while Spring Creek phase sites are more typical of Oneota settlements throughout the southern portion of the state. With regards to pottery, Spring Creek and Bartron phase vessels are virtually indistinguishable, and, as such, the assignment of a particular Oneota tradition vessel from the Red Wing region to one of these phases relies on the above-mentioned differences in settlement location and times of occupation. Silvernale phase vessels, comprised of morphological (e.g., rolled rims and angled shoulders) and decorative (e.g., scroll motifs) features that are suggestive of Middle Mississippian influence, are, however, markedly different from both Spring Creek phase and Bartron phase vessels. Early researchers (e.g., Wilford 1955) emphasized the influence of Middle Mississippian groups, especially those living in Cahokia, on the development of the Silvernale phase in the Red Wing region and the emergence of Oneota in the area, arguing that there was a movement of people into the region from core Middle Mississippian areas to the south. Later researchers (e.g., Fleming 2009; Gibbon and Dobbs 1991; Schirmer 2002, n.d.) have shown that a more plausible explanation is that Oneota emerged from resident Woodland tradition groups at site-complexes like the Red Wing region. From this perspective, the Oneota tradition did not result from Middle Mississippian influence, but, rather, the geneses of Oneota and Middle Mississippian societies occurred parallel to one another, influenced by similar environmental and social factors as well as regional interactions. Further, the *in situ* hypothesis of Oneota origins emphasizes the relationships amongst Red Wing region groups with Middle Mississippian centers in southern Wisconsin and northern Illinois instead of the major centers in Missouri, such as Cahokia (Schirmer 2002).

Brief Environmental Overview of Southern Minnesota

The climate of southern Minnesota is defined as continental (see Gibbon 2012 for an overview of Minnesota prehistory, climate, and environment). Hot, humid summers and cold winters characterize the area. Thunderstorms are common in the summer, and blizzards impact the area in the winter, more severely and frequently in some years than in others. Although the climate has been relatively stable for the past 3,000 years, fluctuations have occurred, evidenced by changes in the location of the prairie-forest border, which, in late prehistory, was slightly east of the Blue Earth River, roughly parallel to the valley. Big blue stem and little bluestem were the most prolific of the prairie grasses. Big blue stem grew most commonly in poorly drained soils and upland depressions, reaching heights of up to three meters or more, while little blue stem grew up to about one meter tall and flourished in dryer, more well drained areas. Other kinds of grasses that were common in the prairies of the state included switchgrass, Indian grass, prairie cordgrass, Canada wild rye, and panic grass. Varieties of forbs, some of which flowered seasonally, and legumes, some of which were nutritious sources of food (e.g. prairie turnips and ground plums), also comprised the prairie vegetation. Isolated patches of trees, mostly oaks, and underbrush occurred within the prairie and away from water; however, forests within the prairie were largely restricted to the bluff edges, slopes, and bottomlands of the major river valleys and areas around lakeshores, marshes, and streams.

Forests increased in frequency and density with movement northwards and eastwards from the Blue Earth River Valley. Species of trees common in southern Minnesota included cottonwoods, willows, hackberry, and walnut. Ironwood, hickory, eastern red cedar, and butternut were represented more on the bluff edges and valley slopes. Oak, aspen, elm, ash, maple, and basswood were more widely distributed. Of the trees present, a number produced edible seeds or fruits (e.g. oak, hackberry, walnut, and butternut). Different types of vining plants also existed throughout the forests: bittersweet, wild hops, Virginia creeper, poison ivy, and bristly greenbrier are examples. Varieties of plants that produce edible fruits—chokecherries, black cherries, raspberries, blackberries, dewberries, hawthorns, thorn apples, and wild plums—were also present in the forests. Other plants that inhabited the wooded portions of the area included smooth sumac, which can be used as a flavoring, dye source, and inhalant; dogwood, a tough, woody plant out of which durable tools can be fashioned; American hazelnut, which produces edible seeds; and common prickly ash, which comprised a significant portion of the undergrowth. The forests of southern Minnesota remain, though to a more restricted degree.

A number of useful aquatic plants were also common in southern Minnesota. Cattails, arrowheads, and bullrushes concentrated around lake margins. The inner stems of cattails and bullrushes are edible, and the plants were used in the construction of padding, mats, and baskets. Arrowheads, as well as bullrushes, possessed edible tubers. Various species of water lilies also inhabited the lakes (e.g. the fragrant water lily, yellow pond lily, and American lotus). The tubers of these water lilies were also edible. Wild rice was present in the area, growing in shallow lakes and along the edges of slowly moving rivers and streams. Although all of these aquatic plants still exist throughout the area, they were much more abundant a century and a half ago—prior to the drainage of a high proportion of the lakes and wetlands in the southern Minnesota.

Examples of large mammals known to inhabitant the state up into the historic period include bison, elk, moose, black bear, whitetail deer, and timber wolf (whitetail deer and black bear continue to be common throughout the state). Examples of large mammals that may have lived in the state between the final glacial retreat and historic period include grizzly bear, mule deer, mountain lion, and prong horned antelope. Many small mammals also inhabit the state. Of these, muskrats, river otters, beavers, jackrabbits, cottontail rabbits, foxes, coyotes, and raccoons are notable in terms of exploitation by humans. Migratory birds and birds of prey also pass through and occupy the state. Amphibians and reptiles are not as numerous in Minnesota as in more southerly areas; however, a few species are present in large numbers, including types of turtles, frogs, and snakes. Numerous species of fish swim through the waters of Minnesota's lakes and rivers as well, including pike, walleye, bass (smallmouth and largemouth), and varies types of sunfish (e.g., bluegill, green, and pumpkinseed) and rough fish (e.g., sucker, bullhead, and catfish).

Chapter 3: Methods

Methodological Overview

A variety of measurements were collected on individual end scraper specimens for this research. The measurements selected for collection were based on standards prevailing in the literature, as well as on discussions with regional experts. The values of measurements were entered into Microsoft Excel 2016, and the software was utilized to create tables and perform statistical tests. Tables of summary statistics, including mean, median, mode, standard deviation (SD), coefficient of variance (CV), range, minimum, maximum, sum, and count were generated for continuous numeric variables. The variances of continuous numeric variables were compared through the use of F-tests and single factor ANOVA tests. Correlation tables were also constructed for some of the numeric variables, using Pearson's coefficients. Categorical variables were compared with Chi-squared tests. A significance level of 0.05 was used, and, to address familywise error rates, the Sidak method was applied to calculate corrected significance levels for the separate data sets (see Sidak 1967).

A number of the measurements were taken on millimeter graph paper, using a cartesian coordinate system. End scrapers were oriented on millimeter graph paper in the following way: the point at which the distal and left lateral edges met represented the origin of the grid (i.e. 0,0), and the width of the distal edge represented the x-axis (i.e., the junction of the distal and right lateral edges was located at n,0). Measurements on graph paper were taken to the nearest millimeter (see Figure 2). Weight measurements were taken with an electronic balance and accurate to the nearest thousandth of a gram. A number of measurements were also taken with a digital caliper and steel protractor. Measurements with the digital caliper were taken to the nearest hundredth of a millimeter, while those with a steel protractor were taken to the nearest degree. When using the steel protractor, the ventral surface of an end scraper was placed against the head of the protractor. A semicircular protractor was also used, measuring to the nearest five-degrees. Some of the anatomical terms utilized are illustrated in Figure 3, which is the dorsal view of the same end scraper that is the subject of the previous figure.

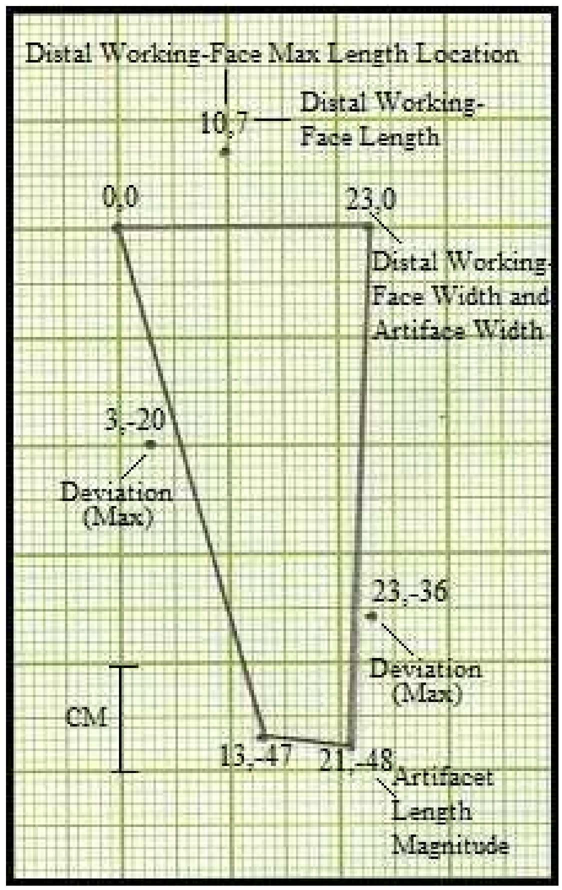

Figure 2: Example of measurements taken on graph paper (Project #127)

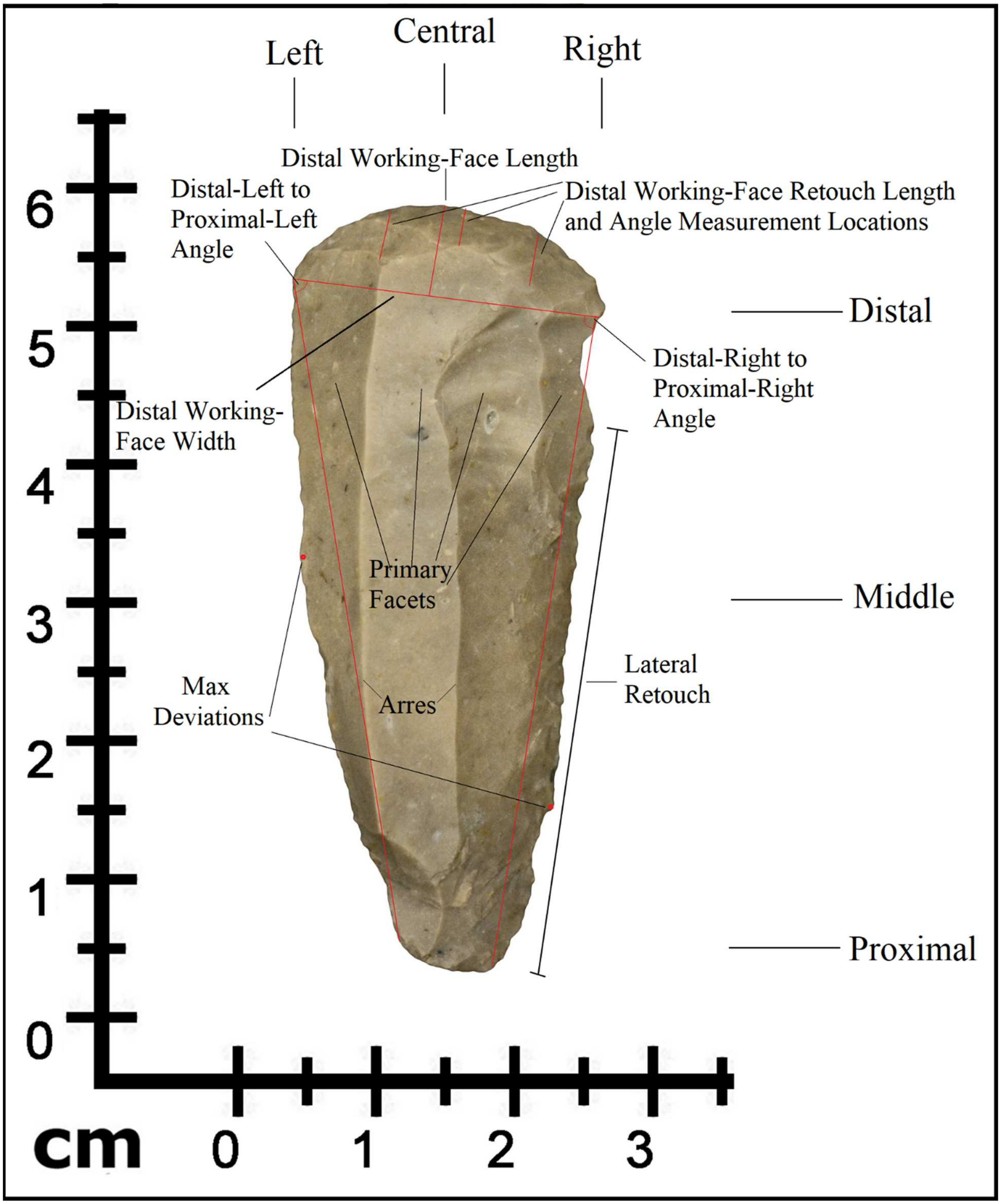

Figure 3: Dorsal view of an end scraper from 21FA2 and anatomical terms (Project #127)

Attributes and Measurements

Basic Dimensions and Shape

The sizes and shapes of end scrapers are related to how the tools were used, as well as how the tools were manufactured (see Barton 1990; Blades 2003; Dibble 1995; Odell 2001). In general, the length of an end scrapers tends to be the dimension that is most sensitive to tool-use, decreasing as the distal working-end is reshaped and resharpened, while the thickness dimension tends to remain most constant throughout use and thus relates more to the initial removal of the tool-blank from a larger piece of lithic material (i.e., initial lithic reduction). The maximum length, maximum width, maximum thickness (away from percussion bulb), and weight of each end scraper was measured. The length and width measurements were taken with millimeter graph paper, the thickness measurements with a digital caliper, and the weight measurements with an electronic balance. The location of the maximum thickness was described using a single one of, combination of, or range of locational terms. The locational terms used are distal, proximal, medial, right lateral, left lateral, and middle.

The planview of an artifact is the general shape of the artifact as it is perceived set flat, dorsal-side up, while looking from above. The use of planview shape-terms simplifies variation in overall shape through the assignment of artifacts to one of several mutually exclusive, general shape-categories. Shape-terms (taken from Morrow 1997) were assigned as follows—triangular (proximal width less than half that of the distal width), tapered (proximal width greater than half that of but less than the distal width), rectangular (proximal width approximately equal to the distal width), convergent (proximal is the widest part), ovate (middle is the widest part), or undetermined (does not conform to other shape terms).

Breaks

Breaks are related to the type/magnitude of tool-use, discard behaviors, and post depositional processes (see Jennings 2011 and Shott 1994). The presence of breaks was noted. If present, the orientations of breaks were described using the terms parallel, perpendicular, or oblique. The orientations of breaks were defined relative to the length dimension of end scrapers.

Bulb of Percussion

Bulbs of percussion form below and behind the surface struck (i.e., platform) to remove a portion of lithic material from a larger piece. Bulbs of percussion are related to initial lithic reduction techniques (see Callahan 1979 and Crabtree 1972). Generally, hard hammers produce larger bulbs than soft hammers. The presence of percussion bulbs was recorded. If present, a thickness measurement was taken at the point of maximum bulb protrusion with a digital caliper.

Cortex

Cortex, an exterior layer present on some stones, results from natural, mechanical and chemical processes (see Morrow et al. 2016). These processes result in differences in color and texture that are easily perceivable. Cortex relates to initial lithic reduction: the location and amount of cortex on artifacts changes as the amount a stone is reduced increases (see Ahler 1989 and Brown 1991). The presence and condition of cortex was noted. If present, the location of the cortex was described through the use of the locational terms described above (see location of maximum thickness).

Curvature

The longitudinal curvature of an end scrapers ventral surface is associated with the initial reduction of lithic materials. End scrapers made through the utilization of a blade-core technology tend to have more highly curved ventral surfaces than end scrapers made through alternative methods (see Wilke et al. 2002). Also, within blade-core technologies, the ventral curvature of blades tends to increase as the amount a core is reduced increases (see Collins 1999). The ventral surfaces of end scrapers were measured using a pottery profiler and digital caliper, and curvature was calculated by dividing this value by the artifacts length.

Distal Working-Face

The distal working-face of an end scraper is comprised of the bevel and edge that is pressed and pulled against the surface on which the tool is used. The angle of the distal bevel is related to curation (i.e., how much the tool was used), becoming progressively steeper as the thinner portions of the artifact are worn away or otherwise removed (See Dibble 1995; Morrow 1997; Weedman 2006). Additionally, the orientation of the distal edge (i.e., the location of the longest protrusion on the distal edge relative to its width) is related to how the tool was hafted and the angle at which it was applied to the worked surface (see Beyries and Rots 2008). Two measurements were taken at three points, the midway and quarters, along the distal bevel, using a digital caliper and steel protractor. These measurements were the length and angle of retouch. The location and length of the longest protrusion (i.e., distal working-face length) along the distal edge, as well as the width of the distal edge, were also measured, using millimeter graph paper. The location (x value) of the maximum length of the distal working-face divided by the width of the distal working-face provides a measure of centeredness/orientation. Undercutting, when present on the distal edge, was noted as well.

The cross-section at the junction of the distal working-face and artifact body, parallel to the artifacts width, was also noted. The cross-section of an end scraper is mostly impacted by the shape of the dorsal surface (i.e., the arrangement of primary facets or the topography of an unmodified surface) and the extent/location of retouch. Cross-section shape-terms were assigned as follows—triangular (apex defined by a roughly centered point or a roughly centered plane with a length less than half that of the distal width), scalene (apex defined by an off-set point or plane with a width less than half that of the distal width), trapezoidal (apex defined by a plane with a width at least half that of but less than the width of the distal width), rectangular (apex defined by a plane approximately the same width of the distal width), hemispherical (arc shaped), or undetermined (does not conform to other shape terms).

Eraillure Scar

An eraillure scar is a facet that occurs on or near the bulb of percussion as a consequence of initial lithic reduction. Eraillur scars tend to be associated with soft-hammer reduction, but the relationship between eraillure scars and hammer-types is not well understood (see Crabtree 1972). When present, the length and width dimensions of eraillure scars were measured with a digital caliper.

Heat Treatment and Burning

Whether or not end scrapers were burned or heat treated was recorded. Heat treatment and burning relate to discard behaviors and lithic raw material modification (see Morrow et al. 2016). The presence of heat spalls and fissures were interpreted as indicators of burning. Heat treatment was identified when the color and texture of an individual specimen markedly differed from those typically displayed by the lithic raw material.

Lateral Edges

The lateral edges of end scrapers often bear modifications, such as retouch, that are related to use. Lateral retouch is related to use in a general sense: the more an end scraper is used (i.e., curated), the more extensive lateral retouch may become (see Dibble 1995). In some cases, however, the shaping of lateral edges is more related to hafting than to curation (see Wilke et al. 2002). The presence of retouch was noted for both sides (i.e., dorsal and ventral) of the left and right lateral edges of end scrapers. Retouch was recorded as present if the edge contained at least three consecutive pressure flakes that extended at least one millimeters up the edge. The extent and location of retouch along lateral edges was determined with the use of millimeter graph paper, while the angle and length of retouch up the edge was measured with a steel protractor and digital caliper at three points (the quarter and mid-points along the length of the artifact). In cases where a lateral edge was convex or otherwise angled outwards, the point of maximum protrusion was marked on millimeter graph paper as well.

Platform

A platform is the surface struck to detach a piece of lithic a portion of lithic material from a larger piece. Platforms are related to a number of variables involved in initial lithic reduction. For instance, interior platform angles (i.e., the angle formed at the juncture of the platform and ventral surface), as well as platform surface-areas, tend to decrease as the amount a stone is reduced increases (see Blades 2003; Collins 1999; Marwik 2007). Platform faceting, on the other hand, tends to increase along with the amount a stone is reduced. Further, the shapes of platforms (i.e., thickness to width ratios) vary in relation to hammer-types (see Collins 1999). The interior platform angle was measured with a steel protractor, and the dimensions of platforms (i.e., thickness and width) were measured with an electronic caliper when the entire platform was present. Interior platform angles were measured when any amount of the platform remained, while platform areas were only measured when a complete platform was present. Platforms were placed into three categories with regards to faceting. Platforms with no facets (i.e., cortex covered) were placed in one category and single faceted platforms in another.

Platforms with two or more facets were placed in the last category. Platform grinding, which relates to an attempt at strengthening the striking surface, was also noted when present. Judgments that related to the presence or absence of platform grinding and faceting were made on platforms that were complete or nearly complete. The final platform measurement was of the degree to which the platform was rotated relative to the width of the artifact. Typically, the width dimension of a platform runs parallel to the width dimension of the end scraper. However, in cases where the platform is ill-aligned with dorsal surface features, it may become twisted off-center (see Wilke et al. 2002). Platform off-centeredness was measured with a semicircular protractor, relative to the width of the end scraper. Platform off-centeredness was measured when the platform was complete or nearly complete.

Primary Facets

Primary facets are flake scars on the dorsal surface of end scrapers that are the result of previous detachments of lithic material from a cobble or core. The number of primary facets increases as the amount a stone is reduced increases (see Shott 1994). Also, the angles of primary facets (relative to an end scrapers ventral surface) tend to become steeper with increased lithic reduction (see Hay and Rogers 1978). The number of primary facets on an end scrapers dorsal surface were counted and recorded. Primary facets were only counted as such if the relation to initial reduction was readily apparent (i.e., if the facet was at least 10 millimeters in length). The angles of primary facets were measured with a steel protractor, relative to the dorsal surface of the end scraper, at three points (the quarter and mid-points along the length of the artifact). In the case of multi-faceted end scrapers, the angle at the junction of facets was measured with a steel protractor in similar fashion.

Raw Material

Lithic raw materials were identified through the use of the comparative collection housed at Minnesota State University, Mankato, as well as through reference to relevant sources (e.g., Bakken 2011; Morrow et al. 2016). Lithic raw materials were also described by Munsell color-code. Variations in lithic raw materials (e.g., in strength and consistency) impact the morphology of the associated artifacts (see Shott 1994; Wendt 1985). Further, variations in the color of lithic raw materials may be a socially relevant (see McElrath and Emerson 2000).

Chapter 4: Study Area

The Woodland Tradition Sites

The Middle Minnesota Major Watershed

The Minnesota River cuts through the southwestern quarter of the state of Minnesota, flowing southeast from its headwaters at Big Stone Lake on the South Dakota border until, near the confluence with the Blue Earth River, it abruptly turns northeast, eventually becoming tributary to the Mississippi River. Along this course, the Minnesota River covers a distance of more than 500 kilometers, averaging a little more than a quarter of a meter in elevation loss every kilometer and a half, and drains an area of nearly 4,500,000 hectares (see Musser et al. 2009 for an overview of the Minnesota River basin). One of twelve major hydraulic units that comprise the Minnesota River system, the Middle Minnesota River Major Watershed drains an area of nearly 500,000 hectares, encompassing the northeasterly turn made by the river. Unlike most other major watersheds of the Minnesota River, the Middle Minnesota Watershed is not characterized by the central channel of a major tributary of the Minnesota. Rather, the watershed is composed of a segment of the Minnesota River and many small tributaries (see United States Department of Agriculture, Natural Resources Conservation Service [USDA, NRCS] 2009 for a technical report on the Middle Minnesota River Major Watershed).

A number of creeks and rivers drain into the Minnesota River within the Middle Minnesota Watershed. The Little Cottonwood River, the largest tributary within the watershed, flows northeast for a distance of about 50 kilometers before it joins the Minnesota River from the south, draining an area of a little over 40,000 hectares. Several smaller tributaries, such as Minneopa, Morgan, and Wabasha creeks, also meet the Minnesota River from the south within the watershed. Other tributaries in the watershed include Rogers, Barney Fry, and Seven Mile creeks, which flow east into the Minnesota after the river has turned northward, and Little Rock Creek, Eight Mile Creek, Fort Ridgely Creek, and the Swan Lake Outlet, which flow south and meet the Minnesota before the Blue Earth River junction. Smaller creeks, less than three kilometers in length, and springs feed into the Minnesota River within the watershed as well. In total, about 2,500 kilometers of river and stream makeup the watershed. The Middle Minnesota Watershed also contains nearly 10,000 hectares of open water, most of which is located in its eastern portion. Accounting for nearly half of the open water acreage, Swan Lake, the largest lake within the watershed, is located about five kilometers to the north of the Minnesota River. Although large in area, Swan Lake is fairly shallow, with an average depth of around a meter. Recent analysis of fish remains from 21NLae, an archaeological site located on an island in Swan Lake, has demonstrated the presence of northern pike (*Esox lucius*), however, indicating that the lake may have been deeper prior to the accumulation of historic-era sediments (Ty Warmka, personal communication 2018). Middle Lake, another broad and shallow water body, is located around one and a half kilometers to the east of Swan Lake and, similarly, may have been deeper in prehistory. Prior to the installation of artificial drainage systems for agricultural purposes around the turn of the twentieth century, much more of the watershed was covered by shallow lakes, wetlands, and marshes.

Outside the Minnesota River Valley, the ground surface of the Middle Minnesota Watershed mostly varies from flat to gently rolling, underlain by up to 60 meters of glacial till (see Winchell and Upham 1884 and 1888 for descriptions of the physical features in southern Minnesota). However, the relatively even topography of the uplands is broken by the river and stream valleys that dissect it. In general, the highest elevations of the Middle Minnesota Watershed occur within its southwest and northern parts, while the lowest elevations are found within the central portion. The dominant geographic feature is the Minnesota River Valley, which typically ranges from about one and a half to three kilometers in width within the watershed. Bluffs, some more than 60 meters tall, border the valley, and bedrock outcrops in certain areas along the ridgeline. Sedimentary rocks outcrop along the river valley in the eastern part of the watershed, while exposures of older, metamorphic and igneous rocks are present along the valley in the western portion. The valley floor itself is much lower than the surrounding area. As a result, some of the tributaries within the Middle Minnesota Watershed gain a significant amount of speed and depth upon approach to the Minnesota River Valley, transitioning from slow and shallow streams into cascades and waterfalls.

The only extensive exposures of bedrock outside of the Minnesota River Valley are in the southwestern part of the watershed, near the source of the Little Cottonwood River. Around the Little Cottonwood headwaters, the Sioux quartzite formation, consisting mostly of rose colored quartzite, sandstone, and mudstone, outcrops over a space that is about five kilometers wide and thirty kilometers long. Thousands of images are etched onto the Sioux quartzite exposures in this area, forming the densest concentration of petroglyphs known to exist in the state of Minnesota (see Connolly 1999). Known as Jeffers Petroglyphs, the oldest images at the site were carved 5,000 years ago or more. Isolated basal exposures of Sioux quartzite in the form of loose beds of materials that range in size from sand grains to boulders and contain quartz, jasper, chert, and quartzite are also present around the area where the Cottonwood and Little Cottonwood rivers meet the Minnesota River.

The Eleanor Site (21NL30)

The Eleanor site (21NL30) is located on one of several island-like rises that connect intermittently, forming a disjointed peninsula that projects into Swan Lake from the south and west (see Figure 4). The rises that comprise the peninsula are elevated from around three to ten meters above the waterline. The Eleanor site was discovered by Richard Strachan, a professor at Mankato State University (now Minnesota State University, Mankato). Strachan supervised three summer field schools at the site from 1976 through 1978, which involved surface surveys and the excavation of a number of units. The field schools were part of a larger survey of the Swan Lake and Middle Lake area conducted by Strachan from the mid-1970s through mid-1980s (see Strachan and Roetzel 1989).

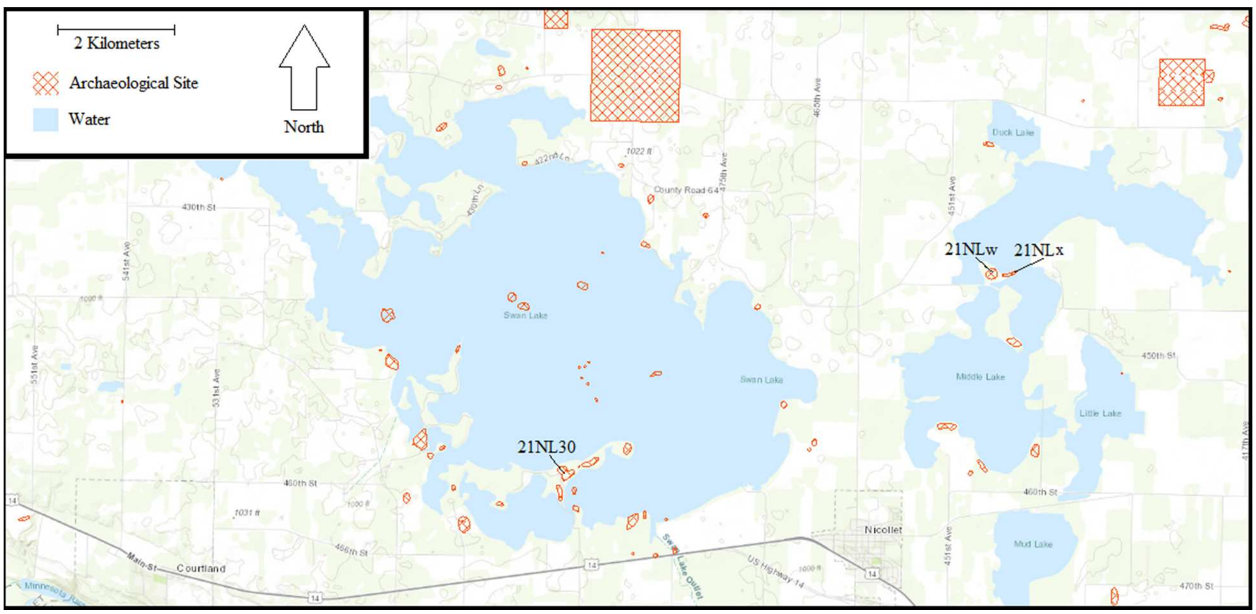

Figure 4: Approximate locations of 21NL30, 21NLw, 21NLx, and surrounding sites (source: Office of the Minnesota State Archaeologist Portal)

The assemblage collected through Strachan's work at 21NL30 is extensive and has yet to be analyzed. Further, Strachan never produced a report that detailed his work at the site. Primary source materials, however, such as field notes and forms, are housed at Minnesota State University, Mankato. Artifacts associated with the site include lithic debitage, scrapers, projectile points, celts, hoes, hammerstones, and mammal bones. The pottery from the site (see field notes) includes both smooth-surfaced and cord-marked sherds, some of which are decorated with rows of dentates or punctates, and is predominantly grit-tempered. Taken as a whole, the artifact assemblage associated with 21NL30 is suggestive of a Woodland habitation. A number of other Woodland tradition artifact scatters are located on the same peninsula as 21NL30 (e.g., 21NL25, 21NL26, 21NL27, 21NL29, 21NL32, and 21NL34).

The Wills Site (21NLw/x)

The Wills Site (21NLw/x) is located on an island in Middle Lake, elevated about three to six meters above the waterline (see Figure 4). Richard Strachan conducted field schools through what is now Minnesota State University, Mankato at the site in 1982 and 1984, surface surveying the site and excavating units. The field schools were part of a larger survey of the Swan Lake and Middle Lake area conducted by Strachan from the mid-1970s through mid-1980s (see Strachan and Roetzel 1989).

Similar to the Eleanor site (21NL30), the assemblage collected through Strachan's work at the Wills site (21NLw/x) has yet to be analyzed or reported on. Field notes associated with Strachan's work at the site are housed at Minnesota State University, Mankato, however. The artifact assemblage from Strachan's research at Wills is also very large. Of particular interest artifactually, large amounts of pottery were recovered from the site (see field notes). The majority of the pottery discovered at Wills was grit-tempered, indicating a Woodland presence, but some was tempered with shell.

The Blue Earth Oneota Phase Sites

The Blue Earth, Le Sueur, and Watonwan Major Watersheds

From its source in the uplands of northcentral Iowa, the Blue Earth River flows north, meandering for over 160 kilometers—nearly twice the straight-line distance—before joining the Minnesota River in the modern-day city of Mankato (see Quade's [2000a, 2000b, 2000c] diagnostic reports for metrics of the Greater Blue Earth River Watershed). Although relatively short in length, the Greater Blue Earth River Watershed, comprised by the Blue Earth, Watonwan, and Le Sueur River major watersheds, has a width of approximately 150 kilometers. The two largest tributaries of the Blue Earth, the Watonwan and Le Sueur rivers, span the western and eastern extents of the watershed respectively, draining a combined area of a little over 400,000 hectares. In total, the Greater Blue Earth River Watershed has an area of more than 800,000 hectares.

Many creeks and rivers contribute to the Greater Blue Earth River Watershed. Nearly 5,000 kilometers of streams comprise the watershed, about half of which flow perennially. Major east-flowing tributaries of the Blue Earth River include the Watonwan River, the western branch of the Blue Earth and Willow, Elm, Center, and South creeks. Willow Creek and Center Creek join the Blue Earth River around 30 and 50 kilometers to the south of the Minnesota River junction, respectively. Major west-flowing tributaries include the Maple, Cobb, and Le Sueur rivers, the eastern branch of the Blue Earth and Coon Creek. More than 100 named lakes exist within the Greater Blue Earth River Watershed as well, covering an area of around 12,000 hectares. A century and a half ago, the watershed contained a substantial number of shallow lakes and wetlands, but the vast majority, or about 90 percent, have since been artificially drained (see Quade 2000a, 2000b, 2000c).

The gradient of the Blue Earth River bed tends to decrease with distance from the headwaters. Overall, the gradient of the main stem of the Blue Earth River is fairly slight, averaging a little over one meter in elevation change every one and a half kilometers. Gradients of the tributary creeks and rivers are generally steeper, however. The terrestrial topography, underlain by drift, varies from flat to moderately rolling throughout most of the Greater Blue Earth River Watershed, but numerous ravines are also present (see Winchell and Upham 1884 and 1888 for descriptions of the physical features in southern Minnesota). The Blue Earth River Valley itself is relatively narrow along much of its length and deeply incised; however, the floodplain widens around the Willow Creek and Center Creek junctions. Typically, the floodplain of the Blue Earth River is about 25 meters below the uplands. Sheer bluffs are often adjacent to the river in its lower reaches, where erosive processes have exposed the sedimentary bedrock that underlies the glacial drift. Dramatic limestone and sandstone prominences can rise over 50 meters above the river in some these places.

The Center Creek Locality

Clark Dobbs (1984) completed the most substantial synthesis of the Center Creek and Willow Creek localities, which is the source for the information in this section unless otherwise specified (see also Dobbs and Shane 1982 for an abbreviated synthesis). Following Willey and Phillips (1958:18-19), Dobbs defined Center Creek as an archaeological locality. As defined by Dobbs, the Center Creek locality encompasses the flood plains and uplands immediately west of the portion of the Blue Earth River into which Elm Creek, Center Creek, and South Creek drain (see Figure 5). At least 32 Oneota tradition sites of the Blue Earth phase comprise the locality

(Dobbs 1984:69). It should be noted that the Center Creek locality is defined differently than the associated archaeological district: as an archaeological locality, Center Creek includes all likely or confirmed Oneota tradition sites in the vicinity of the creek and Blue Earth River junction, as well as adjacent sites that may or may not be related to the occupations associated with Blue Earth Oneota, while the Center Creek Archaeological District is more spatially restricted and focused around the two largest habitation sites, Humphrey (21FA1) and Vosburg (21FA2).

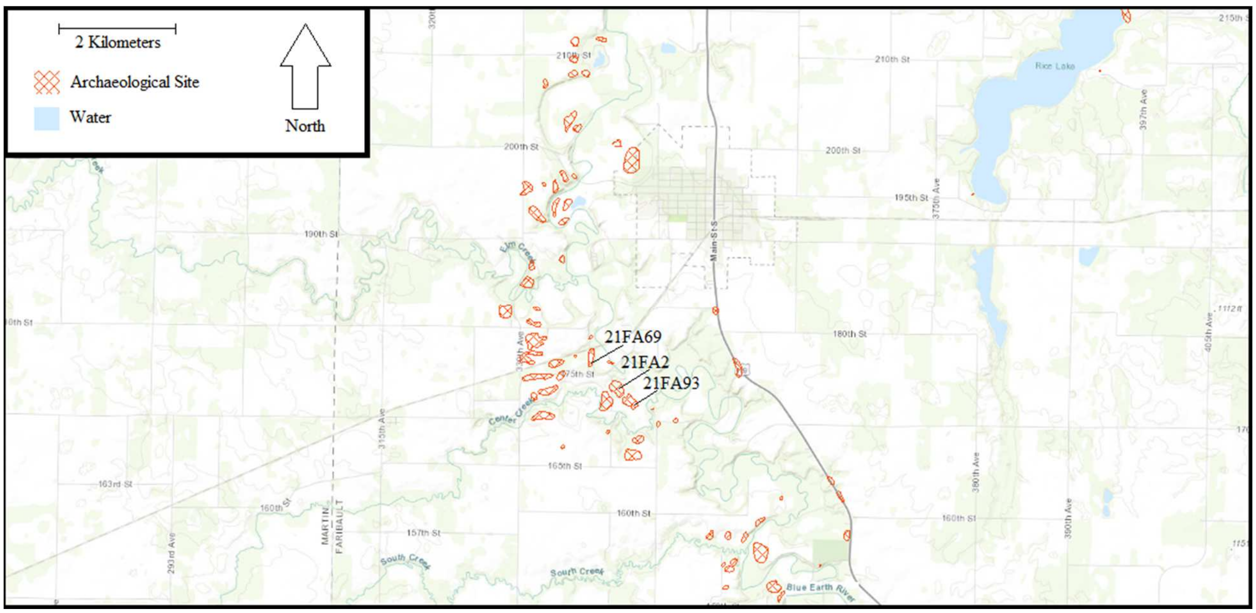

Figure 5: Approximate locations of 21FA2, 21FA69, 21FA93, and surrounding sites (source: Office of the Minnesota State Archaeologist Portal)

Archaeology has been conducted in the Center Creek locality for around a century (see Dobbs 1984:62-67 for a historical overview of the archaeological work that has occurred at the Center Creek locality). Throughout that period of time, local residents have investigated sites within the locality. The Winnebago Area Museum curates many of the artifacts collected by local residents. Albert Jenks of the University of Minnesota was the first professional archaeologist to visit Center Creek, doing so sometime prior to the mid-1930s. No written or artefactual materials are known to exist from his work in the area, however, and the exact dates of his presence at the Center Creek locality are unknown. Charles Keyes, a professor at Cornell College in Mount Vernon, visited several sites within the Center Creek locality in the summer of 1935, noting similarities between the archaeological materials at the locality and Oneota tradition materials he had encountered in Iowa (see Keyes in Guthe 1937).

Beginning in the late 1930s, Lloyd Wilford of The University of Minnesota conducted archaeological excavations at the Center Creek locality (see Wilford 1941; 1945a; 1945b; 1952). Wilford's first recorded work at the locality was in 1938, when, due in part to the use of the site as a gravel mine, he excavated a part of Humphrey (21FA1). Wilford returned to the locality in 1947, performing an excavation at the Vosburg site (21FA2). Wilford encountered large quantities of decorated pottery and other artifacts at the two sites, as well as more than three dozen pit features, defining what would become known as the Blue Earth phase of the Oneota tradition based on the finds. In 1953, prompted by information from a local construction contractor, Wilford visited a burial site in the Center Creek locality (21FA84) but, due to the disturbances associated with the historic extraction of gravel from the site, was unable to identify any archaeological remnants. It was reported to Wilford that over 100 individuals, along with grave goods that included Blue Earth phase pottery, were disturbed at 21FA84 by gravel miners but that the uncovered individuals and artifacts were destroyed or displaced.

The mid-1950s through 1960s spanned a hiatus in professional archaeological work at the Center Creek locality. It was not until the mid-1970s that field research resumed. Guy Gibbon of the University of Minnesota and Michael Scullin, a professor at Mankato State University (now Minnesota State University, Mankato), surveyed sites within the Center Creek locality in 1974 and 1975. The next year, uncovering fire pits and artifacts, gravel extraction at a location within the locality resulted in the discovery of a site (21FA50). Graveling operations were suspended, and a number of local volunteers mapped and excavated the features. Margaret Hanks analyzed and documented the 1976 finds for what would become the Winnebago Area Museum (see Hanks 1976).

The University of Minnesota returned to the Center Creek locality in 1979, sponsoring a field school at Vosburg (21FA2) in conjunction with the Science Museum of Minnesota. The 1979 excavations at 21FA2 resulted in the documentation of more than 60 features, many of which overlapped, and the recovery of a diverse array of artifacts. Most of the features encountered at 21FA2 in 1979 were refuse pits, some of which contained large amounts of bone and pottery, shallow basins of an unknow function, or gravel capped, bell-shaped storage pits (see Dobbs 1984:89-92 for descriptions of the features excavated at 21FA2 in 1979). Some of the pit features were up to a meter in depth and circumference. The storage pits were comprised of highly organic soils and most often a dearth of artifacts, except for the inclusion of bison scapula hoes or other large, bone tools (e.g., grainers) in some instances. Several of the refuse pits uncovered in 1979 contained evidence for multiple, discrete dumping episodes.

The broadest archaeological investigation of the Center Creek locality occurred in the early 1980s and was conducted by Clark Dobbs. Dobbs, then a doctoral candidate at the University of Minnesota, surface surveyed more than a dozen sites within the locality. The results of Dobb's survey are presented in his 1984 dissertation, the previously mentioned source for most of the material presented in this section. Around the same time as Dobb's research, municipal and county highway archaeologists surface surveyed and excavated two habitation sites within the Center Creek locality (21FA72 and 21FA97) in association with the reconstruction of a road, CSAH 10, through the area (see Anfinson 1984, 1985, and 1986). Municipal and county highway archaeologists excavated ten features, most of which appeared to be the bottoms of hearths, at 21FA72 and 21FA97 and recovered large portions of two Blue Earth phase pottery vessels from 21FA97.

After the 1980s, professional archaeological investigations of the Center Creek locality did not resume until the 21st century. Patrick McLoughlin, an archaeologist for the Natural Resources Conservation Service, surface surveyed 21FA50 in 2007 ahead of a sediment control project (see McLoughlin 2007). McLoughlin did not encounter any archaeological materials at 21FA50 and determined that the site had been destroyed by gravel mining. In 2010, Anne Ketz and the 106 Group dug shovel tests through a small portion of 21FA69, which was to be traversed by a pipeline, discovering a single piece of lithic shatter (see Ketz 2010). Minnesota State University, Mankato, under the direction of Ronald Schirmer, investigated three sites within the Center Creek locality (21FA2, 21FA69, and 21FA93) in 2012 and 2013. Postmolds that outlined portions of a domestic structure were encountered at 21FA93 by Minnesota State University, Mankato. Excavations were halted at 21FA93, however, when a bundle burial associated with the structure was uncovered. Contiguous units revealed more than a dozen features at Vosburg (21FA2), the site most intensely excavated by Minnesota State University, Mankato, and multiple surface surveys resulted in the collection of many artifacts from the site. The features encountered from 2012 through 2013 at 21FA2 were consistent with those revealed by the 1979 excavations in terms of morphology, content, and distribution, the exception being a linear feature that was composed of dark soil and devoid of artifacts. The linear feature was about three meters long, a quarter-meter wide, five centimeters thick, and had a flat bottom.

Nearly a century of large and small scale archaeological efforts in the Center Creek locality have resulted in the collection of a vast and diverse array of artifacts, including floral, faunal, and lithic materials, as well as large amounts of pottery (see Dobbs 1984:69-89 for descriptions of the artifacts that have been found in the locality). However, many of the artifacts associated with the Center Creek locality were either analyzed some time ago, using methods that are now considered incomplete or obsolete, or not analyzed at all. The majority of the Center Creek artifact assemblage was recovered through the various excavations and surveys of the two largest habitation sites within the locality, Humphrey (21FA1) and Vosburg (21FA2).

The carbonized remains of wild plants such as hazel (*Corylus*), wild plum (*Prunus americana*), and hawthorn (*Crataegis sp.*) have been identified in feature samples from the locality. The carbonized remains of cultigens such as maize (*Zea mays*), common bean (*Phaseolus vulgaris*), and sunflower (*Helianthus annuus*) have also been found. The absence of cultigens from the Cucurbita genus (e.g. squashes and gourds) at the Center Creek locality is conspicuous, as these plants are commonly found at other Oneota tradition sites in the region. Dobbs, however, hypothesized that the absence of Cucurbita was likely do to sampling. Preliminary analysis of floated materials from feature contexts excavated by Minnesota State University, Mankato, at 21FA2, which resulted in the identification of squashes and gourds, confirmed Dobb's hypothesis (Ronald Schirmer, personal communication 2018). The preliminary analysis also indicated that little barley (*Hordeum pusillum*), panic grass (*Panicum sp*), and wild fruits (e.g., cherries, grapes, and strawberries) were not commonly consumed at 21FA2.

A variety of small and large mammal remains have been found at the Center Creek locality. Of small mammals, beaver (*Castor canadensis*), raccoon (*Procyon lotor*), and porcupine (*Erethizon dorsatum*) remains have been discovered within the archaeological contexts of the locality. Large mammals represented at sites in the Center Creek locality included white-tailed deer (*Odocoileus virginianus*), elk (*Cervus canadensis*), and bison (*Bison bison*). Many of the bones associated with large mammals were highly fragmented and appear to have been deliberately broken, leading Dobbs to hypothesize that bone marrow and grease extraction was practiced at the locality. The remains of large mammals also occurred in the form of bone tools at the locality. Numerous bison scapula hoes have been recovered from storage pits at Humphrey (21FA1) and Vosburg (21FA2). At least one hide grainer, flesher, and elk-antler haft have been found at the Center Creek locality as well.

The remains of a diverse array of fish, representative of the species native to the Blue Earth River, have been discovered at the Center Creek locality. Most of the fish remains recovered from the locality belonged to the Ictaluridae family (e.g., bullheads and catfish), however. This, combined with the tendency of Ictaluridaes to congregate in tributary streams at the time of the spring spawn, lead Dobbs to hypothesize that the fish were targeted in the spring and harvested through the use of a mass-capture technique (e.g., a fish weir). Few bird remains have been recovered from the locality. Of the birds identified, two individuals of the genus Phalacrocorax (i.e., cormorants) were represented, and, given that these birds followed and fed on schools of fish, Dobbs suggested that the cormorants may have become trapped in a fish weir. Even fewer reptile remains have been found at the Center Creek locality than bird remains, and only one species of reptile has been identified at the locality, a painted turtle (Chrysemys picta).

The vast majority of lithic artifacts recovered from the Center Creek locality were made from either Prairie du Chien Chert or Grand Meadow Chert. Prairie du Chien Chert is available throughout the Blue Earth River Valley in secondary deposits, while primary sources of the material within the valley are likely restricted to areas north of the Watonwan River junction. The majority of Prairie du Chien artifacts found within the Center Creek locality appear to be made of materials from secondary deposits (see Tim Ready in Dobbs 1984). The only known source for Grand Meadow Chert in Minnesota, on the other hand, is a quarry site (21MW8) located around 100 kilometers to the east of the Center Creek locality (see Trow 1981). Projectile points and end scrapers were by far the most common lithic tools found at the locality. Most of the projectile points are small, triangular, and unnotched. About 50 percent of the projectile points associated with the locality are made from Prairie du Chien Chert and about 30 percent are made of Grand Meadow Chert. More than 90 percent of the end scrapers are made of Grand Meadow Chert. Dobbs noted the high frequency of end scrapers at most sites within the Center Creek locality and observed evidence for a blade-core technology associated with Grand Meadow Chert. Other lithic tools found at the locality included drills, gravers, knives, and side scrapers. With regard to lithic debitage, all stages of stone reduction were represented at all of the sites; however, some sites contained a much higher proportion of primary reduction debris. Overall, around half of the debitage at the locality by count is Prairie du Chien Chert, while a little over 30 percent is Grand Meadow Chert. A little less than 50 percent of the Grand Meadow Chert debitage from the Center Creek locality retains some cortex. Quartzite and unknown materials account for the remainder of the debitage associated with the Center Creek locality. Fragments of catlinite (i.e., pipestone), a soft stone that was quarried about 200 kilometers to the west and used in the manufacture of spiritually significant items (e.g., pendants, pipes, and engraved tablets), and other groundstone artifacts have also been found at the Center Creek locality.

An immense amount of pottery associated with the Blue Earth phase has been discovered at the Center Creek locality, including large vessel fragments. Blue Earth phase pottery from the locality was almost exclusively shell tempered and smooth-surfaced, although some examples had a smoothed-over, cord-marked surface. Morphologically, the Blue Earth phase pottery vessels from the locality were generally globular in shape, round-bottomed, and thin-walled with broad, gently curving shoulders. Rims on the vessels ranged from vertical to everted and were typically rounded. In terms of handles, strap handles were the most common on the vessels, but loop handles also occurred. Decoration on Blue Earth Phase pottery from the Center Creek locality was typically restricted to the exterior portion of the shoulder; however, the interiors and exteriors of lips and rims were sometimes decorated with tool impressions or trailed lines. Shoulder decorations often involved trailed, vertical lines that segmented the vessel into panels. Chevrons, usually bordered by punctuates or short, trailed lines, typically spanned the panels. Simpler decorations, comprised of parallel trailed lines and a row of tool impressions or punctuates, also occurred on vessels. Overall, the decorations associated with Blue Earth phase pottery from the Center Creek locality were most often rectilinear. Curvilinear design elements, the most common of which were concentric circles of trailed lines, occurred on some vessels, however. Although the designs on Blue Earth Phase pottery usually followed the form of geometric abstraction, at least one example of a vessel with more representational imagery, a Thunderbird motif, has been recovered from the Center Creek locality (Neumann 2017:50).

Completed more than three decades ago, Dobb's 1984 dissertation remains the only comprehensive analysis and interpretation of the Center Creek locality. The materials Dobbs analyzed for the study included those discovered by Wilford at Humphrey (21FA1) and Vosburg (21FA2) in the 1930s and 1940s, the University of Minnesota and the Science Museum of Minnesota at 21FA2 in 1979, and himself throughout the locality in the early 1980s. The purpose of Dobb's work was to better understand the internal organization of the Center Creek locality through the identification, description, and comparison of the sites within the complex. In terms of the general situation of the locality, Dobbs observed that all of the Blue Earth phase sites were located on the west side of the Blue Earth River except for, notably, a large cemetery site (21FA84) and, possibly, one or more unverified burials (e.g., Site Area 1). Further, Dobbs noted that no Blue Earth phase sites existed between the Center Creek and Willow Creek localities (see Dobbs 1984:136-148 with regards to the lack of Blue Earth phase sites east of the Blue Earth River and between the Center Creek and Willow Creek localities). Other surveys along and near the Blue Earth River, which also failed to locate any non-burial Blue Earth phase sites on the east side of the river or between the localities, support these observations (e.g., Lofstrom 1979 and 1981; Peterson 1975 and 1976). In terms of the relationships amongst the sites within the Center Creek locality, Dobbs proposed a system to classify the sites by possible function. The characteristics Dobbs found most useful in discriminating between different categories of sites included the frequencies of specific artifact types, the diversity of artifact types, artifact density (i.e., the total number of artifacts divided by site-area), feature prevalence and type, location, and soil type.

Dobbs discerned six types of sites (settlements) within the Center Creek locality (see Dobbs 1984:167-184). Settlement Type 1 is characterized by a high scraper to projectile point ratio and a lack of bifacial tools. Grand Meadow Chert and Prairie du Chien Chert tend to occur in equal proportions at Type 1 sites. Type 1 sites (e.g., 21FA60 and 21FA83) are located in the uplands and along the bluff edges of the Blue Earth River Valley, are small in size relative to the other sites in the locality and are thought to be special purpose areas associated with hide working. Sites of Type 2 (e.g., 21FA64, 21FA69, and 21FA72) are recognized by a high scraper to projectile point ratio, a lithic assemblage comprised mostly of Prairie du Chien Chert, and a close proximity to Humphrey (21FA1) and Vosburg (21FA2). Type 2 sites are located in the uplands and the along bluff edges of the Blue Earth River Valley, as well, and are hypothesized to be habitation sites at which hide-working was a major activity. Type 3 sites (e.g., 21FA76 and 21FA79) are thought to be habitations with an emphasis on lithic core extraction and, similarly to site types 1 and 2, are located both in the uplands and along the bluff edges of the Blue Earth River Valley. Settlement Type 4 is characterized by a high frequency of knives, a mixed assemblage of lithic raw materials, and a hypothesized association with animal processing activities (e.g. butchering). Sites of Type 4 (e.g., 21FA65, 21FA71, 21FA73, and 21FA81) are located in the uplands and along the bluff edges that overlook the Blue Earth River or tributary creeks. Type 5 sites are distinguished by high knife frequencies and lithic assemblages dominated by Prairie du Chien Chert. Type 5 sites (e.g., 21FA45 and 21FA74) are restricted to the bluffs that overlook tributary creeks, tend to be small with few artifacts and are thought to be associated with lithic core reduction and animal processing activities. Sites that likely fall in the final category identified by Dobbs (e.g., 21FA1, 21FA2, 21FA50, and 21FA75), Settlement Type 6, are thought to be semi-permanent, horticultural villages. Type 6 sites contain the most diverse artifact assemblages of all the site-types in the locality and are characterized by large numbers of often overlapping features, especially refuse pits and gravel capped, bell-shaped storage pits. Type 6 sites are situated on well-drained knolls of glacial outwash that overlook the widest portions of the Blue Earth River floodplain in the vicinity.

Dobbs submitted eight samples of wood charcoal from features at Vosburg (21FA2) for radiocarbon dating (see Dobbs 1984:93-99 for a hypothesized chronology of the Center Creek locality). The corrected dates associated with the charcoal samples varied considerably, ranging from the 10^{th} through 18th centuries, but clustered around the 13^{th} through 14th centuries. Dobbs proposed two basic interpretations of the radiocarbon dates from 21FA2: either the Blue Earth phase occupations of the site were restricted to the 13^{th} and 14th centuries, in which case the wide date range may have resulted from sample contamination, or the occupation spanned the 11^{th} through 17^{th} centuries. Dobbs favored the latter view, arguing that the Center Creek locality was occupied periodically from the 11^{th} through 17^{th} centuries and that the densest occupations occurred from the 13^{th} through 14^{th} centuries. In support of this view, Dobbs cited the common occurrence of superimposed features and the diversity of Blue Earth phase pottery. The issue of chronology has implications with regards to the inter-site dynamics of the locality: if, as Dobbs suggested, the locality was occupied periodically for around 500 years, some of the differences amongst the sites may be the result of changes through time rather than just function. Plant material from a feature excavated at 21FA2 was more recently carbon dated and assigned to the mid-14^{th} through early 15^{th} centuries (see Schirmer 2016). Regarding the final occupation of 21FA2 and the Center Creek locality as a whole, no historic artifacts have been found within Blue Earth phase contexts at the locality. Further, Pierre-Charles Le Sueur entered the area in the early 18^{th} century and sent representatives up the Blue Earth River from the Minnesota River junction in search of the Ioway and Oto but made no mention of settlements along the Blue Earth River Valley.

The Willow Creek Locality

Following Willey and Phillips (1958:18-19), Dobbs and Shane defined Willow Creek as an archaeological locality. As defined by Dobbs and Shane (1982), the locality includes the lowlands and uplands on the west side of the Blue Earth River, around the Willow Creek junction (see Figure 6). At least 31 Oneota tradition sites of the Blue Earth phase comprise the locality (Dobbs and Shane 1982:67). Unlike the Center Creek locality, no large-scale excavations have occurred within the Willow Creek locality, and, as such, much less archaeological information is available.

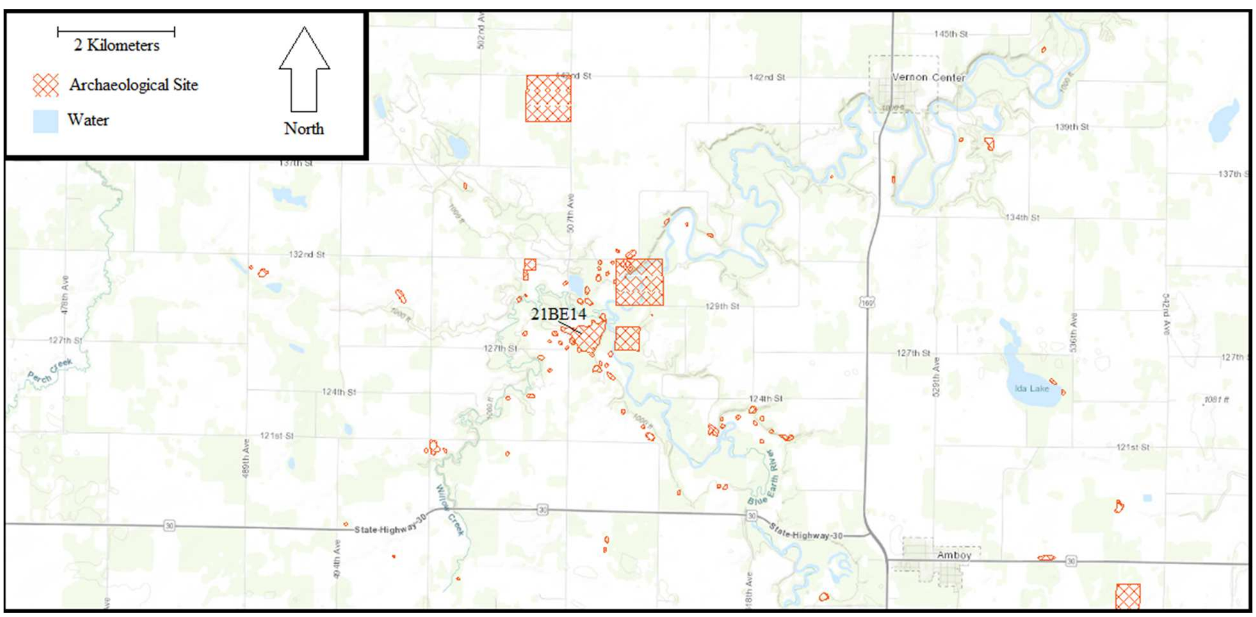

Figure 6: Approximate locations of 21BE14 and surrounding sites (source: Office of the Minnesota State Archaeologist Portal)

Local residents were the first to document collections from sites within the Willow Creek locality. One area resident, Earl Kopischke, surface surveyed two Oneota tradition habitations (21BE13 and 21BE14) within the locality on multiple occasions, beginning in the late 1950s (see Kopischke 1962). Kopischke also excavated two features at one of the sites. The features had diameters of around one meter and extended a little less than half a meter into the ground. The features contained red earth and burnt clam shells. Kopischke proposed that 21BE13 and 21BE14 were referable to what would become known as the Blue Earth Phase. Orrin Shane III, an archaeologist with the Science Museum of Minnesota, systematically surveyed the portion of the Blue Earth River Valley that traverses Blue Earth County in the early 1980s (see Dobbs and Shane 1982). Shane identified and delineated the cluster of sites near the mouth of Willow Creek, confirming the Blue Earth phase association and lack of related sites on the east side of the river. Shane also noted that 21BE14 was composed of at least ten discrete artifact concentrations that were spread over a 70-hectare area (Dobbs and Shane 1982:59).

Although much less artifactual material has been recovered from the Willow Creek locality than the Center Creek locality, the assemblages appear largely similar (see Kopischke 1962 for an overview of materials recovered from the Willow Creek locality). Willow Creek locality pottery followed the same forms described by Dobbs (1984) for the Center Creek locality. Projectile points and end scrapers, which occurred in about equal numbers, were the most common chipped-stone artifacts found at the Willow Creek locality as well. Also, similarly to the Center Creek locality, projectile points from the Willow Creek locality were most often triangular and unnotched, while more than 90 percent of the end scrapers were made from Grand Meadow Chert. Other chipped-stone artifacts recovered from the locality include knives and drills. Groundstone tools, such as grooved hammers, hammerstones, celts, and sandstone shaft abraders, as well as manos and metates, have also been found. Catlanite artifacts from the Willow Creek locality include pendants/gorgets and pipe fragments. Few faunal or floral remains have been recovered from the locality; however, Kopischke noted the presence of numerous concentrations of fragmented mammal bones on the surface of the sites he visited.

A detailed analysis of the artifacts recovered from the Willow Creek locality has not been published, and it has not been determined whether or not Dobb's site-types for the Center Creek locality are applicable to the Willow Creek locality. However, in broad terms, Willow Creek sites are, like Center Creek sites, mostly located near bluff edges that overlook the Blue Earth River Valley and tributary streams within the locality. Given the similarities between the assemblages associated with Center and Willow creeks, especially with regards to pottery, the occupations of the localities are thought to be partially, if not largely, contemporaneous and the occupants closely related. A recent carbon date from the Willow Creek locality, which is assigned to the mid-14th through early 15th centuries, supports this notion (Schirmer 2016). Further, similarly to the Center Creek locality, no historic trade items are associated with any of the Blue Earth phase sites within the Willow Creek locality.

The Spring Creek Oneota Phase Sites

The Cannon and Rush-Vermillion Major Watersheds

The Cannon River originates from a cluster of shallow lakes near the eastern borders of the Greater Blue Earth River Watershed and the Middle Minnesota River Major Watershed. Flowing in a generally northeasterly direction, the Cannon River travels more than 150 kilometers before it meets the Mississippi River near Lake Pepin and the modern-day city Red Wing (see United States Department of Agriculture, Natural Resources Conservation Service [USDA, NRCS] 2007a for an assessment of the Cannon River Major Watershed). Along this course, the bed of the Cannon River drops in elevation an average of about one meter every kilometer. The length of the watershed is roughly oriented east to west, extending between the headwaters and mouth of the Cannon River. A portion of the Cannon River Watershed projects to the south, however, along the Straight River. The Straight River is the largest tributary of the Cannon River, draining an area of more than 100,000 hectares. In total, the Cannon River Watershed drains an area of nearly 400,000 hectares.

Major tributaries that join the Cannon River from the south other than the Straight River include, moving from west to east, Prairie Creek, the Little Cannon River, Belle Creek, and Spring Creek, which meets the Cannon within the Red Wing region. Major tributaries of the Cannon that meet the river from the north include, from west to east, Chub Creek, Trout Brook, and Pine Creek. Numerous other creeks and drainages feed the Cannon River Watershed as well, comprising, in combination with the tributaries discussed above, a stream network of nearly 3,000 kilometers (see Sanockl and Winterstein 1999 for an overview of the stream basins within the Cannon River Watershed). The streams that drain into the Cannon River vary considerably in terms of entrenchment and course: some tributaries are deeply incised and fairly straight flowing, while others meander considerably and lack valleys all together. Over 22,000 hectares of lakes and wetlands are also present within the Cannon River Watershed, the vast majority of which are located in its northwestern portion. One exception is Lake Byllesby, an artificial reservoir in the northeastern part of the watershed, which subsumes the junctions of the Cannon River with Prairie and Chub creeks. Prior to historic development within the watershed, lakes and wetlands covered an area about five times larger than that of today.

The topography of the Cannon River Watershed is highly varied. Small, irregular hills swell throughout the northwestern portion of the watershed, while the ground surface remains comparatively level within the northeastern part. The southwestern portion of the Cannon River Watershed, although encompassing the most elevated part, is also relatively consistent in terms of topography, except for some deeply incised stream valleys and small knolls. Surficial features are most dramatic along the eastern reach of the Cannon, south of the river, increasing in relief with distance towards the Mississippi River Valley. Bluffs, some of which include exposures of sandstone and limestone, rise more than 70 meters above the Cannon River in the southeastern portion of the watershed. Hills and ridges up to more than 150 meters tall, as well as the valleys in between, also characterize the southeastern portion of the Cannon River Watershed.

The mouth of the Cannon River is wedged between extensions of the Rush-Vermillion Major Watershed (see United States Department of Agriculture, Natural Resources Conservation Service [USDA, NRCS] 2007b for an assessment of the Rush-Vermillion Major Watershed). The Rush-Vermillion Watershed is centered on a stretch of the Mississippi River that is about 60 kilometers long, running from the Saint Croix River junction to the southeastern tip of Lake Pepin, and drains an area of nearly 300,000 hectares. The Mississippi River Valley ranges from around one and a half to five kilometers wide throughout the watershed and is up to about 80 meters deep in some places. The steep to sheer slope of the Mississippi Valley wall results in the issuance of springs and waterfalls along its edge and base.

Similar to the Cannon River Major Watershed, the Rush-Vermillion Major Watershed encompasses an area of highly variable topography. The topographic diversity is related to the events of the last glaciation: much of the eastern portion of the watershed was never covered by ice throughout the Wisconsin Episode (see Ojakangas and Matsch 1982 for an overview of Minnesota geology). As such, the eastern part of the Rush-Vermillion Watershed is comprised of the rugged terrain that characterizes the driftless region, containing large hills, ridges, and bluffs that expose sedimentary bedrock in places, while the western part is overlain with till and comparatively level. The differences between the surface features in the western and eastern portions of the watershed are encapsulated by its two largest tributaries, the Rush and Vermillion rivers, which define the northeastern and northwestern extensions of the watershed respectively.

The Vermillion River covers a distance of around 60 kilometers between its source and the Mississippi River Valley and, before joining the river near its junction with the Cannon, parallels the Mississippi for about 30 kilometers. Although the Vermillion River meets the Mississippi River Valley as an approximately 30-meter tall waterfall, the Vermillion is a slow and valley-less river along most of its course. The Rush River, which covers a distance of around 60 kilometers, is defined by a deep, narrow valley and is comparatively swift, on the other hand. In total, the stream network associated with the Rush-Vermillion Watershed is more than 2,000 kilometers in length. The Rush-Vermillion Watershed also contains more than 20,000 hectares of lakes and wetlands. Very few individual lakes exist within the watershed, however, virtually all of which are in the extreme northwestern portion or within the Mississippi River Valley. Lake Pepin, with a surface area of more than 10,000 hectares, is by far the largest lake within the watershed.

The Red Wing Region

Ronald Schirmer (2002) and Edward Fleming (2009) provide recent analyses of archaeological materials from the Red Wing region, which are the sources for the information in this section unless otherwise specified (see also Gibbon 1979 and Gibbon and Dobbs 1991 for older syntheses of archaeological information about the Red Wing region). The Red Wing region encompasses the floodplains, terraces, creeks, valleys, and bluffs around the junction of the Mississippi River with Lake Pepin and the Cannon River (see Figure 7). Other rivers, such as the Trimbelle and Vermillion, as well as numerous creeks, including Spring and Hay, also join the Mississippi within the region. The Red Wing region contains seven major villages (21GD2, 21GD3, 21GD4, 21GD72, 21GD158, 47PI2, and 47PI12). Other habitation sites (e.g. 21GD96, 21GD159, 21GD204, 21GD258, and 47PI81) are also present within the region.

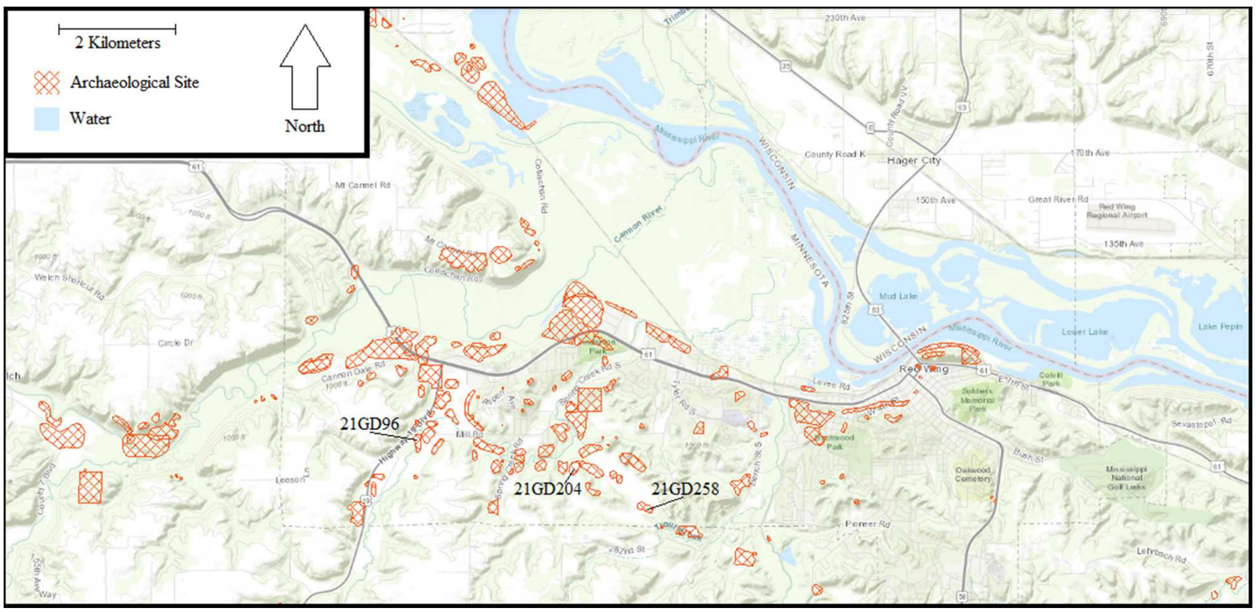

Figure 7: Approximate locations of 21GD96, 21GD204, 21GD258 and surrounding sites (source: Office of the Minnesota State Archaeologist Portal)

Investigations of the archaeological remains within and adjacent to the city of Red Wing have occurred for over a century. Initially, research within the area was focused on the cairns, which perch on the tops of bluffs and ridges throughout the Red Wing region, and large mound groups (see Dobbs 1993 for an overview of the documented mounds within the Red Wing region and Bergervoet 2007 for a more recent analysis of Red Wing mounds). Documentation of the mound groups around the city of Red Wing began in the middle of the 19th century (see Brower 1903). The most extensive survey of mounds in and near the city was conducted by Theodore Lewis in the 1880s (see Winchell 1911). Lewis mapped more than 2,000 mounds in the Red Wing area, including those associated with the Bartron (21GD2), Silvernale (21GD3), Bryan (21GD4), Belle Creek (21GD72), Energy Park (21GD158), Mero (47PI2), Adams (47PI12), and Double (47PI81) sites.

The University of Minnesota, under the direction of Lloyd Wilford and latter Elden Johnson, conducted extensive surveys and excavations of three sites within the Red Wing region (21GD2, 21GD3, and 21GD4) from the 1940s through the 1960s. Field notes associated with the work performed by the University of Minnesota within the region is housed by the State Historic Preservation Office and the Minnesota Historical Society (see Wilford 1957 and Gibbon 1979). The excavations undertaken by the University of Minnesota at Bartron (21GD2) resulted in the discovery of dozens of features, most of which were bell or basin-shaped storage/refuse pits. Firepits and a depressed house floor were also encountered by the University of Minnesota at 21GD2. A wall trench and palisade line were also noted at 21GD2, but later work determined these to be misidentifications (see Hildebrant 2008). The modern history of Bartron includes the presence of a nuclear power plant on the same island, which has resulted in several investigations near the site (e.g., Dobbs 1986a). Bryan (21GD4) was the site most intensely investigated by the

University of Minnesota, partially because the site had been largely stripped of topsoil in relation to gravel mining operations. The University of Minnesota discovered more than 100 features at 21GD2, most of which were storage/refuse pits. The storage/refuse pits varied in form and included circular pits with sides that ranged from straight to undercut and bottoms that ranged from flat to bowled, as well as elongated and amorphous forms. Three small structures, two of which were rectangular and semi-subterranean, fire bits, burials, and a possible palisade line were also identified by the University of Minnesota at 21GD4.

A substantial amount of archaeological material was recovered from the Red Wing region by the University of Minnesota. Resulting from observations of the materials recovered and the features encountered by the University of Minnesota within the Red Wing region, Wilford recognized the area as a site-complex (i.e., a cluster of related sites). Based on the pottery he found, Wilford identified two major components that cooccurred at the sites he investigated within the region, one of which, later termed the Bartron phase, showed similarities to Oneota tradition materials from the Willow Creek and Center Creek localities while the other, later termed the Silvernale phase, appeared connected to Middle Mississippian groups to the south. Although the University of Minnesota did not return to the region after the 1960s, archaeological work continued in the Red Wing area throughout the 1970s. A number of institutions performed archaeological research within the Red Wing region in the 1970s, including the Minnesota Historical Society, the Minnesota Archaeological Society, and Carleton College. Of this work, the most notable in terms of discovery was conducted by the Minnesota Historical Society at the Bryan site (21GD4). The Minnesota Historical Society uncovered a large oval structure, extending about 12 meters in one direction and ten meters in the other, as well as 29 associated storage/refuse pits (see Birk 1970 and Nystuen 1970) at 21GD4 in 1970.

Beginning in the 1980s and continuing into the 1990s, the Institute for Minnesota Archaeology, which is no longer in existence, conducted a number of surveys and excavations within the Red Wing region (see Dobbs 1986b, 1985, 1987, and 1990). Through this work, the Institute for Minnesota Archaeology discovered more than a dozen previously unrecorded sites within the region (e.g., 21GD155-21GD170) and investigated a number of previously identified sites (e.g., 21GD31, 21GD44, 21GD53, 21GD96, and 21GD109). The Institute for Minnesota Archaeology also performed a large-scale salvage operation at the Bryan site (21GD4), relating to the replacement of a bridge on Minnesota Highway 61. William Yourd, an archaeologist with the Minnesota Trunk Highway Reconnaissance Survey, assessed 21GD4 ahead of the bridge construction and determined that, although the site was largely destroyed, intact portions remained and required salvage (see Yourd 1983). As a result of Yourd's recommendation, the Institute for Minnesota Archaeology, led by Clark Dobbs, excavated units at the site and mechanically stripped a portion of topsoil in 1983 and 1984, revealing nearly 500 pit features and more than 500 postmolds (see Dobbs 1987). The 1983 and 1984 investigations of 21GD4 also resulted in the identification of portions of a palisade wall and the recovery of an immense amount of pottery, lithic debitage, and bone and stone tools, as well as unmodified faunal and floral remains. The final excavation of 21GD4 occurred in 1999 and was conducted by Ronald Schirmer, then of Hemisphere Field Services. Schirmer uncovered three clusters of features within the last remnant of the site, containing a total of 44 pits, and postmolds associated with a rectangular, super-terranean structure.

In 2003 Minnesota State University, Mankato, under the direction of Ronald Schirmer, began to conduct summer field schools within the Red Wing region. The approaches employed in each field school alternated yearly between survey and data recovery. Minnesota State

University, Mankato has investigated a large number of sites within the Red Wing region through these field schools (e.g., 21GD3, 21GD17, 21GD39, 21GD40, 21GD48, 21GD49, 21GD85, 21GD96 21GD97, 21GD143, 21GD181, 21GD204, and 21GD254-268). The surveys and excavations undertaken by Minnesota State University, Mankato at the Sell (21GD96), Horse (21GD204), and McClelland (21GD258) sites are of particular relevance to this thesis. In 2006, 21GD258 was discovered by Minnesota State University, Mankato through a surface survey. Schirmer and field school students returned to 21GD258 in 2010 and 2015, excavating five blocks of units and ten large pit features. Vessel fragments, lithic debitage, bone and stone tools, as well as unmodified faunal and floral remains, were recovered from 21GD258 in 2010 and 2015. Also in 2010, Minnesota State University, Mankato excavated five blocks of units at 21GD96, a site reported by the landowner in 1972, and portions of one pit feature, discovering lithic artifacts and pottery fragments. Volunteers from Minnesota State University, Mankato and Great River High School surface surveyed 21GD204, which was discovered by Dan Wendt of the Institute for Minnesota Archaeology in 1983, in 2014, finding large amounts of lithic artifacts and some pottery. The next year a formal field school, led by Schirmer, was partially held at 21GD204. Minnesota State University, Mankato students excavated three trenches at 21GD204 in 2015, revealing two pit features and a postmold.

One of the legacies of more than a century of field work within the Red Wing region is a collection of artifactual assemblages that is vast (hundreds of thousands of artifacts have been recovered from 21GD4 alone), diverse, dispersed amongst several institutions (e.g., the Minnesota Historical Society, the Science Museum of Minnesota, and Minnesota State University, Mankato), and has been subjected to varying levels and types of analysis. Given, also, the sheer complexity of the archaeological record of the Red Wing region, the assemblages are not easily synopsized. Further, the artifacts recovered from 21GD96, 21GD204, and 21GD258 by Minnesota State University, Mankato are currently under analysis, and a thesis focused on the Spring Creek phase sites is forthcoming (i.e., Koncur 2018). As such, the discussion that follows is meant only to highlight some broad similarities and differences between the Red Wing region and Center/Willow Creek localities in terms of the associated artifact assemblages.

The largest and most well documented collection of faunal remains associated with a Red Wing region site is from Bryan (21GD4). Small and large mammals, as well as varieties of birds, fish, and reptiles, have been documented within archaeological contexts at 21GD4. (see Gibbon 1979 and Dobbs 1991 for preliminary analyses of artifacts from 21GD4). Of particular note in terms of faunal remains are the numerous bone and antler tools from the site, most of which relate to agricultural or hide-working activities, including hoes, sickles, grainers, cleavers, beamers, knives, spatulas, needles, awls, fish hooks, picks, punches, and hafts. Miscellaneous bone and shell artifacts from 21GD4 include beads, whistles, and pendants/armlets. Copper beads and pendants, as well as Catlinite fragments, are other nonutilitarian artifacts that were discovered at the site.

The Bryan site (21GD4) is also one of the most well documented Red Wing region sites in terms of floral assemblages. Ronald Schirmer (2002) analyzed floral remains from features at 21GD4 as part of a doctoral dissertation through the University of Minnesota. Major cultigens identified in feature samples from 21GD4 include maize (*Zea mays*), sunflower (*Helianthus annuus*), and tobacco (*Nicotiana sp*.), as well as squashes (*Curcurbita sp*.) and gourds (*Lagenaria sp*.). The remains of other edible plants, such as goosefoot (*Chenopodium berlandieri*), amaranth (*Amaranthus sp*.), little barley (*Hordeum pusillum*), wild rice (*Zizania* *palustris*), and panic grass (*Panicum sp*.), were also identified by Schirmer. Further, the presence of low numbers of fruits (e.g., cherries, grapes, and strawberries) and nuts (e.g., acorns, hazel nuts, and hickory nuts) was documented at 21GD4. Recent research has also demonstrated the presence of cultigens (e.g., maize, beans, squash, and sunflower), as well as the relative rarity of nuts and fruits, at 21GD258 (Koncur 2018).

Although the lithic assemblages from most of the sites within the Red Wing region have been documented, changes through time in the application of lithic raw material names by archaeologists disallows for a complete and consistent tabulation of lithic raw material frequencies. Edward Fleming (2009), however, provides a general overview of lithic raw material use within the Red Wing region. The vast majority of chipped-stone artifacts from the Red Wing region are made from three lithic material types—Prairie du Chien Chert, Grand Meadow Chert, and Hixton Silicified Sandstone. Prairie du Chien Chert, the most commonly used lithic material within the region, is available locally in primary and secondary deposits. Grand Meadow Chert and Hixton Silicified Sandstone are, on the other hand, associated with quarry sites around 100 kilometers to the south and 130 kilometers to the east of the Red Wing region respectively. Grand Meadow chert artifacts are much more common at sites on the west side of the Mississippi River, while Hixton Silicified Sandstone artifacts are much more common at sites on the east side of the river. The suite of chipped-stone tools associated with Red Wing region habitation sites is typical of other, contemporaneous habitation sites in the area and is comprised of mostly unnotched projectile points and end scrapers. Varieties of groundstone tools are also found within the region (e.g., celts, grooved mauls, manos, metates, and hammer stones) of which shaft abraders are the most common.

Grand Meadow Chert accounts for most of the lithic debitage from the Bryan site (21GD4), amounting to around 40 percent of the entire assemblage of debitage by count, followed closely by Prairie du Chien Chert (Fleming 2009). The total weight of Prairie du Chien Chert debitage from 21GD4, however, is higher than that of Grand Meadow Chert. Nearly 70 percent of the end scrapers found at 21GD4 are made of Grand Meadow Chert (Wendt 1985). End scrapers tend to be most often made of Grand Meadow Chert at other Bartron and Silvernale phase sites as well (e.g., 21GD3), although typically to a lesser degree than at 21GD4 (Gibbon 1979). In contrast to the debitage profile at 21GD4, more than half of the debitage at the Silvernale site (21GD3) by count is Prairie du Chien Chert, while around a quarter is Grand Meadow Chert (see Harvey 2012). Other lithic raw materials found at 21GD3 include Hixton Orthoquartzite, Cedar Valley Chert, Galena Chert, Hudson Bay Lowland Chert, Jasper Taconite, Maynes Creek Chert, Plattsmouth Chert, Winterset Chert, Swan River Chert, Tongue River Silica, quartz, quartzite, and Knife River Flint. An analysis of projectile points from the Red Wing region is found in Wendt (2000). About 35 percent of the projectile points found at Bartron and Silvernale phase sites on the west side of the Mississippi River are made from Prairie du Chien Chert. Grand Meadow Chert, which accounts for around a quarter of the projectile points, and Hixton Orthoquartzite, which accounts for a little over 10 percent, are the next most common lithic materials from which projectile points were made on the west side of the river. The situation is different for Bartron and Silvernale phase sites on the east side of the river, where around 50 percent of the projectile points are made of Hixton Orthoquartzite, more than 40 percent are of Prairie du Chien Chert, and less than five percent of Grand Meadow Chert.

The majority of projectile points, or around 65 percent, found at 21GD258 are made of Prairie du Chien Chert, while about 20 percent are made of Grand Meadow Chert (Koncur

2018). Over 80 percent of the lithic debitage from 21GD258 is Prairie du Chien Chert and a little more than 10 percent is Grand Meadow Chert. The Prairie du Chien Chert debitage is also larger in size on average than the Grand Meadow Chert debitage at 21GD258: most of the Prairie du Chien Chert debitage (almost 90 percent) is G1 through G3 sized (one to a quarter inch), while the majority of Grand Meadow Chert debitage (more than 80 percent) is G3 and G4 sized (quarter inch to a tenth of an inch). Other lithic raw materials found at 21GD258 include, in order of frequency, Cedar Valley Chert, Hixton Orthoquartzite, and Swan River Chert. A number of lithic materials from more southern origins are also present at 21GD258 but occur in low amounts (e.g., Argentine Chert, Wapsipinnicon Chert, Galena Chert, and Spring Branch Chert).

Michelle Neumann, as part of a master's thesis through Minnesota State University, Mankato, analyzed pottery from a number of Oneota tradition sites in southeastern Minnesota (see Neumann 2017), including two sites from the Center Creek locality (21FA1 and 21FA2) and a number of sites from the Red Wing region (e.g., 21GD2, 21GD96, 21GD159, 21GD204, and 21GD258). Broadly, Oneota tradition vessels from the Center Creek locality (i.e. Blue Earth phase pottery) are similar to those from the Red Wing region (i.e. Bartron phase and Spring Creek phase pottery) in terms of morphology, construction, and decoration, the most apparent difference being that Red Wing region vessels tend to be larger. Neumann, however, did note several other differences between the Oneota tradition pottery found at the Center Creek locality and Red Wing region. For instance, significantly more variation occurs with regards to the orifice diameters, neck angles, and handle dimensions of Oneota tradition vessels from the Red Wing region than from the Center Creek locality. Also, while strap handles are most common on Center Creek locality vessels, loop handles predominate on Red Wing region vessels. Further, the rims on Red Wing vessels are curved or everted more often than those on Center Creek locality vessels. In terms of decoration, birdtail motifs, while extremely rare on vessels from the Center Creek locality, are common on vessels from the Red Wing region. Paneling, on the other hand, is common on Center Creek locality vessels but less so on Red Wing region vessels.

The most intense prehistoric occupations of the Red Wing region in terms of the number of settlements and settlement sizes occurred from the late 12th through early 13th centuries and are associated with two contemporaneous phases, the Bartron and Silvernale (see Dobbs 1992 for an overview of radiocarbon dates from the Red Wing region and Schirmer 2016 for a more recent analysis). At least seven large (2.5-8 hectares in extent), semi-permanent (i.e., occupied for a portion of the year) agricultural villages date to this period (21GD2, 21GD3, 21GD4, 21GD72, 21GD158, 47PI2, and 47PI12). All of the large Bartron/Silvernale phase settlements, except for 21GD2, which is located on an island that rises from the valley floor, are situated on portions of a glacial outwash terrace that project into the Cannon or Mississippi River Valleys. Extensive mound-groups, with individual mounds numbering in the hundreds, border the landward sides of these sites. Ronald Schirmer (2002) and Edward Fleming (2009) have argued that, during the Bartron and Silvernale phases, the Red Wing region functioned as a regional aggregation center, or, that is, a place where people from distant areas and different backgrounds gathered together to participate in a range of significant social activities. Schirmer and Fleming cite multiple lines of evidence in support of their argument, including signs of feasting behavior, differences in resource use amongst the sites that are suggestive of populations with different hinterlands, and stylistic differences amongst the pottery and chipped-stone tool assemblages. Research into the stylistic similarities and differences amongst end scrapers from the Red Wing region (see Wendt 1985), as well as projectile points (see Wendt 2000), revealing stylistic variation between sites on opposite sides of the Mississippi River, supports Schirmer's and Fleming's interpretation.

The Spring Creek phase sites within the Red Wing region (e.g., 21GD96, 21GD204, and 21GD258), although also large, semi-permanent agricultural villages, differ from the Bartron/Silvernale phase sites in several respects. Bartron phase and Silvernale phase materials (i.e., pottery) cooccur at sites within the region and appear to be contemporaneous, while Spring Creek phase materials are slightly younger in age, dating to the 14th and 15th centuries, and are not found at Bartron/Silvernale phase sites (see Schirmer 2016). In terms of location, the large Bartron/Silvernale phase habitations are restricted to the Mississippi River and Cannon River valleys, while Spring Creek phase habitations have only been identified within the narrow, sheltered valleys of Spring and Hay creeks. Further, it does not appear that the Red Wing region acted as an aggregation center to nearly the same degree during the Spring Creek phase.

Chapter 5: Results

Lithic Raw Materials

Of the 145 end scrapers analyzed, 137 were assigned to a specific lithic raw material type (Table 1). Fifty-five percent of the analyzed end scrapers from Spring Creek phase sites are made of Grand Meadow Chert, while 36 percent are made of Prairie du Chien Chert (Figure 8). The remainder of the Spring Creek phase end scrapers studied in this thesis are made of Galena Chert (three percent) or till-derived cherts (e.g. Red River Chert). Grand Meadow Chert also accounts for the majority (90 percent) of the analyzed end scrapers associated with the Blue Earth phase, but there is a statistically significant difference ($p < .0001$) between the Spring Creek phase and Blue Earth phase in terms of the lithic raw materials from which end scrapers were made (Table 2). The remainder of the Blue Earth phase end scrapers are made from Prairie du Chien Chert (five percent) or unidentified materials (Figure 9). One of the end scrapers associated with the Blue Earth phase for which a specific lithic raw material type was not identified is made of a highly fossiliferous material, likely originating from southwestern Iowa or adjacent areas in Missouri, Kansas, or Nebraska (see Bakken in Morrow 2016:256). The end scrapers in question is represented in Figure 10 (project number 74), along with other end scrapers from 21FA2 and associated project numbers. The lithic raw material profile of the Woodland tradition end scrapers that are included in this thesis is slightly more mixed than those of the Blue Earth and Spring Creek phases. Forty percent of the Woodland tradition end scrapers are made of Grand Meadow Chert, while Prairie du Chien Chert and Knife River Flint each account for about a quarter of the Woodland end scrapers (Figure 11). The remainder of the Woodland end scrapers were not identified with regards to lithic raw material. Prairie du Chien

Chert, Grand Meadow Chert, Knife River Flint, unknown lithic materials, and till-derived cherts are abbreviated, respectively, as PDC, GMC, KRF, UNK, and TDC in the following tables.

Table 1: End scraper count by context and lithic material

Context		Lithic Material						
Phase/Tradition	Site	GMC	PDC	Galena	KRF	TDC	UNK	Total
Spring Creek	21GD258	16	15	2	0	3	0	36
	21GD204	15	9	0	0	0	0	24
	21GD96	7	1	0	0	1	0	9
	Total	38	25	2	0	4	0	69
Blue Earth	21FA2	13	1	0	0	0	2	16
	21FA69	3	2	0	0	0	1	6
	21FA93	2	0	0	0	0	0	2
	21BE14	37	0	0	0	0	0	37
	Total	55	3	0	0	0	3	61
Woodland	21NL30	3	0	0	3	0	1	7
	21NLw/x	3	4	0	1	0	0	8
	Total	6	4	0	4	0	1	15
Grand Total		99	32	2	4	4	4	145

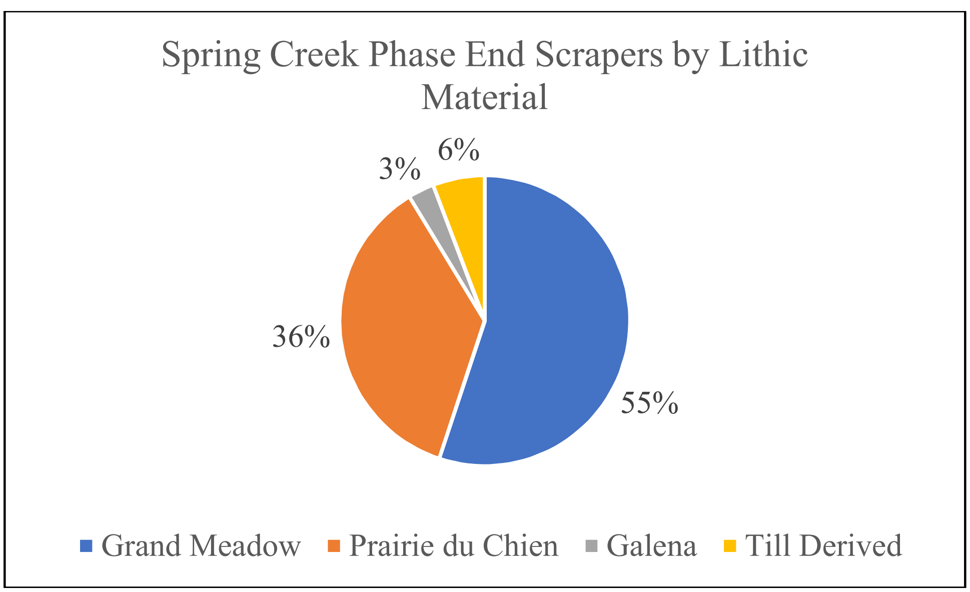

Figure 8: Pie chart of Spring Creek end scrapers by lithic material percentage

Table 2: Chi-squared test of lithic material counts for end scrapers by phase

Phase	Lithic Material				
	GMC	PDC	Other	Total	P-Value
Spring Creek	38	25	6	69	2.78E-05
Blue Earth	55	3	3	61	
Total	93	28	9	130	

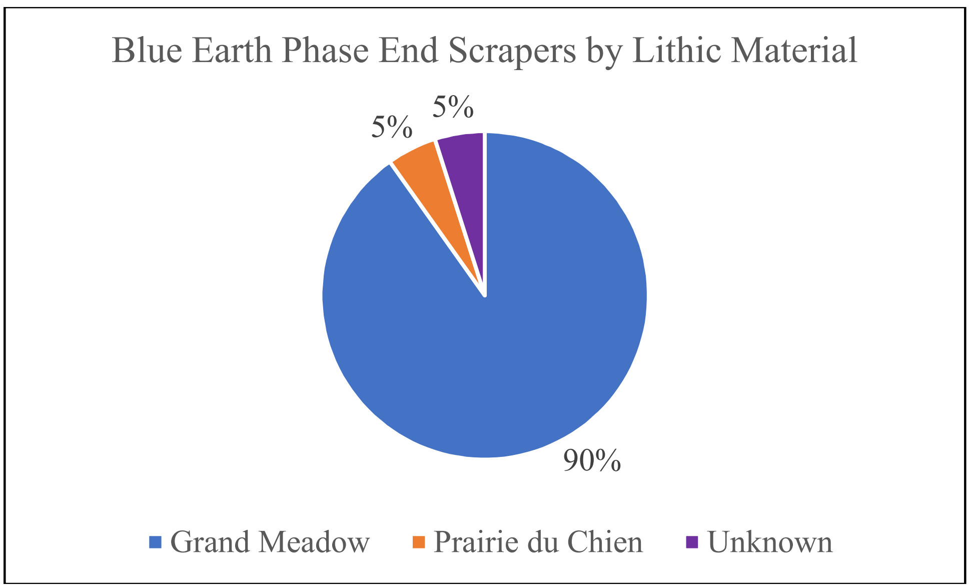

Figure 9: Pie chart of Blue Earth end scrapers by lithic material percentage

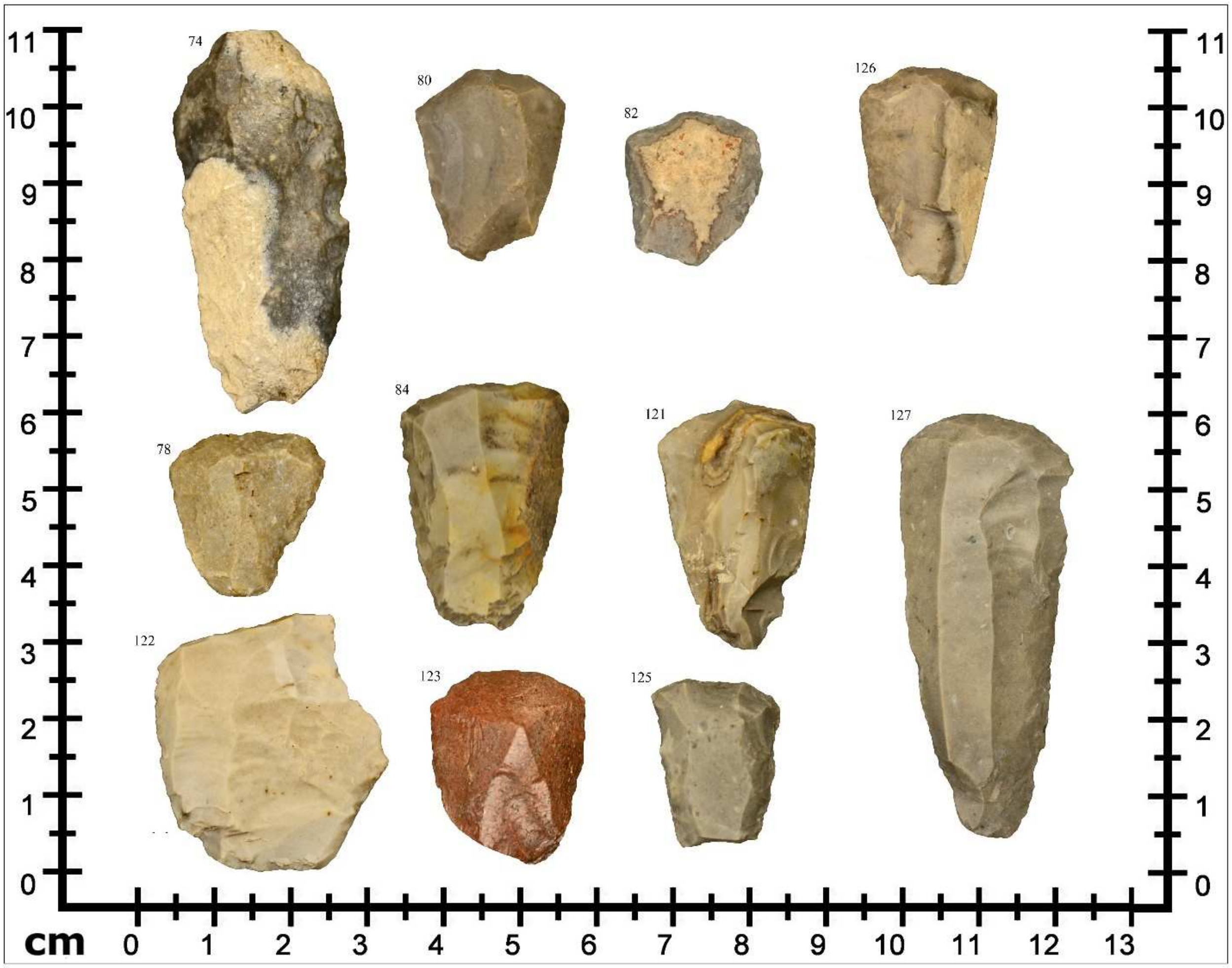

Figure 10: End scrapers from 21FA2 (photos edited and template created by Cory Nowak)

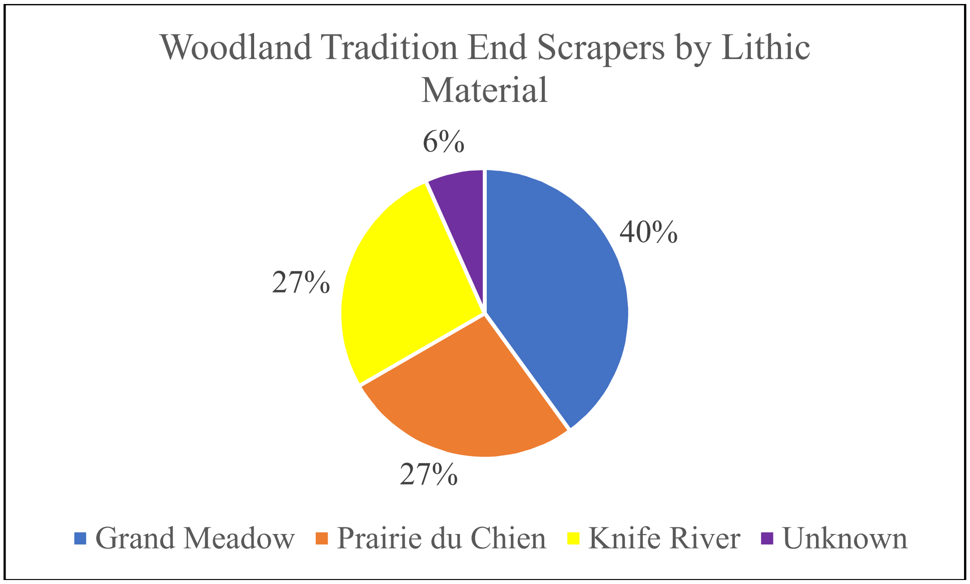

Figure 11: Pie chart of Woodland end scrapers by lithic material percentage

Grand Meadow versus Prairie du Chien End Scrapers from Spring Creek Phase Sites

A total of 26 independent comparisons are made between Grand Meadow Chert and Prairie du Chien Chert end scrapers from Spring Creek phase sites. To achieve a 0.05 significance level for the set of data, a corrected (Sidak) significance level of 0.001971 is used per individual comparison. Thirty-eight of the Spring Creek phase end scrapers analyzed in this thesis are made from Grand Meadow Chert, while 25 are made of Prairie du Chien Chert. Of these, 25 of the Grand Meadow Chert end scrapers are complete (i.e., not broken), and 13 of the Prairie du Chien end scrapers are complete. The comparisons of dimensions that follow include only the unbroken end scrapers. Figure 12 presents a selection of the Prairie du Chien Chert and Grand Meadow Chert end scrapers analyzed from 21GD258, as well as the project numbers (specific to this work) associated with each.

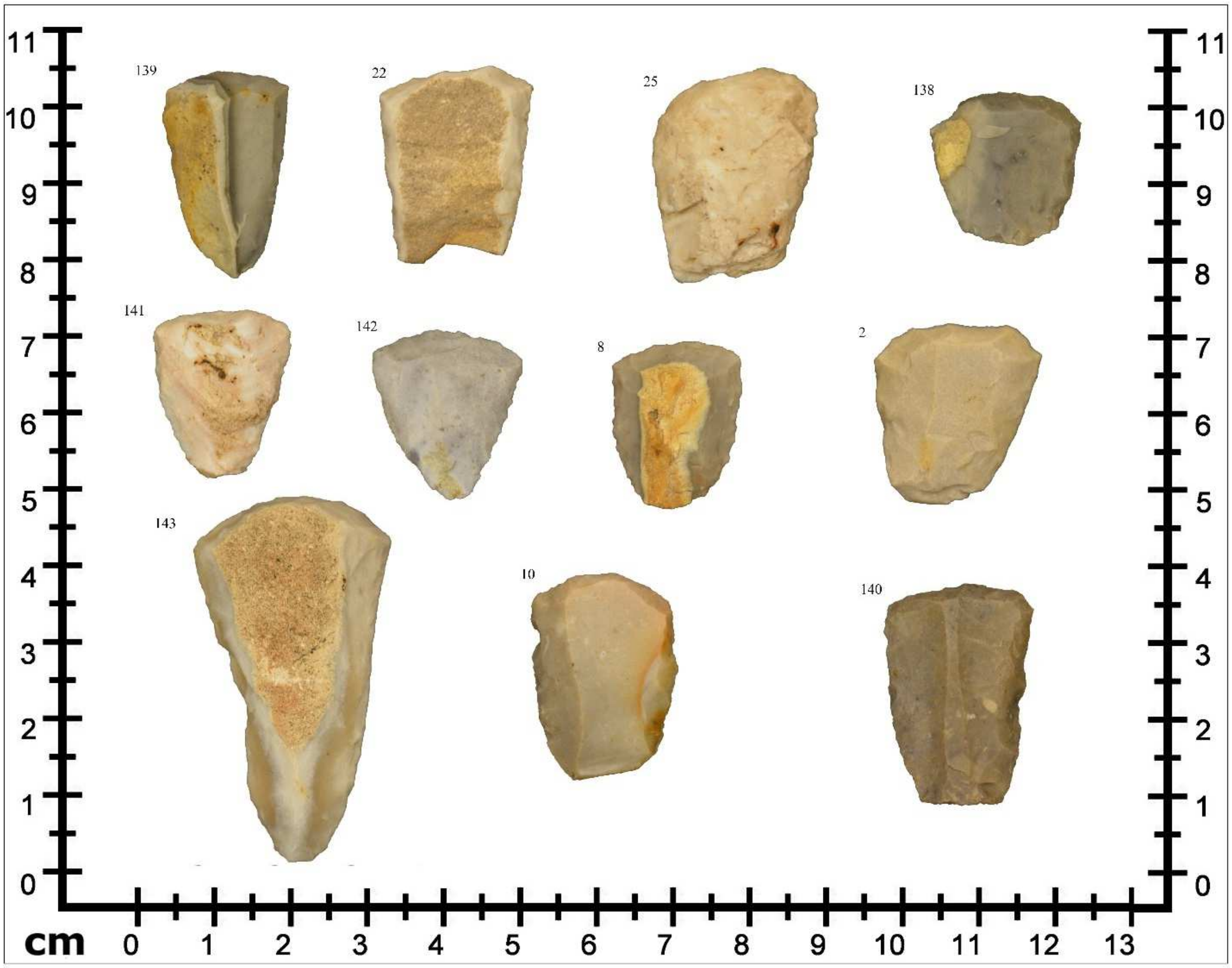

Figure 12: Prairie du Chien Chert and Grand Meadow Chert end scrapers from 21GD258 (template created by Cory Nowak)

The Praire du Chien Chert end scrapers are, on average, longer (about 23.9 mm versus 21.6 mm), wider (about 19.9 mm versus 18.5 mm), thicker (about 6.8 mm versus 6.4 mm), and heaver (about 4.7 g versus 3.4 g) than the Grand Meadow Chert end scrapers (Tables 3 through 6 and Figures 13 through 16). The only statistically significant difference between Grand Meadow Chert and Prairie du Chien Chert end scrapers with regards to the attributes discussed above relates to weight ($p < .0004$). The coefficients of variance are also higher for the Prairie du Chien Chert end scrapers in all of the above-mentioned cases, being, rounded to the nearest whole percentage, 35 versus 29 for length, 14 versus 11 for width, 28 versus 20 for thickness, and 57 versus 35 for weight). Figures 17 and 18 are heatmaps of the lengths and widths of all (i.e. broken and unbroken) the Prairie du Chien Chert and Grand Meadow Chert end scrapers analyzed from Spring Creek phase sites in this thesis.

Table 3: Summary and associated F-test for complete Spring Creek end scraper lengths (mm) by lithic material

Grand Meadow		Prairie du Chien	
Mean	21.64	Mean	23.92307692
Median	20	Median	20
Mode	20	Mode	20
SD	6.290733926	SD	8.4898129
CV	0.29069935	CV	0.354879639
Range	31	Range	26
Minimum	12	Minimum	16
Maximum	43	Maximum	42
Sum	541	Sum	311
Count	25	Count	13
F	1.821350819		
P(F<=f) one-tail	0.102116403		
F Critical one-tail	2.183380082		

Table 4: Summary and associated F-test for complete Spring Creek end scraper widths (mm) by lithic material

Grand Meadow		Prairie du Chien	
Mean	18.52	Mean	19.92307692
Median	19	Median	20
Mode	19	Mode	20
SD	1.98158186	SD	2.691391786
CV	0.106996861	CV	0.135089163
Range	8	Range	10
Minimum	14	Minimum	15
Maximum	22	Maximum	25
Sum	463	Sum	259
Count	25	Count	13
F	1.844717252		
P(F<=f) one-tail	0.097505308		
F Critical one-tail	2.183380082		

Table 5: Summary and associated F-test for complete Spring Creek end scraper thicknesses (mm) by lithic material

Grand Meadow		Prairie du Chien	
Mean	6.434	Mean	6.825384615
Median	6.54	Median	6.47
Mode	N/A	Mode	N/A
SD	1.29818463	SD	1.940140095
CV	0.201769448	CV	0.284253592
Range	5.4	Range	7.15
Minimum	3.55	Minimum	3.35
Maximum	8.95	Maximum	10.5
Sum	160.85	Sum	88.73
Count	25	Count	13
F	2.23353754		
P(F<=f) one-tail	0.045324348		
F Critical one-tail	2.183380082		

Table 6: Summary and associated F-test for complete Spring Creek end scraper weights (g) by lithic material

Grand Meadow		Prairie du Chien	
Mean	3.4326	Mean	4.754153846
Median	3.007	Median	4.039
Mode	N/A	Mode	N/A
SD	1.208926521	SD	2.705816323
CV	0.352189746	CV	0.569147825
Range	4.879	Range	9.062
Minimum	1.496	Minimum	1.368
Maximum	6.375	Maximum	10.43
Sum	85.815	Sum	61.804
Count	25	Count	13
F	5.009528071		
P(F<=f) one-tail	0.000393833		
F Critical one-tail	2.183380082		

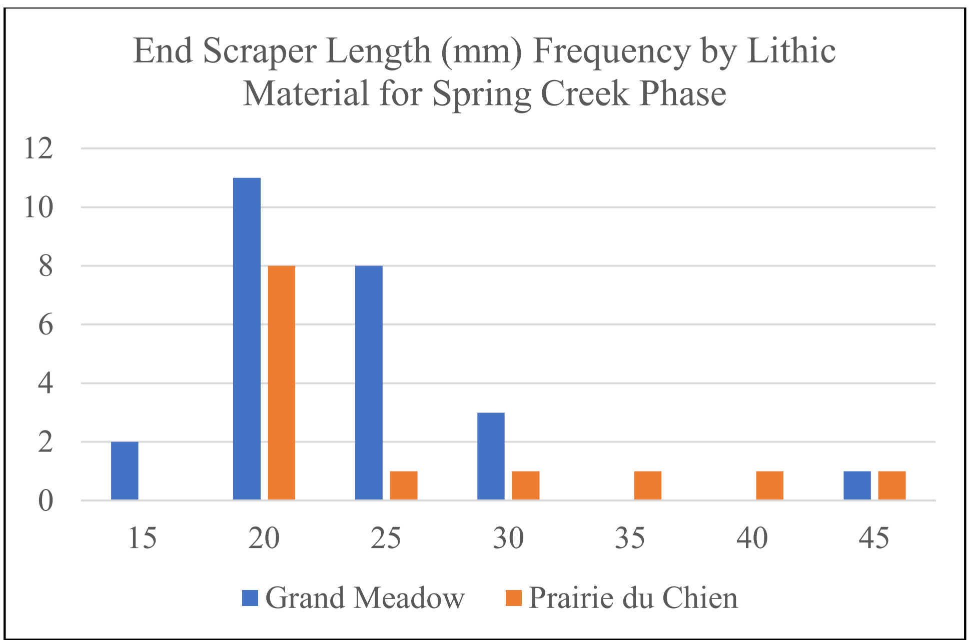

Figure 13: Histogram of complete Spring Creek end scraper lengths by lithic material

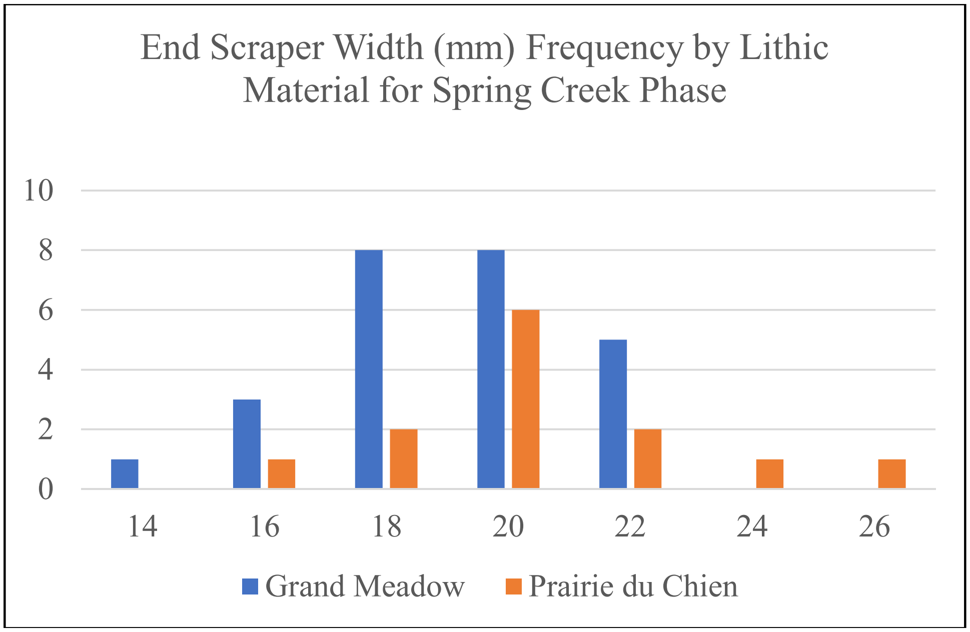

Figure 14: Histogram of complete Spring Creek end scraper widths by lithic lithic material

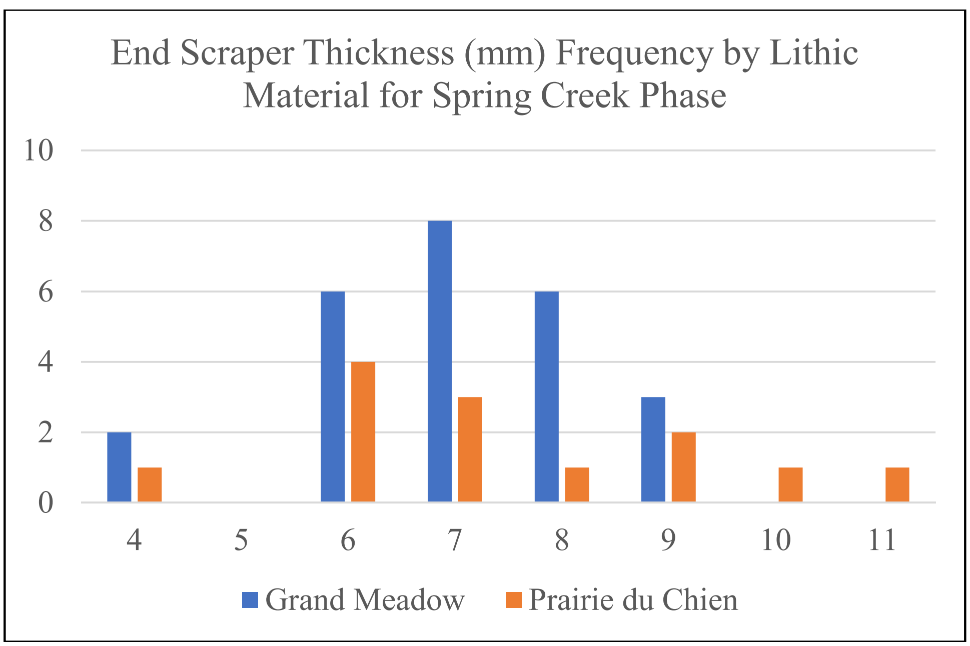

Figure 15: Histogram of complete Spring Creek end scraper thicknesses by lithic material

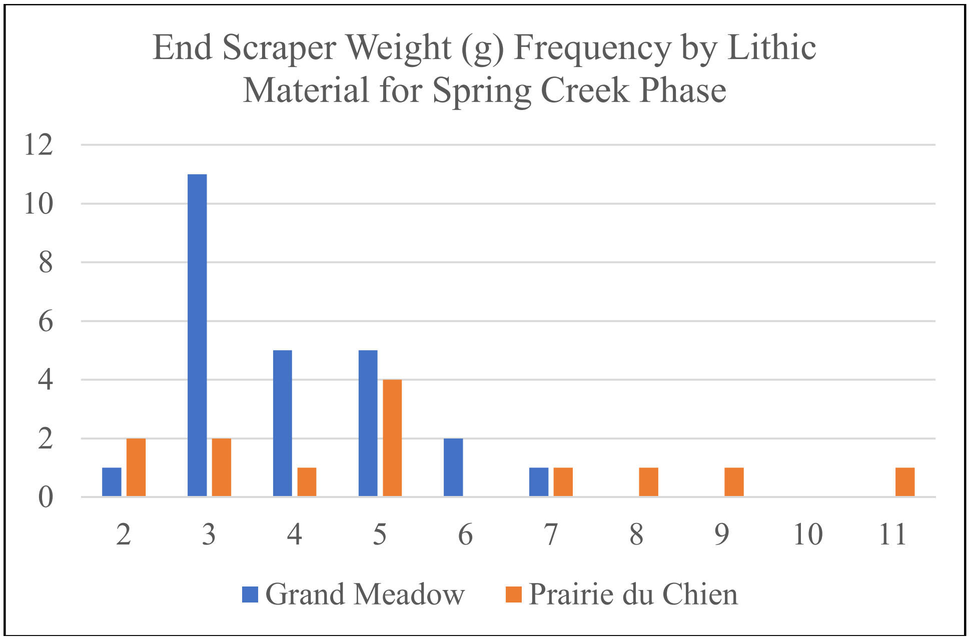

Figure 16: Histogram of complete Spring Creek end scraper weights by lithic material

	Width															
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
Len-gth																Total
10										1						1
11																0
12																0
13																0
14								1								1
15																0
16							2	1								3
17																0
18						1			1							2
19							1	1								2
20				1				1				1				3
21																0
22										1						1
23								1								1
24								1								1
25																0
26						1										1
27																0
28															1	1
29									1					1		2
30																0
31							1									1
32					1											1
33						1		1								2
34																0
35																0
36																0
37													1			1
38																0
39																0
40																0
41																0
42					1											1
43																0
Total	0	0	0	1	2	3	4	7	2	2	0	1	1	1	1	25

Figure 17: Heatmap of all Spring Creek end scraper length/width counts for PDC

	Width															
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
Len-gth																Total
10																0
11																0
12						2										2
13																0
14																0
15				1	1		1									3
16	1			2		1		1	1							6
17				1		1	1		1							4
18						1										1
19							1	2								3
20		1		2		1				1						5
21					1	1			1							3
22				1								1				2
23							1	1								2
24																0
25							2		1							3
26																0
27																0
28							1									1
29							1									1
30					1											1
31																0
32																0
33																0
34																0
35																0
36																0
37																0
38																0
39																0
40																0
41																0
42																0
43					1											1
Total	1	1	0	7	4	7	8	4	4	1	0	1	0	0	0	38

Figure 18: Heatmap of all Spring Creek end scraper length/width counts for GMC

Thirty-seven of the Grand Meadow Chert and 23 of the Prairie du Chien Chert end scrapers from Spring Creek phase contexts are complete enough to confidently assign a planview. The distribution of planview-shapes is nearly equal between the Grand Meadow Chert and Prairie du Chien end scrapers: end scrapers made of either material are triangular or tapered in planview about 90 percent of the time (Tables 7 and 8). The Grand Meadow Chert and Prairie du Chien Chert end scarpers from Spring Creek phase sites are also very similar in terms of broadness among the unbroken specimens, each having a mean width to length ratio of around 0.9 and coefficients of variance of about 27 and 28 percent (Table 9 and Figure 19).

Table 7: Chi-squared test of planview counts for Spring Creek end scrapers by lithic material

Lithic Material	Planview					
	Ovate	Rectangular	Tapered	Triangular	Total	P-Value
Grand Meadow	1	3	15	18	37	0.82052
Prairie du Chien	0	2	8	13	23	
Total	1	5	23	31	60	

Table 8: Chi-squared test of planview counts (grouped) for Spring Creek end scrapers by lithic material

Lithic Material	Planview			
	Rectangular/Ovate	Tapered/Triangular	Total	P-Value
Grand Meadow	4	33	37	0.7906
Prairie du Chien	2	21	23	
Total	6	54	60	

Table 9: Summary and associated F-test for complete Spring Creek end scraper width to length ratios by lithic material

Grand Meadow		Prairie du Chien	
Mean	0.9168	Mean	0.905384615
Median	0.87	Median	1
Mode	1	Mode	1
SD	0.250976759	SD	0.252804779
CV	0.273753009	CV	0.27922363
Range	1.1	Range	0.8
Minimum	0.4	Minimum	0.4
Maximum	1.5	Maximum	1.2
Sum	22.92	Sum	11.77
Count	25	Count	13
F	1.014620302		
P(F<=f) one-tail	0.46627191		
F Critical one-tail	2.183380082		

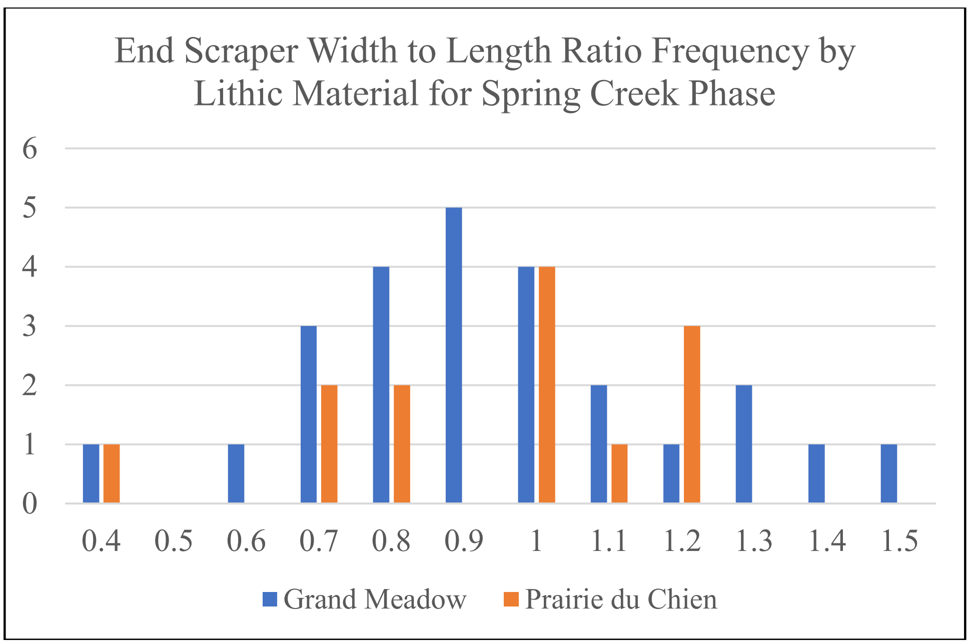

Figure 19: Histogram of Spring Creek end scraper width to length ratios by lithic material

Fifteen of the Grand Meadow Chert and seven of the Prairie du Chien Chert end scrapers from Spring Creek phase sites retain complete platforms. The mean areas and thickness to width ratios of the complete platforms of the Grand Meadow Chert and Prairie du Chien Chert end scrapers are very similar, being about 32 mm^2 and 0.4, respectively (Tables 10 through 11and Figures 20 through 21). The coefficient of variance for both attributes are higher for Grand Meadow Chert end scrapers, being, to the nearest whole percentage, 68 versus 58 for platform area and 24 versus 18 for platform thickness to width ratio). Eighteen of the Grand Meadow Chert and 11 of the Prairie du Chien Chert end scrapers were complete enough to determine the number of platform facets, the presence or absence of platform grinding, and the degree to which the platform was twisted off-center. Most of the platforms, regardless of lithic material, are single-faceted, and there is no statistically significant difference between lithic materials with regards to platform-faceting (Table 12). However, the Prairie du Chien Chert end scrapers have single-faceted platforms more often than the Grand Meadow Chert end scrapers: about 73 percent of the Prairie du Chien Chert end scrapers have single-faceted platforms, while about 67 percent of the Grand Meadow Chert end scrapers have single-faceted platforms. The Prairie du Chien Chert end scrapers also have a higher rate of double-faceted platforms: about 27 percent of the Prairie du Chien Chert end scrapers have double-faceted platforms, while about 17 percent of the Grand Meadow Chert end scrapers have double-faceted platforms. None of the Prairie du Chien Chert end scrapers have cortex present on the platform, while about 17 percent of the Grand Meadow Chert end scrapers have cortex-covered platforms. Grand Meadow Chert end scrapers exhibit ground platforms at a higher rate than Prairie du Chien Chert end scrapers (approximately 72 versus 55 percent); however, the difference is not statistically significant (Table 13). In terms of platform off-centeredness, the majority (about 70 to 90 percent) of end scrapers of both materials have centered to slightly off-centered (five degrees) platforms (Table 14). Interior platform angle measurements were taken on 20 Grand Meadow Chert and 12 Prairie du Chien Chert end scrapers from Spring Creek phase contexts (Table 15 and Figure 22). The interior platform angles associated with both materials are very similar, averaging around 66 degrees, while the coefficient of variance is higher for Prairie du Chien Chert end scrapers (about 24 versus 16 percent).

Table 10: Summary and associated F-test for Spring Creek end scraper platform areas (mm^2) by lithic material

Grand Meadow		Prairie du Chien	
Mean	32.14666667	Mean	32.74285714
Median	29.7	Median	28.66
Mode	N/A	Mode	N/A
SD	21.7110685	SD	19.14607942
CV	0.67537542	CV	0.584740645
Range	66.49	Range	62.43
Minimum	8.32	Minimum	8.14
Maximum	74.81	Maximum	70.57
Sum	482.2	Sum	229.2
Count	15	Count	7
F	1.285886636		
P(F<=f) one-tail	0.399252061		
F Critical one-tail	3.955933943		

Table 11: Summary and associated F-test for Spring Creek end scraper platform thickness to width ratios by lithic material

Grand Meadow		Prairie du Chien	
Mean	0.398	Mean	0.407142857
Median	0.37	Median	0.44
Mode	0.36	Mode	N/A
SD	0.09645132	SD	0.072275926
CV	0.24234	CV	0.177519819
Range	0.34	Range	0.18
Minimum	0.26	Minimum	0.31
Maximum	0.6	Maximum	0.49
Sum	5.97	Sum	2.85
Count	15	Count	7
F	1.780856882		
P(F<=f) one-tail	0.246004134		
F Critical one-tail	3.955933943		

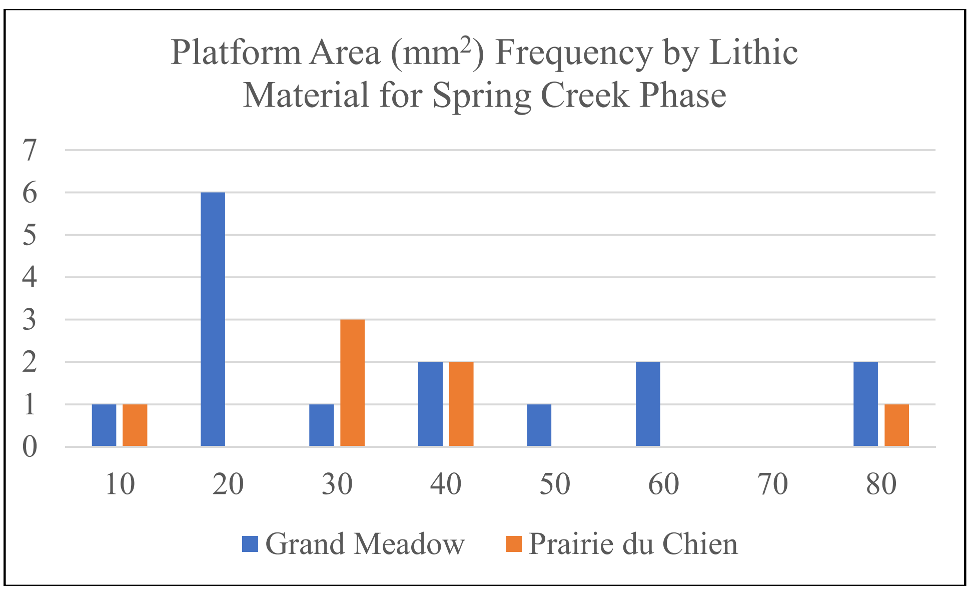

Figure 20: Histogram of Spring Creek end scraper platform areas by lithic material

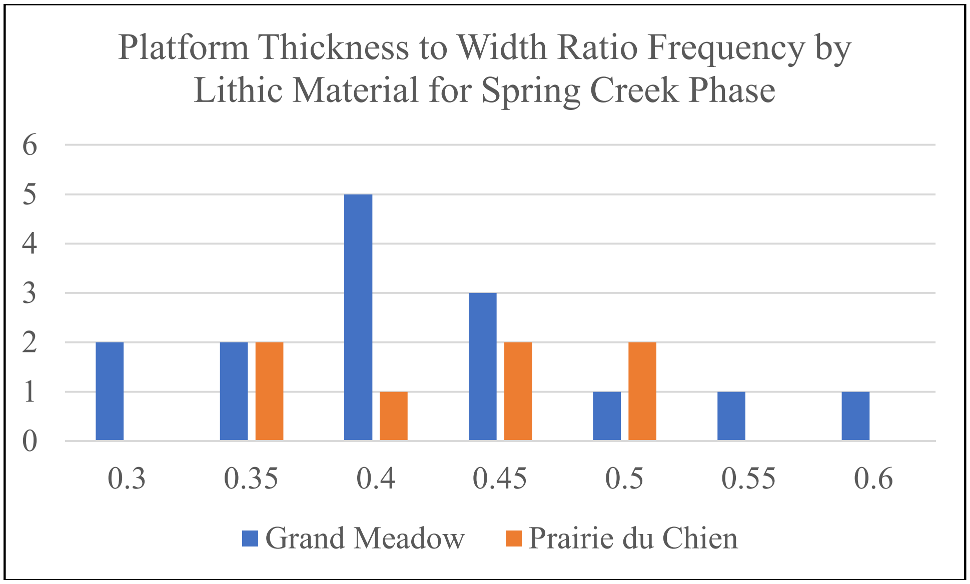

Figure 21: Histogram of Spring Creek end scraper platform thickness to width ratios by lithic material

Table 12: Chi-squared test of platform facet counts for Spring Creek end scrapers by lithic material

Lithic Material	Platform Facets				
	0	1	2	Total	P-Value
Grand Meadow	3	12	3	18	0.326132
Prairie du Chien	0	8	3	11	
Total	3	20	6	29	

Table 13: Chi-squared test of platform grinding presence counts for Spring Creek end scrapers by lithic material

Lithic Material	Platform Ground			
	Yes	No	Total	P-Value
Grand Meadow	13	5	18	0.331171
Prairie du Chien	6	5	11	
Total	19	10	29	

Table 14: Chi-squared test of platform twistedness counts for Spring Creek end scrapers by lithic material

Lithic Material	Platform Width to Artifact Width Angle (Degrees)						
	0	5	10	15	20	Total	P-Value
Grand Meadow	7	8	2	1	0	18	0.173981
Prairie du Chien	6	2	0	1	2	11	
Total	13	10	2	2	2	29	

Table 15: Summary and associated F-test for Spring Creek end scraper interior platform angles (degrees) by lithic material

Grand Meadow		Prairie du Chien	
Mean	66.15	Mean	65.66666667
Median	64.5	Median	68
Mode	58	Mode	64
SD	10.66363718	SD	15.51148157
CV	0.161203888	CV	0.236215455
Range	42	Range	55
Minimum	45	Minimum	32
Maximum	87	Maximum	87
Sum	1323	Sum	788
Count	20	Count	12
F	2.115903428		
P(F<=f) one-tail	0.072990129		
F Critical one-tail	2.340210441		

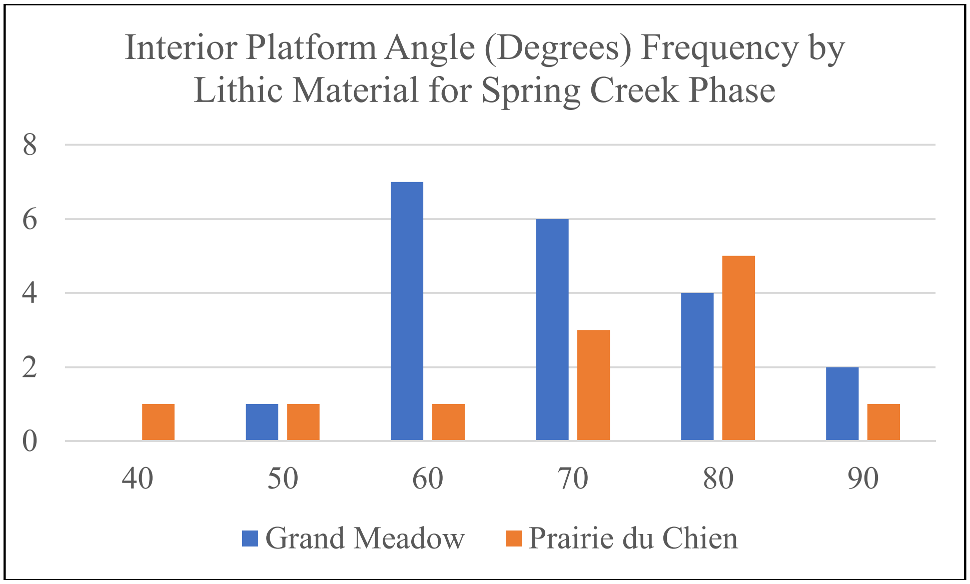

Figure 22: Histogram of Spring Creek end scraper interior platform angles by lithic material

Bulbs of percussion are present on 23 of the Grand Meadow Chert and 14 of the Prairie du Chien Chert end scrapers from Spring Creek phase sites. The Prairie du Chien Chert end scrapers tend to have thicker bulbs of percussion, averaging about 6.2 mm compared to 4.9 mm for Grand Meadow Chert end scrapers. The difference, however, is not statistically significant, and the coefficients of variance are similar (about 23 and 29 percent) between the materials (Table 16 and Figure 23). Of the end scrapers with bulbs of percussion, nine made of Grand Meadow Chert and six made of Prairie du Chien Chert have associated eraillure scars. The difference in rate of eraillure scar presence between raw materials is not statistically significant (Table 17). The areas of the eraillure facets present on Prairie du Chien Chert end scrapers, with a mean of about 39 mm^2, are typically larger than those present on Grand Meadow Chert, which have a mean of about 21 mm^2, but the difference is not statistically significant (Table 18 and Figure 24). Eraillure facets on Grand Meadow Chert end scrapers, with a mean width to length ratios of about 0.65, tend to be broader than those on Prairie du Chien Chert end scrapers, which have a mean width to length ratio of about 0.51 (Table 19 and Figure 25). The coefficients of variance for both eraillure scar attributes are higher in the case of Grand Meadow Chert end scrapers (about 69 versus 51 percent for area and 24 versus 19 percent for width to length ratio). The ventral surfaces of Prairie du Chien Chert end scrapers are slightly more curved than those made of Grand Meadow Chert on average (about 0.03 versus 0.02), but the coefficient of variance is higher (about 91 versus 76 percent) for Grand Meadow Chert (Table 20 and Figure 26). The differences in ventral curvature are not statistically significant.

Table 16: Summary and associated F-test for Spring Creek end scraper bulb of percussion thicknesses (mm) by lithic material

Grand Meadow		Prairie du Chien	
Mean	4.910434783	Mean	6.159285714
Median	4.4	Median	5.965
Mode	N/A	Mode	N/A
SD	1.406266748	SD	1.435867276
CV	0.286383347	CV	0.233122369
Range	4.62	Range	5.82
Minimum	2.8	Minimum	3.21
Maximum	7.42	Maximum	9.03
Sum	112.94	Sum	86.23
Count	23	Count	14
F	1.042541089		
P(F<=f) one-tail	0.449913355		
F Critical one-tail	2.197501631		

Table 17: Chi-squared test of eraillure scar presence counts for Spring Creek end scrapers by lithic material

Lithic Material	Eraillure Scar Presence			
	Yes	No	Total	P-Value
Grand Meadow	9	14	23	0.82281782
Prairie du Chien	6	8	14	
Total	15	22	37	

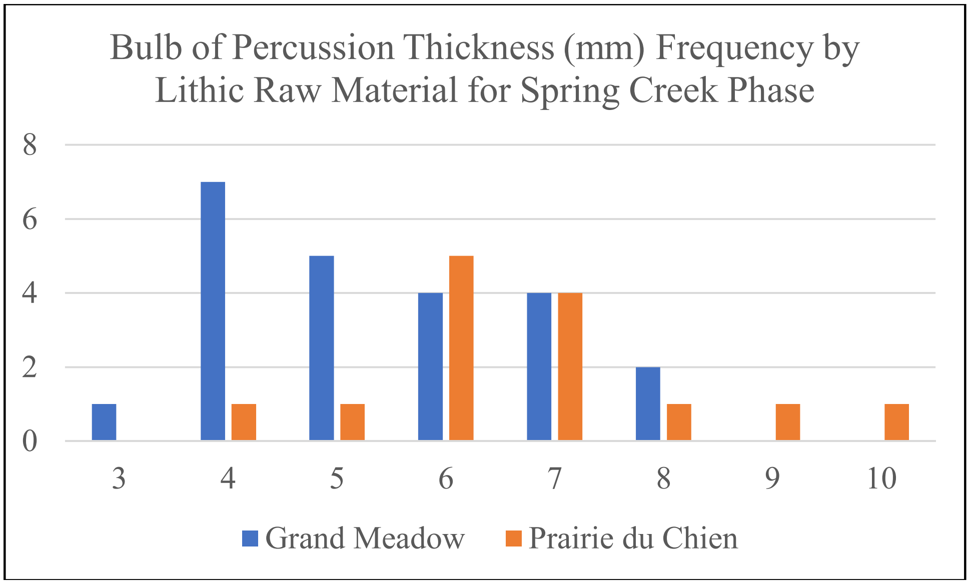

Figure 23: Histogram of Spring Creek end scraper bulb of percussion thicknesses by lithic material

Table 18: Summary and associated F-test for Spring Creek end scraper eraillure scar areas (mm^2) by lithic material

Grand Meadow		Prairie du Chien	
Mean	20.88555556	Mean	39.125
Median	12.58	Median	42.645
Mode	N/A	Mode	N/A
SD	14.38421714	SD	19.81482551
CV	0.688716041	CV	0.506449214
Range	33.72	Range	53.91
Minimum	9.82	Minimum	5.87
Maximum	43.54	Maximum	59.78
Sum	187.97	Sum	234.75
Count	9	Count	6
F	1.897614733		
P(F<=f) one-tail	0.200516517		
F Critical one-tail	3.687498666		

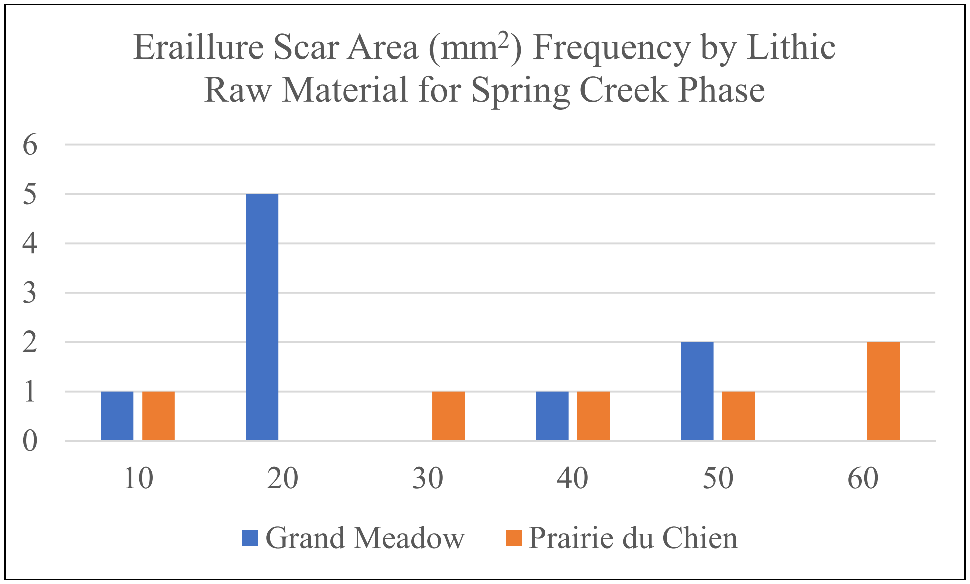

Figure 24: Histogram of Spring Creek end scraper eraillure scar areas by lithic material

Table 19: Summary and associated F-test for Spring Creek end scraper eraillure scar width to length ratios by lithic material

Grand Meadow		Prairie du Chien	
Mean	0.652222222	Mean	0.508333333
Median	0.6	Median	0.515
Mode	N/A	Mode	0.4
SD	0.154497393	SD	0.09495613
CV	0.236878456	CV	0.186798945
Range	0.48	Range	0.23
Minimum	0.42	Minimum	0.4
Maximum	0.9	Maximum	0.63
Sum	5.87	Sum	3.05
Count	9	Count	6
F	2.647258164		
P(F<=f) one-tail	0.149238965		
F Critical one-tail	4.818319536		

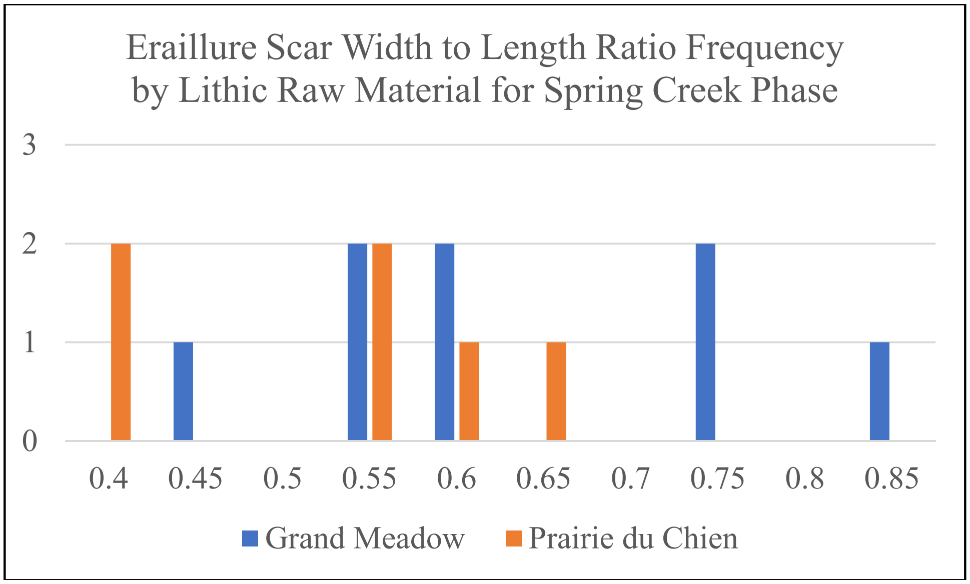

Figure 25: Histogram of Spring Creek end scraper eraillure scar width to length ratios by lithic material

Table 20: Summary and associated F-test for Spring Creek end scraper ventral curvatures by lithic material

Grand Meadow		Prairie du Chien	
Mean	0.023513514	Mean	0.0304
Median	0.02	Median	0.03
Mode	0.01	Mode	0.01
SD	0.021501449	SD	0.023180452
CV	0.914429443	CV	0.762514853
Range	0.09	Range	0.1
Minimum	0	Minimum	0
Maximum	0.09	Maximum	0.1
Sum	0.87	Sum	0.76
Count	38	Count	25
F	1.162273465		
P(F<=f) one-tail	0.334729337		
F Critical one-tail	1.824213381		

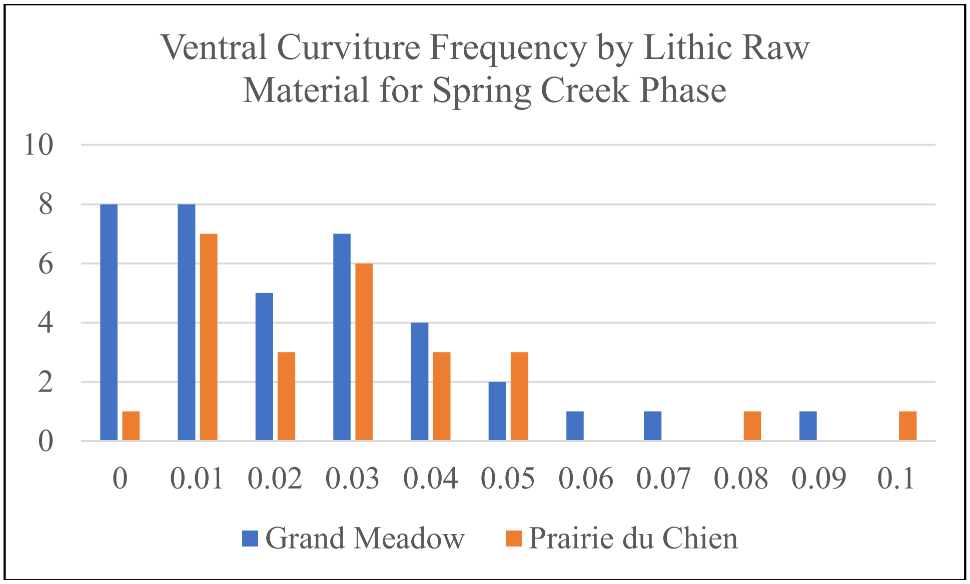

Figure 26: Histogram of Spring Creek end scraper ventral curvatures by lithic material

Grand Meadow Chert end scrapers from Spring Creek phase sites typically have more primary facets on the dorsal surface than those made of Prairie du Chien Chert: about 29 percent of the Grand Meadow Chert end scrapers have three or more primary flake scars compared to about 12 percent for Prairie du Chien Chert (Tables 21 and 22). The difference, however, is not statistically significant. The primary facets on Prairie du Chien Chert end scrapers tend to be slightly more level with the ventral surface than those on Grand Meadow Chert end scrapers when two facets occur: the grand mean angle at the primary facet junction on end scrapers with two primary facets is about 144 degrees for Prairie du Chien Chert and 129 degrees for Grand Meadow Chert, while the coefficient of variances, at about 16 and 19 percent, are very similar (Table 23 and Figure 27). The grand mean angle of the primary facet relative to the ventral surface on single-faceted end scrapers is about 20 to 21 degrees for both materials and the coefficients of variance, at about 62 and 59 percent, are very similar (Table 24 and Figure 28).

Table 21: Chi-squared test of primary facet counts for Spring Creek end scrapers by lithic material

Lithic Material	Facet Count					
	0	1	2	3	4 or More	Total	P-Value
Grand Meadow	5	10	12	9	2	38	0.3718608
Prairie du Chien	7	6	9	3	0	25	
Total	12	16	21	12	2	63	

Table 22: Chi-squared test of primary facet counts (grouped) for Spring Creek end scrapers by lithic material

Lithic Material	Facet Count			
	0-2	3 or more	Total	P-Value
Grand Meadow	27	11	38	0.1134286
Prairie du Chien	22	3	25	
Total	49	14	63	

Table 23: Summary and associated F-test for Spring Creek end scraper primary facet junction angle (degrees) on two-facet artifacts by lithic material

Grand Meadow		Prairie du Chien	
Grand Mean	128.6363636	Grand Mean	144.1111111
Median	131	Median	145
Mode	N/A	Mode	N/A
SD	24.08847329	SD	22.37992652
CV	0.187260216	CV	0.155296329
Range	88	Range	73
Minimum	80	Minimum	107
Maximum	168	Maximum	180
Sum	1415	Sum	1297
Count	12	Count	9
F	1.158513873		
P(F<=f) one-tail	0.425654119		
F Critical one-tail	3.34716312		

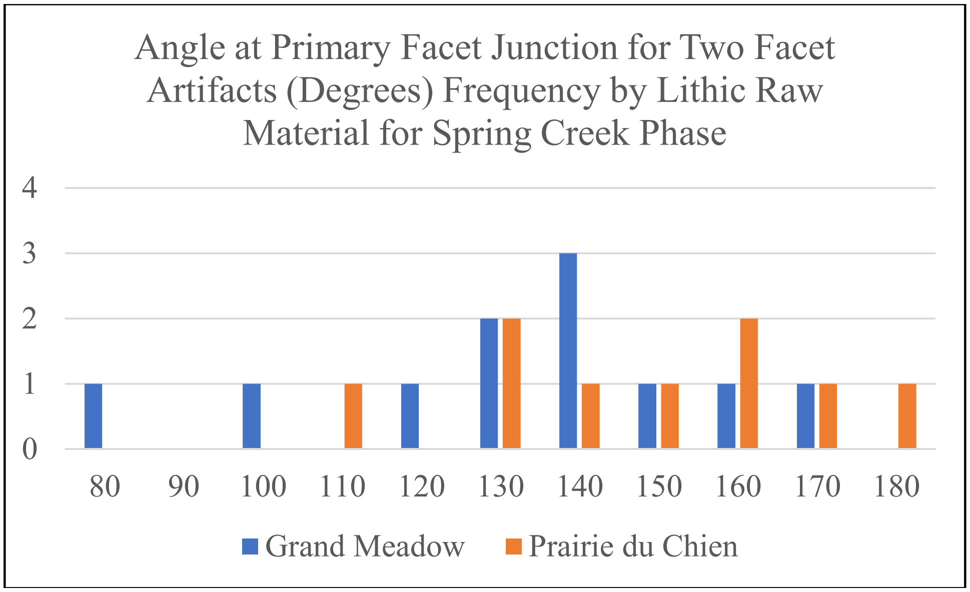

Figure 27: Histogram of Spring Creek end scraper primary facet junction angles for two-facet artifacts by lithic material (grand mean)

Table 24: Summary and associated F-test for Spring Creek end scraper primary facet angle (degrees) on one-facet artifacts by lithic material

Grand Meadow		Prairie du Chien	
Grand Mean	21	Grand Mean	20.5
Median	27.5	Median	18.5
Mode	3	Mode	N/A
SD	13.02988019	SD	12.17784874
CV	0.620470485	CV	0.594041402
Range	32	Range	29
Minimum	3	Minimum	8
Maximum	35	Maximum	37
Sum	210	Sum	123
Count	10	Count	6
F	1.144826553		
P(F<=f) one-tail	0.465055394		
F Critical one-tail	4.772465613		

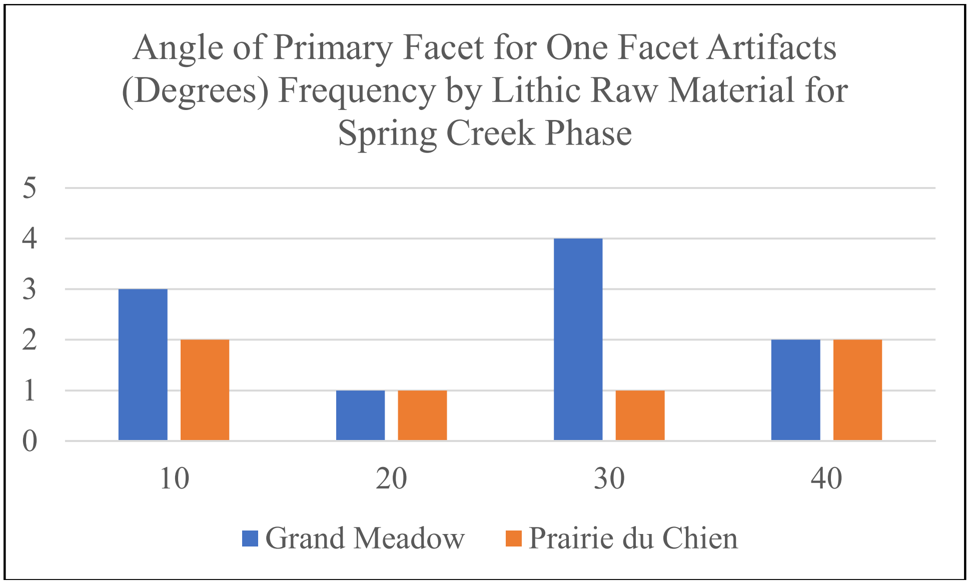

Figure 28: Histogram of Spring Creek end scraper primary facet angles for one-facet artifacts by lithic material (grand mean)

Cross-section frequencies vary by lithic material at Spring Creek phase sites, but the difference between Grand Meadow Chert and Prairie du Chien Chert end scrapers is not statistically significant in this regard (Tables 25 and 26). The cross-section of one Grand Meadow Chert end scrapers was not determined due to an intrusive heat-spall. End scrapers made of both materials have scalene cross-sections about 32 percent of the time. Grand Meadow Chert end scrapers have trapezoidal (38 percent versus 28 percent) and triangular (16 percent versus 8 percent) cross-sections more often than those made of Prairie du Chert. Prairie du Chein Chert end scrapers have hemispherical (20 percent versus 14 percent) and rectangular (12 percent versus 0 percent) cross-sections more often, on the other hand. The maximum thicknesses of end scrapers made of both materials tend to be centered, occurring as such nearly 70 percent of the time on end scrapers made of either material (Table 27). When the maximum thickness is off-centered, it does not occur on one side more often for either material. The maximum thickness of Grand Meadow Chert end scrapers occurs distally a little over 70 percent of the time, compared to about 56 percent of the time on Prairie du Chien Chert End Scrapers, but the difference is not statistically significant (Table 28).

Table 25: Chi-squared test of cross-section counts for Spring Creek end scrapers by lithic material

Lithic Material	Cross Section						
	Hemispherical	Rectangular	Trapezoidal	Triangular	Scalene	Total	P-Value
Grand Meadow	5	0	14	6	12	37	0.1964094
Prairie du Chien	5	3	7	2	8	25	
Total	10	3	21	8	20	62	

Table 26: Chi-squared test of cross-section counts (grouped) for Spring Creek end scrapers by lithic material

Lithic Material	Cross Section				
	Hemispherical	Rectangular/ Trapezoidal	Triangular/ Scalene	Total	P-Value
Grand Meadow	5	14	18	37	0.72097146
Prairie du Chien	5	10	10	25	
Total	10	24	28	62	

Table 27: Chi-squared test of longitudinal thickness orientation counts for Spring Creek end scrapers by lithic material

Lithic Raw Material	Longitudinal Thickness Orientation				
	Left	Center	Right	Total	P-Value
Grand Meadow	6	25	7	38	0.9694292
Prairie du Chien	4	17	4	25	
Total	10	42	11	63	

Table 28: Chi-squared test of latitudinal thickness orientation counts for Spring Creek end scrapers by lithic material

Lithic Raw Material	Latitudinal Thickness Orientation				
	Distal	Middle	Proximal	Total	P-Value
Grand Meadow	27	11	0	38	0.1494737
Prairie du Chien	14	9	2	25	
Total	41	20	2	63	

Prairie du Chien Chert end scrapers from Spring Creek phase sites are broken at a higher rate (about 48 percent versus 34 percent) than those made of Grand Meadow Chert (Table 29). Prairie du Chien Chert end scrapers also tend to break in more varied orientations (Table 30). Neither difference, however, is statistically significant. The average angle of retouch on the central portion of the distal working-face is nearly identical between the two materials, at about 70 degrees (Table 31). The grand mean of the angles of distal edge retouch, at about 69 degrees for Prairie du Chien Chert and 67 degrees for Grand Meadow Chert, is also similar between lithic material types (Table 32). In both cases, the coefficients of variance are very similar between the two lithic materials as well (about 12 and 14 percent for the central portion and 11 and 12 for the average). The distal edges are undercut more often on end scrapers made of Grand Meadow Chert that on those made of Prairie du Chein Chert: at least half of the distal edge is undercut about 21 percent of the time on Grand Meadow Chert end scrapers, while about 13 percent of the Prairie du Chien Chert end scrapers have at least half of the distal edge undercut (Table 33). The difference in distal-edge undercutting, however, is not statistically significant.

Table 29: Chi-squared test of break presence counts for Spring Creek end scrapers by lithic material

Lithic Material	Break Presence			
	Yes	No	Total	P-Value
Grand Meadow	13	25	38	0.273733318
Prairie du Chien	12	13	25	
Total	25	38	63	

Table 30: Chi-squared test of break orientation counts for Spring Creek end scrapers by lithic material

Lithic Material	Break Orientation			
	Perpindicular	Oblique	Total	P-Value
Grand Meadow	12	1	13	0.109314576
Prairie du Chien	8	4	12	
Total	20	5	25	

Table 31: Summary and associated F-test for Spring Creek end scraper distal working-face retouch (central portion) angle (degrees) by lithic material

Grand Meadow		Prairie du Chien	
Mean	71.70588235	Mean	71.91304348
Median	72	Median	70
Mode	77	Mode	70
SD	8.84386249	SD	9.958609996
CV	0.123335244	CV	0.138481276
Range	40	Range	36
Minimum	50	Minimum	53
Maximum	90	Maximum	89
Sum	2438	Sum	1654
Count	34	Count	23
F	1.267983163		
P(F<=f) one-tail	0.262863735		
F Critical one-tail	1.873468169		

Table 32: Summary and associated F-test for Spring Creek end scraper distal working-face retouch angle (degrees) by lithic material

Grand Meadow		Prairie du Chien	
Grand Mean	67.44117647	Grand Mean	69.30434783
Median	67.5	Median	68
Mode	73	Mode	68
SD	7.118866	SD	8.198862352
CV	0.10555667	CV	0.11830228
Range	30	Range	32
Minimum	51	Minimum	54
Maximum	81	Maximum	86
Sum	2293	Sum	1594
Count	34	Count	23
F	1.326433721		
P(F<=f) one-tail	0.22639275		
F Critical one-tail	1.873468169		

Table 33: Chi-squared test of distal edge undercutting presence counts for Spring Creek end scrapers by lithic material

Lithic Material	Distal Edge Undercut			
	Yes	No	Total	P-Value
Grand Meadow	7	27	34	0.462494299
Prairie du Chien	3	20	23	
Total	10	47	57	

Blue Earth Phase versus Spring Creek Phase Grand Meadow End Scrapers

A total of 38 independent comparisons are made between Grand Meadow Chert end scrapers from Blue Earth phase and Spring Creek phase sites. To achieve a 0.05 significance level for the data set, a corrected (Sidak) significance level of 0.001349 is used per individual comparisons. Fifty-five of the Grand Meadow Chert end scrapers analyzed in this thesis are from Blue Earth phase contexts and 38 are from Spring Creek phase contexts. Of these, 36 of the Blue Earth phase end scrapers are complete and 25 of the Spring Creek phase end scrapers are complete. The comparisons of dimensions that follow include only the unbroken end scrapers. A number of the end scrapers studied from 21BE14, all of which being Grand Meadow Chert, are portrayed in Figure 29 alongside the associated project number.

The Grand Meadow Chert end scrapers from Blue Earth phase sites are, on average, longer (about 24 mm versus 21.6 mm), thicker (about 6.4 mm vs 7 mm), and heaver (about 4.4 g versus 3.4 g) than those from Spring Creek phase sites (Tables 34 through 36 and Figures 30 through 32). The only statistically significant difference between Grand Meadow Chert end scrapers from sites associated with the different phases and the above-mentioned averages relates to weight ($p < .0002$). Grand Meadow Chert end scrapers from sites associated with both phases have very similar widths, averaging about 18 to 19 mm (Table 37 and Figure 33). Grand Meadow Chert end scrapers from the Blue Earth phase sites have higher coefficients of variance in terms of length (about 34 versus 29 percent), width (about 15 versus 11 percent), thickness (about 23 versus 20 percent), and weight (about 60 versus 35 percent) compared to Grand Meadow Chert end scrapers from Spring Creek phase sites. Figures 34 and 35 are heatmaps of the lengths and widths of all (i.e. broken and unbroken) the Grand Meadow Chert end scrapers analyzed from Blue Earth phase and Spring Creek phase sites in this thesis.

Figure 29: Grand Meadow Chert end scrapers from 21BE14 (template created by Cory Nowak)

Table 34: Summary and associated F-test for complete Grand Meadow Chert end scraper lengths (mm) by phase

Spring Creek		Blue Earth	
Mean	21.64	Mean	24
Median	20	Median	22.5
Mode	20	Mode	20
SD	6.290733926	SD	8.092324406
CV	0.29069935	CV	0.337180184
Range	31	Range	35
Minimum	12	Minimum	13
Maximum	43	Maximum	48
Sum	541	Sum	864
Count	25	Count	36
F	1.654793993		
P(F<=f) one-tail	0.099885404		
F Critical one-tail	1.912390178		

Table 35: Summary and associated F-test for complete Grand Meadow Chert end scraper thicknesses (mm) by phase

Spring Creek		Blue Earth	
Mean	6.434	Mean	6.963611111
Median	6.54	Median	6.955
Mode	N/A	Mode	7.53
SD	1.29818463	SD	1.625497116
CV	0.201769448	CV	0.233427325
Range	5.4	Range	7.5
Minimum	3.55	Minimum	3.4
Maximum	8.95	Maximum	10.9
Sum	160.85	Sum	250.69
Count	25	Count	36
F	1.567831842		
P(F<=f) one-tail	0.126043014		
F Critical one-tail	1.912390178		

Table 36: Summary and associated F-test for complete Grand Meadow Chert end scraper weights (g) by phase

Spring Creek		Blue Earth	
Mean	3.4326	Mean	4.363638889
Median	3.007	Median	3.55
Mode	N/A	Mode	3.9
SD	1.208926521	SD	2.603555055
CV	0.352189746	CV	0.596647688
Range	4.879	Range	10.608
Minimum	1.496	Minimum	1.192
Maximum	6.375	Maximum	11.8
Sum	85.815	Sum	157.091
Count	25	Count	36
F	4.638031791		
P(F<=f) one-tail	0.000104488		
F Critical one-tail	1.912390178		

Table 37: Summary and associated F-test for complete Grand Meadow Chert end scraper widths (mm) by phase

Spring Creek		Blue Earth	
Mean	18.52	Mean	18.27777778
Median	19	Median	18
Mode	19	Mode	16
SD	1.98158186	SD	2.824496022
CV	0.106996861	CV	0.154531697
Range	8	Range	12
Minimum	14	Minimum	13
Maximum	22	Maximum	25
Sum	463	Sum	658
Count	25	Count	36
F	2.031692134		
P(F<=f) one-tail	0.036358843		
F Critical one-tail	1.912390178		

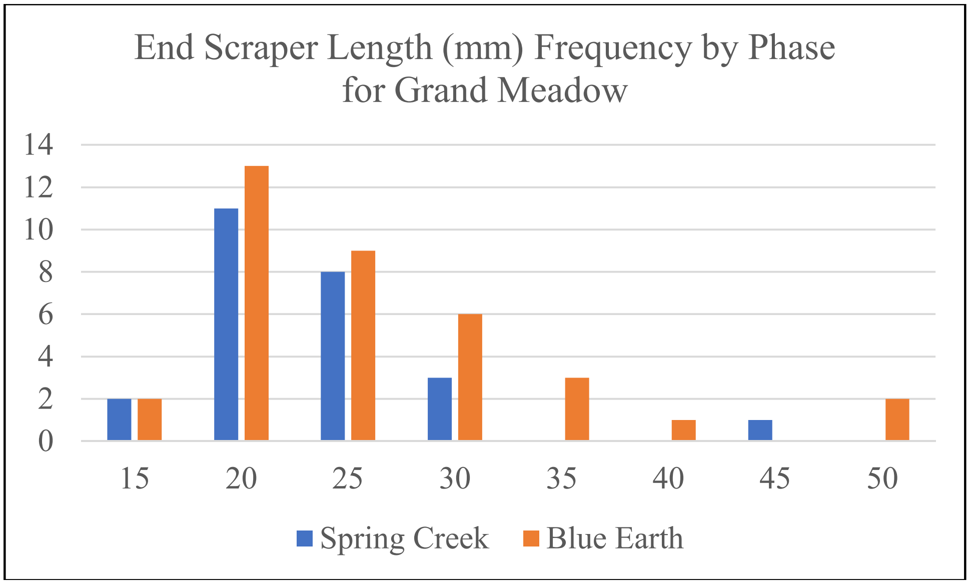

Figure 30: Histogram of complete Grand Meadow Chert end scraper lengths by phase

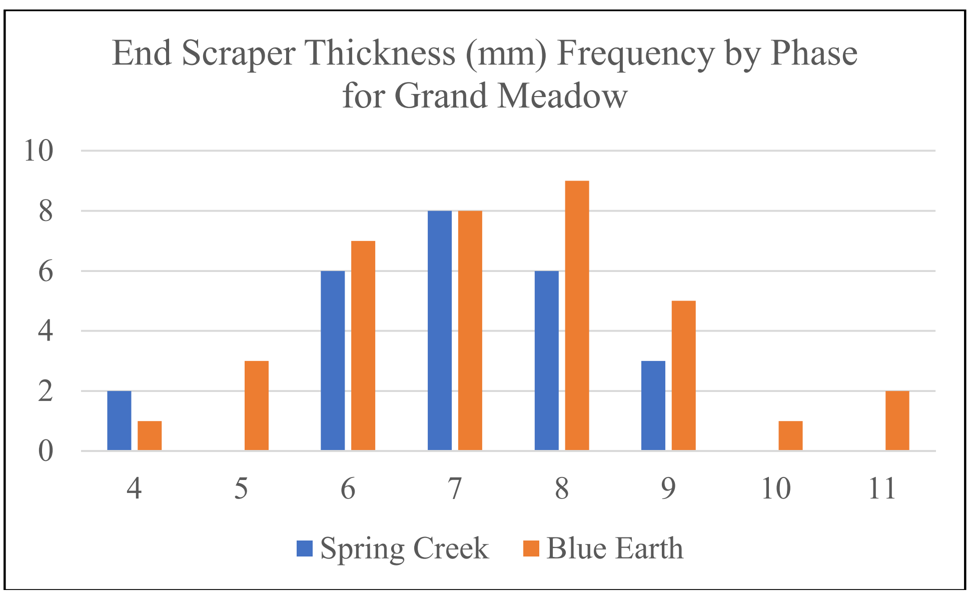

Figure 31: Histogram of complete Grand Meadow Chert end scraper thicknesses by phase

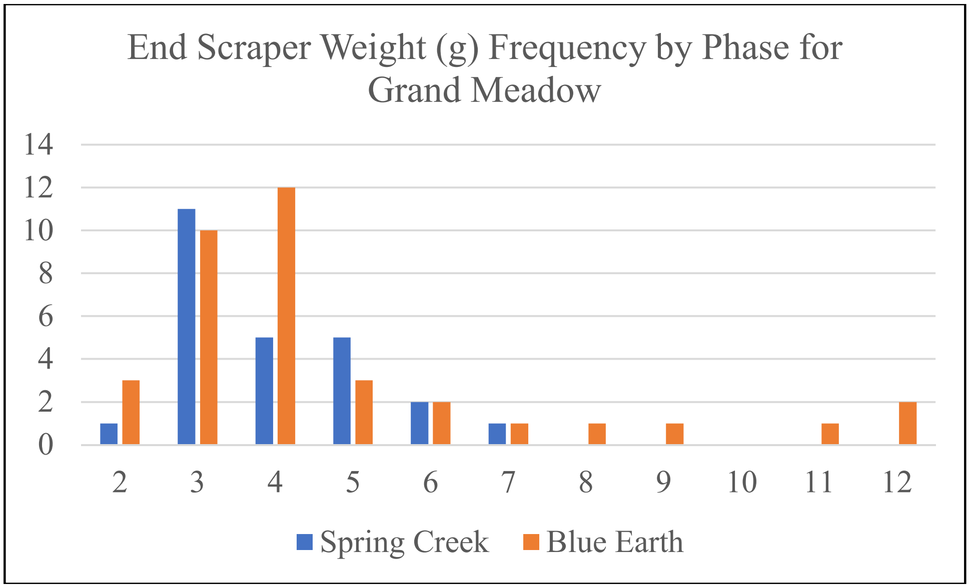

Figure 32: Histogram of complete Grand Meadow Chert end scraper weights by phase

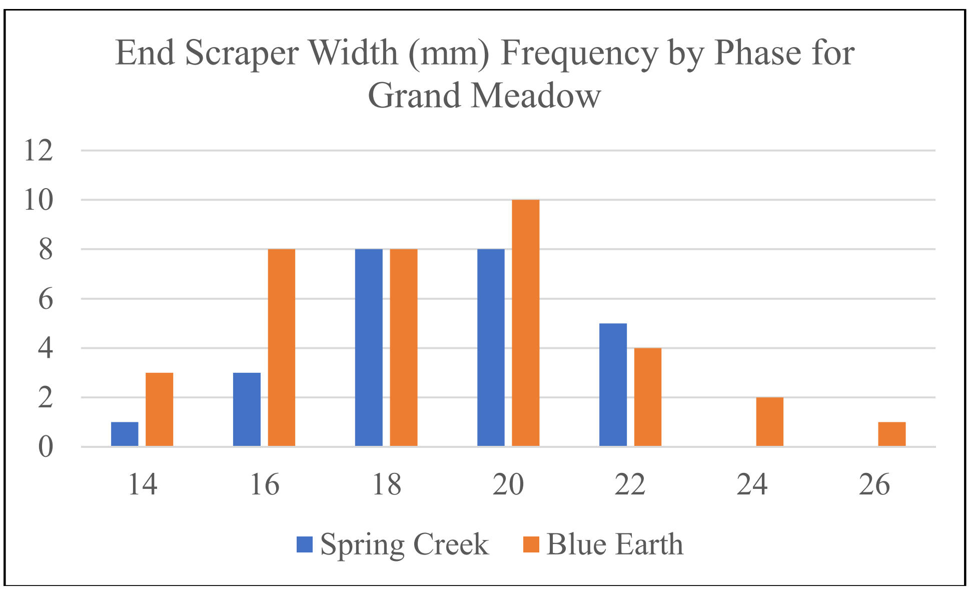

Figure 33: Histogram of complete Grand Meadow Chert end scraper widths by phase

	Width														
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Length															Total
12							2								2
13															0
14															0
15					1	1		1							3
16		1			2		1		1	1					6
17					1		1	1		1					4
18							1								1
19								1	2						3
20			1		2		1				1				5
21						1	1			1					3
22					1								1		2
23								1	1						2
24															0
25								2		1					3
26															0
27															0
28								1							1
29								1							1
30						1									1
31															0
32															0
33															0
34															0
35															0
36															0
37															0
38															0
39															0
40															0
41															0
42															0
43						1									1
44															0
45															0
46															0
47															0
48															0
Total	0	1	1	0	7	4	7	8	4	4	1	0	1	0	38

Figure 34: Heatmap of all Spring Creek end scraper length/width counts for GMC

	Width														
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Length															Total
12															0
13					1										1
14										1					1
15					2				1						3
16						1		1	1						3
17					2			2		1					5
18			1		1		2		1	1					6
19						1	1								2
20		1		1		1	1	1							5
21					1										1
22	1						2	1	1						5
23			1		1			1							3
24							1	1			1				3
25							1								1
26					1	1									2
27									2						2
28															0
29		1											1		2
30											1				1
31		1				1				1					3
32						1							1		2
33															0
34									1						1
35															0
36															0
37															0
38														1	1
39															0
40															0
41															0
42															0
43															0
44															0
45															0
46															0
47															0
48								1				1			2
Total	1	3	2	1	9	6	8	8	7	4	2	1	2	1	55

Figure 35: Heatmap of all Blue Earth end scraper length/width counts for GMC

Fifty-two of the Grand Meadow Chert end scrapers from Blue Earth phase sites and 37 of the Grand Meadow Chert end scrapers from Spring Creek phase sites were complete enough to confidently assign a planview. The distribution of planview-shapes is nearly equal between the phases for Grand Meadow Chert end scrapers: Grand Meadow Chert end scrapers associated with both phases are triangular or tapered in planview nearly 90 percent of the time (Tables 38 and 39). The Grand Meadow Chert end scrapers from Spring Creek phase contexts, with a mean width to length ratio of about 0.92, are typically broader than those from Blue Earth phase contexts, which have a mean width to length ratio of about 0.82, but the difference is not statistically significant (Table 40 and Figure 36). The coefficients of variance, around 27 percent in both cases, are also very similar.

Table 38: Chi-squared test of planview counts for Grand Meadow Chert scrapers by phase

Phase	Planview					
	Ovate	Rectangular	Tapered	Triangular	Total	P-Value
Spring Creek	1	3	15	18	37	0.851054825
Blue Earth	1	6	17	28	52	
Total	2	9	32	46	89	

Table 39: Chi-squared test of planview (grouped) counts for Grand Meadow Chert scrapers by phase

Phase	Planview			
	Rectangular/Ovate	Tapered/Triangular	Total	P-Value
Spring Creek	4	33	37	0.708053408
Blue Earth	7	45	52	
Total	11	78	89	

Table 40: Summary and associated F-test for complete Grand Meadow Chert end scraper width to length ratios (mm) by phase

Spring Creek		Blue Earth	
Mean	0.9168	Mean	0.819444444
Median	0.87	Median	0.755
Mode	1	Mode	0.75
SD	0.250976759	SD	0.221139186
CV	0.273753009	CV	0.26986477
Range	1.1	Range	0.85
Minimum	0.4	Minimum	0.4
Maximum	1.5	Maximum	1.25
Sum	22.92	Sum	29.5
Count	25	Count	36
F	1.288058529		
P(F<=f) one-tail	0.242770107		
F Critical one-tail	1.833184385		

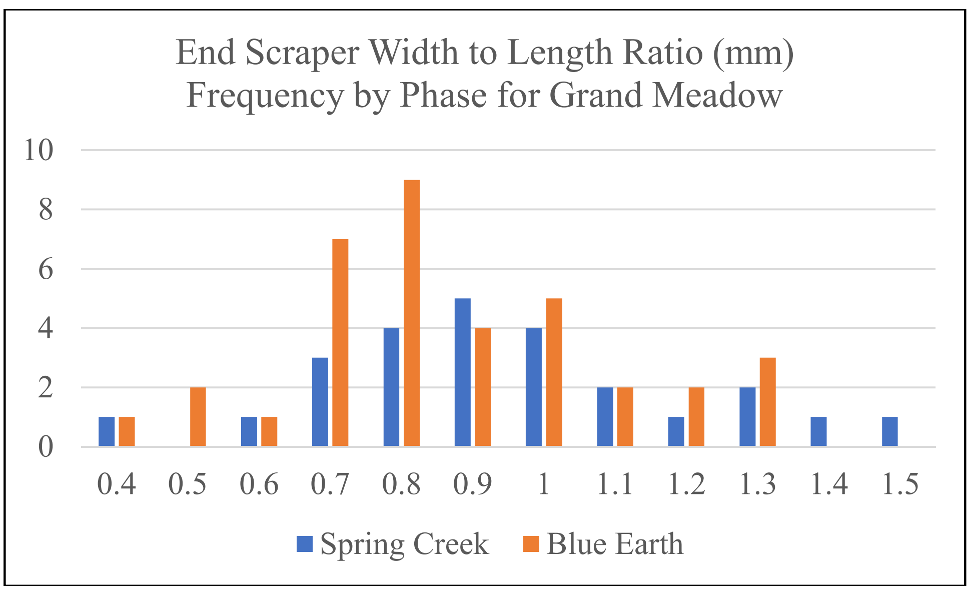

Figure 36: Histogram of complete Grand Meadow Chert end scraper width to length ratios by phase

Thirty-four Grand Meadow Chert end scrapers retain complete platforms, 19 of which are from Blue Earth phase sites and 15 of which are from Spring Creek phase sites. In terms of platform area, Grand Meadow Chert end scrapers are similar between sites from the two phases, having means of about 31 to 32 mm^2 and coefficients of variance of about 68 percent (Table 41 and Figure 37). The means of the platform thickness to width ratios, which range from about 0.40 to 0.41 (Table 42 and Figure 38), are also similar between Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites; however, the coefficient of variance is higher for the Spring Creek phase (about 24 versus 17 percent). Eighteen of the Grand Meadow Chert end scrapers from Spring Creek phase sites and 21 from Blue Earth phase sites have platforms complete enough to determine the number of platform facets, the presence or absence of platform grinding, and the degree to which the platform is twisted off-center. There is a slight tendency for the platforms of Grand Meadow Chert end scrapers from Blue Earth phase contexts to be more heavily faceted: all of the Grand Meadow Chert end scrapers from Blue Earth phase sites have one or two facets, while 84 percent of the Grand Meadow Chert end scrapers from Spring Creek phase contexts have one or two facets (Table 43). Spring Creek phase end scrapers made of Grand Meadow Chert have ground platforms more often than Blue Earth phase counterparts: about 72 percent of the Spring Creek phase and 62 percent of the Blue Earth phase Grand Meadow Chert end scrapers have ground platforms (Table 44). The degree to which platforms are twisted remains fairly consistent for Grand Meadow Chert end scrapers between the two phases. The platforms associated with the Blue Earth phase are most often (about 48 percent of the time) centered, however, and those associated with the Spring Creek phase are most often (about 39 percent of the time) off-center by five degrees (Table 45). None of the differences between Grand Meadow Chert end scrapers from Spring Creek phase and Blue

Earth phase sites in terms of platform faceting, grinding, and twistedness are statistically significant. Interior platform angles were measured on 20 Grand Meadow Chert end scrapers from Spring Creek phase sites and 22 from Blue Earth phase sites. The mean interior platform angle for Grand Meadow Chert end scrapers from Blue Earth phase sites is steeper (about 70 versus 66 degrees) than those from Spring Creek phase sites (Table 46 and Figure 39). The coefficients of variance with regards to interior platform angle, however, are similar between the phases (about 16 to 18 percent), and there are no statically significant differences between the variances.

Table 41: Summary and associated F-test for Grand Meadow Chert end scraper platform areas (mm^2) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	32.14666667	Mean	31.24684211
Median	29.7	Median	20.62
Mode	N/A	Mode	N/A
SD	21.7110685	SD	21.29143178
CV	0.67537542	CV	0.681394674
Range	66.49	Range	71.1
Minimum	8.32	Minimum	10.52
Maximum	74.81	Maximum	81.62
Sum	482.2	Sum	593.69
Count	15	Count	19
F	1.039806817		
P(F<=f) one-tail	0.461168871		
F Critical one-tail	2.290032892		

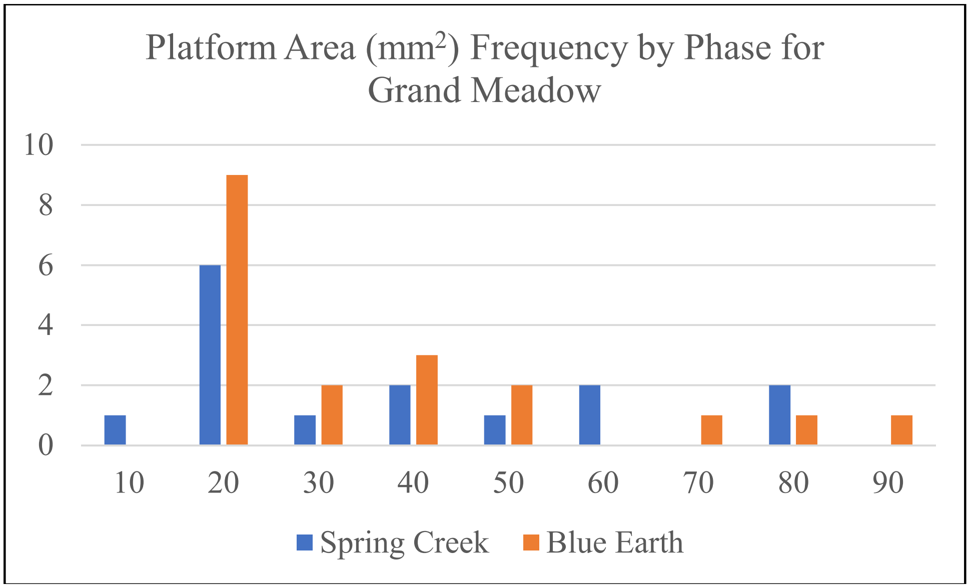

Figure 37: Histogram of Grand Meadow Chert end scraper platform areas by phase

Table 42: Summary and associated F-test for Grand Meadow Chert end scraper platform thickness to width ratios by phase

Spring Creek Phase		Blue Earth Phase	
Mean	0.398	Mean	0.406315789
Median	0.37	Median	0.4
Mode	0.36	Mode	0.4
SD	0.09645132	SD	0.068330124
CV	0.24234	CV	0.168169994
Range	0.34	Range	0.27
Minimum	0.26	Minimum	0.26
Maximum	0.6	Maximum	0.53
Sum	5.97	Sum	7.72
Count	15	Count	19
F	1.992470656		
P(F<=f) one-tail	0.084723451		
F Critical one-tail	2.290032892		

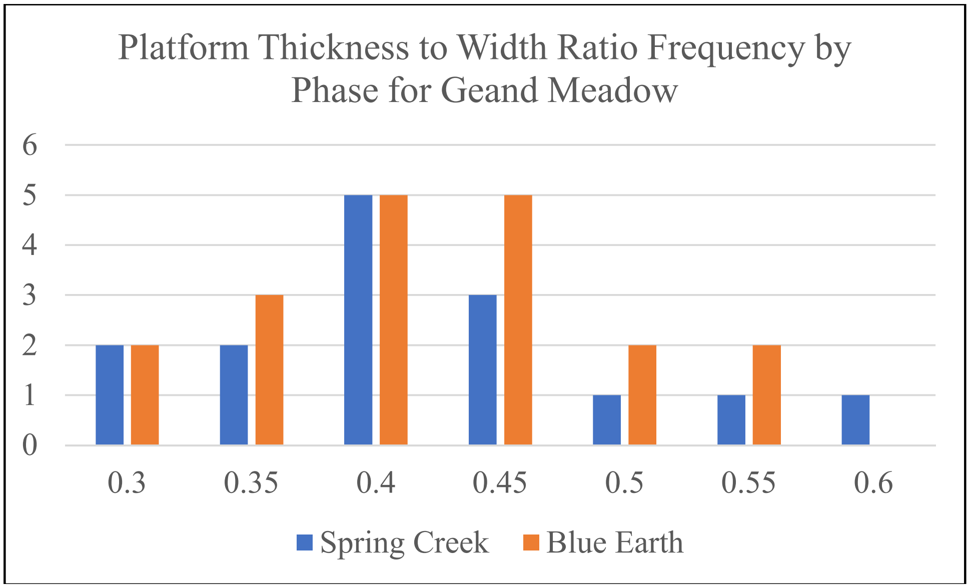

Figure 38: Histogram of Grand Meadow Chert end scraper platform thickness to width ratios by phase

Table 43: Chi-squared test of platform facet counts for Grand Meadow Chert end scrapers by phase

Phase	Platform Facets				
	0	1	2	Total	P-Value
Spring Creek	3	12	3	18	0.149821447
Blue Earth	0	17	4	21	
Total	3	29	7	39	

Table 44: Chi-squared test of platform grinding presence counts for Grand Meadow Chert end scrapers by phase

Phase	Platform Ground			
	Yes	No	Total	P-Value
Spring Creek	13	5	18	0.49562782
Blue Earth	13	8	21	
Total	26	13	39	

Table 45: Chi-squared test of platform twistedness counts for Grand Meadow Chert end scrapers by phase

Phase	Platform Width to Artifact Width Angles (Degrees)						
	0	5	10	15	20	Total	P-Value
Spring Creek	7	8	2	1	0	18	0.613870902
Blue Earth	10	5	4	1	1	21	
Total	17	13	6	2	1	39	

Table 46: Summary and associated F-test for Grand Meadow Chert end scraper interior platform angle (degrees) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	66.15	Mean	70.18181818
Median	64.5	Median	71.5
Mode	58	Mode	56
SD	10.66363718	SD	12.42361945
CV	0.161203888	CV	0.177020484
Range	42	Range	42
Minimum	45	Minimum	48
Maximum	87	Maximum	90
Sum	1323	Sum	1544
Count	20	Count	22
F	1.357330349		
P(F<=f) one-tail	0.253556814		
F Critical one-tail	2.143834021		

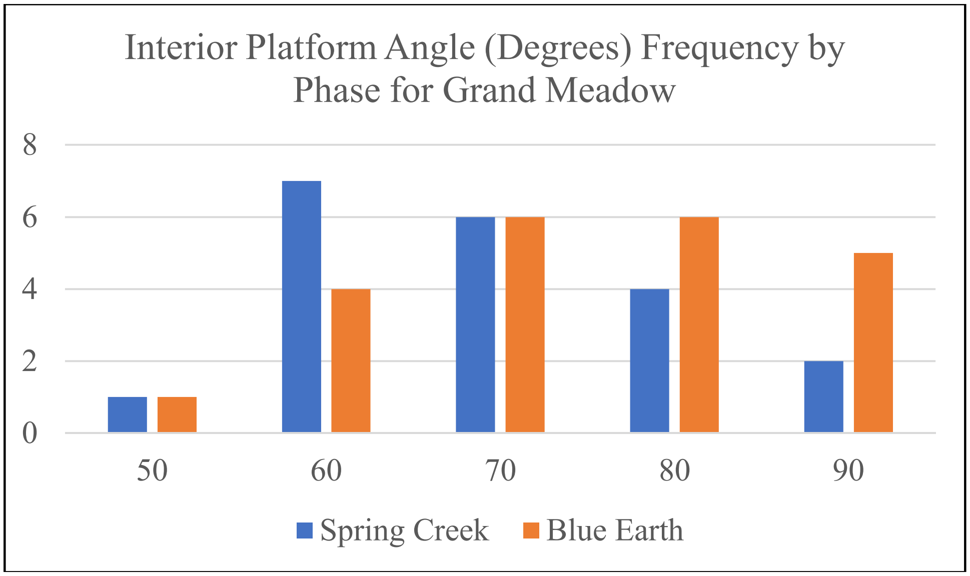

Figure 39: Histogram of Grand Meadow Chert end scraper interior platform angles by phase

Bulbs of percussion are present on 23 Grand Meadow Chert end scrapers from Spring Creek phase sites and 32 Grand Meadow Chert end scrapers from Blue Earth phase sites. The mean thickness of the bulbs of percussion on Grand Meadow Chert end scrapers from Blue Earth sites is larger (about 5.4 mm versus 4.9 mm) than that of those from Spring Creek phase sites (Table 47 and Figure 40). There is no statistically significant difference between the phases with regards to bulb of percussion thickness, however, and the coefficients of variance are very similar (about 29 to 30 percent). Of the Grand Meadow Chert end scrapers with bulbs of percussion, nine from each of the two phases also have eraillure facets (Table 48). The difference in the rate of bulbs of percussion with associated eraillure facets is not statistically significant, however. The mean eraillure scar area and related coefficient of variance is larger (about 41 mm^2 versus 21 mm^2 and 116 versus 69 percent) for Grand Meadow Chert end scrapers from Blue Earth phase sites than the same from Spring Creek phase sites (Table 49 and Figure

41). The difference in eraillure scar areas for Grand Meadow Chert end scrapers from the two phases is not statistically significant, but a low p-value was arrived at (p < 0.0015). The width to length ratio means for eraillure scars on Grand Meadow Chert end scrapers, at about 0.65 in both cases, as well as the associated coefficients of variance (about 24 to 29 percent), are very similar between the phases (Table 50 and Figure 42). The ventral surfaces of Grand Meadow Chert end scrapers from Blue Earth phase sites are typically more curved than those from Spring Creek phase sites, with mean ventral curvatures of about 0.03 versus 0.02 (Table 51 and Figure 43). The coefficient of variance with regards to ventral curvature is higher for the Grand Meadow Chert end scrapers from Spring Creek phase sites (about 91 versus 79 percent), however, and there is no statistically significant difference between the phases.

Table 47: Summary and associated F-test for Grand Meadow Chert end scraper bulb of percussion thicknesses (mm) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	4.910434783	Mean	5.381875
Median	4.4	Median	5.15
Mode	N/A	Mode	N/A
SD	1.406266748	SD	1.587754425
CV	0.286383347	CV	0.295018822
Range	4.62	Range	6.29
Minimum	2.8	Minimum	2.44
Maximum	7.42	Maximum	8.73
Sum	112.94	Sum	172.22
Count	23	Count	32
F	1.274768279		
P(F<=f) one-tail	0.280067333		
F Critical one-tail	1.978358495		

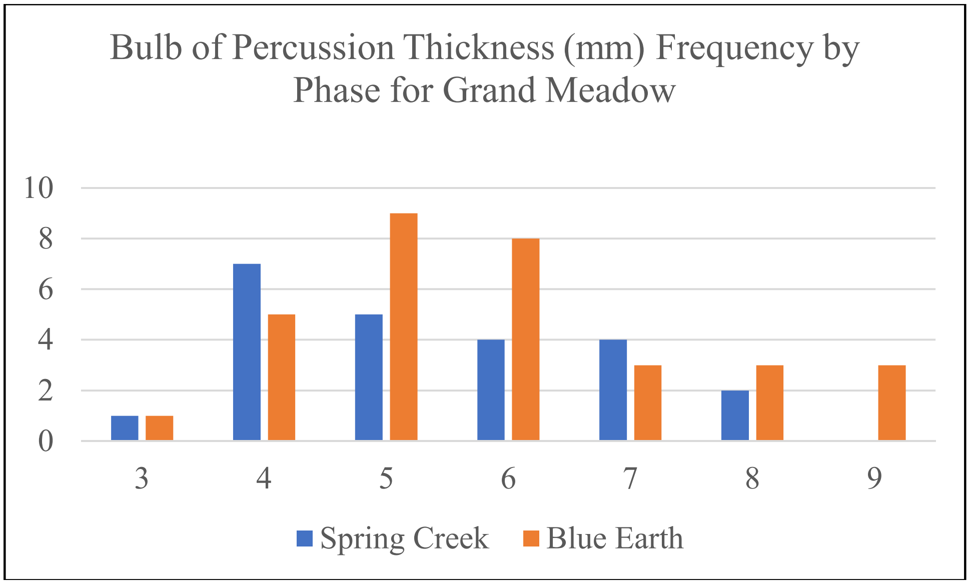

Figure 40: Histogram of Grand Meadow Chert end scraper bulb of percussion thicknesses by phase

Table 48: Chi-squared test of eraillure scar presence counts for Grand Meadow Chert end scrapers by phase

Phase	Eraillure Scar Presence			
	Yes	No	Total	P-Value
Spring Creek	9	14	23	0.390889132
Blue Earth	9	23	32	
Total	18	37	55	

Table 49: Summary and associated F-test for Grand Meadow Chert end scraper eraillure scar areas (mm^2) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	20.88555556	Mean	41.08555556
Median	12.58	Median	24.65
Mode	N/A	Mode	N/A
SD	14.38421714	SD	47.56205449
CV	0.688716041	CV	1.15763445
Range	33.72	Range	143.71
Minimum	9.82	Minimum	7.32
Maximum	43.54	Maximum	151.03
Sum	187.97	Sum	369.77
Count	9	Count	9
F	10.93323672		
P(F<=f) one-tail	0.001402511		
F Critical one-tail	3.438101233		

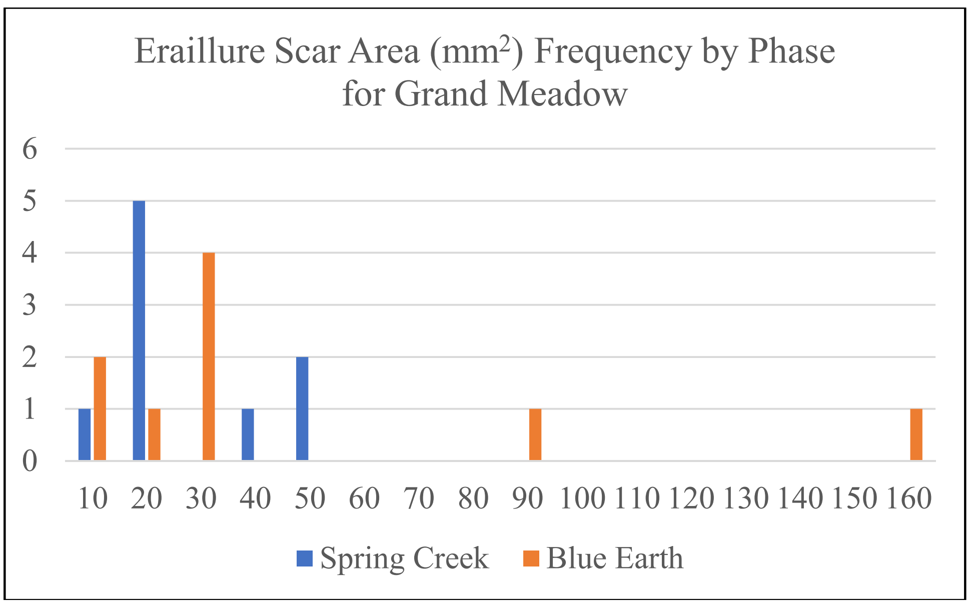

Figure 41: Histogram of Grand Meadow Chert end scraper eraillure scar areas by phase

Table 50: Summary and associated F-test for Grand Meadow Chert end scraper eraillure scar width to length ratios by phase

Spring Creek Phase		Blue Earth Phase	
Mean	0.652222222	Mean	0.653333333
Median	0.6	Median	0.63
Mode	N/A	Mode	0.47
SD	0.154497393	SD	0.192613603
CV	0.236878456	CV	0.294816739
Range	0.48	Range	0.55
Minimum	0.42	Minimum	0.44
Maximum	0.9	Maximum	0.99
Sum	5.87	Sum	5.88
Count	9	Count	9
F	1.554288374		
P(F<=f) one-tail	0.273517413		
F Critical one-tail	3.438101233		

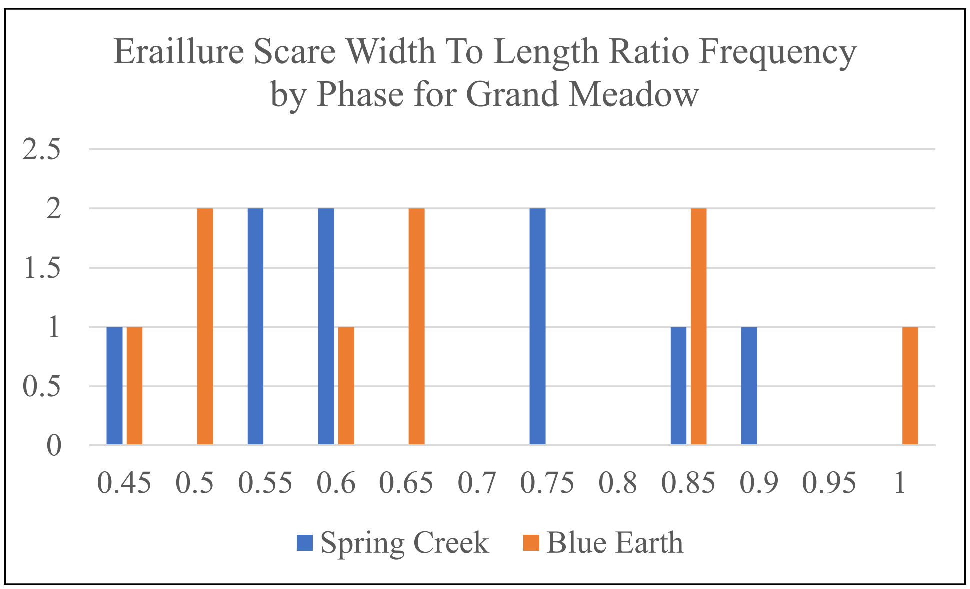

Figure 42: Histogram of Grand Meadow Chert end scraper eraillure scar width to length ratios by phase

Table 51: Summary and associated F-test for Grand Meadow Chert end scraper ventral curvature by phase

Spring Creek Phase		Blue Earth Phase	
Mean	0.023513514	Mean	0.030566038
Median	0.02	Median	0.03
Mode	0.01	Mode	0.03
SD	0.021501449	SD	0.024291111
CV	0.914429443	CV	0.794709175
Range	0.09	Range	0.09
Minimum	0	Minimum	0
Maximum	0.09	Maximum	0.09
Sum	0.87	Sum	1.62
Count	38	Count	55
F	1.276319145		
P(F<=f) one-tail	0.221904738		
F Critical one-tail	1.688522356		

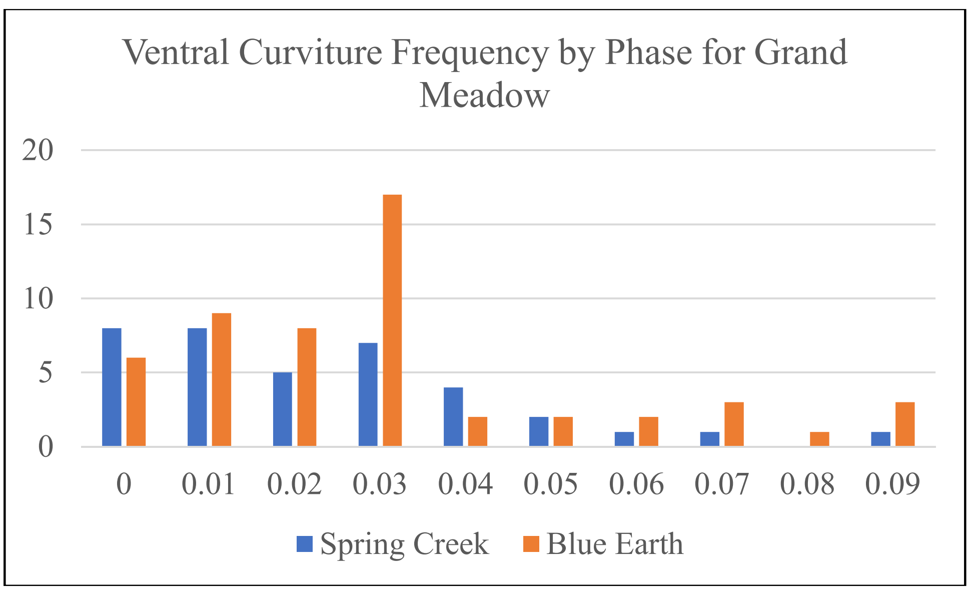

Figure 43: Histogram of Grand Meadow Chert end scraper ventral curvatures by phase

Cortex is present at a higher rate (about 58 versus 42 percent) on the Grand Meadow Chert end scrapers from Spring Creek phase sites than those from Blue Earth phase sites (Table 52). The difference, however, is not statistically significant. Complete coverage of the dorsal surface by cortex is also more common on Spring Creek phase, Grand Meadow Chert end scrapers, occurring about 25 percent of the time cortex is present compared to about 17 percent of the time for the Blue Earth phase, but the difference is not statistically significant (Table 53). Note that Table 53 does not include two Spring Creek phase end scrapers that only have cortex present on the platform. Grand Meadow Chert end scrapers from Blue Earth phase sites are heat treated at a higher rate (about 9 versus 3 percent) than those from Spring Creek phase sites, while Grand Meadow Chert end scrapers from Spring Creek phase sites are burned at a higher rate (about 13 versus 5 percent) than those from Blue Earth phase sites (Table 54). The difference in rates of heat treatment and burning between the phases is not statistically significant.

Table 52: Chi-squared test of cortex presence counts for Grand Meadow Chert end scrapers by phase

Phase	Cortex Presence			
	Yes	No	Total	P-Value
Spring Creek	22	16	38	0.127249561
Blue Earth	23	32	55	
Total	45	48	93	

Table 53: Chi-squared test of cortex orientation counts for Grand Meadow Chert end scrapers by phase

Phase	Cortex Orientation					
	All	Left	Center	Right	Total	P-Value
Spring Creek	5	7	1	7	20	0.678692887
Blue Earth	4	10	3	6	23	
Total	9	17	4	13	43	

Table 54: Chi-squared test of heat treatment and burning presence for Grand Meadow Chert end scrapers by phase

Phase	Heat Treatment/Burning				
	Heat Treated	Burned	Neither	Total	P-Value
Spring Creek	1	5	32	38	0.22226803
Blue Earth	5	3	47	55	
Total	6	8	79	93	

Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites tend to be similar in terms of the number of primary facets on the dorsal surface (Tables 55 and 56). Two-faceted end scrapers are the most common for both phases within Grand Meadow Chert, occurring about 30 to 35 percent of the time. The angles of primary facets on Grand Meadow Chert end scrapers are also very similar between the phases. The grand mean angle at the junction of facets for two-facet Grand Meadow Chert end scrapers is between 128 and 129 degrees for both phases, while the coefficient of variance is slightly higher (about 19 versus 14 percent) for the Spring Creek phase (Table 57 and Figure 44). The grand mean angle for single-facet Grand Meadow Chert end scrapers, at about 21 to 23 degrees, is also similar between the phases. In the case of single-facet angles, however, the coefficient of variance is higher (about 79 versus 62 percent) for Grand Meadow Chert end scrapers from Blue Earth phase sites than it is for those from Spring Creek phase sites (Table 58 and Figure 45). There is no statistically significant difference between Grand Meadow Chert end scrapers from the Blue Earth and Spring Creek phases in terms of the primary facet angles discussed above.

Table 55: Chi-squared test of primary facet counts for Grand Meadow Chert end scrapers by phase

Phase	Primary Facet Count						
	0	1	2	3	4 or More	Total	P-Value
Spring Creek	5	10	12	9	2	38	0.68014029
Blue Earth	4	19	20	8	4	55	
Total	9	29	32	17	6	93	

Table 56: Chi-squared test of primary facet counts (grouped) for Grand Meadow Chert end scraper by phase

Phase	Primary Facet Count			
	0-2	3 or More	Total	P-Value
Spring Creek	27	11	38	0.433436631
Blue Earth	43	12	55	
Total	70	23	93	

Table 57: Summary and associated F-test for Grand Meadow Chert end scraper primary facet junction angle (degrees) on two-facet artifacts by phase

Spring Creek Phase		Blue Earth Phase	
Grand Mean	128.6363636	Grand Mean	128
Median	131	Median	132.5
Mode	N/A	Mode	117
SD	24.08847329	SD	17.95608679
CV	0.187260216	CV	0.140281928
Range	88	Range	62
Minimum	80	Minimum	96
Maximum	168	Maximum	158
Sum	1415	Sum	2560
Count	12	Count	20
F	1.799679459		
P(F<=f) one-tail	0.129784528		
F Critical one-tail	2.377933687		

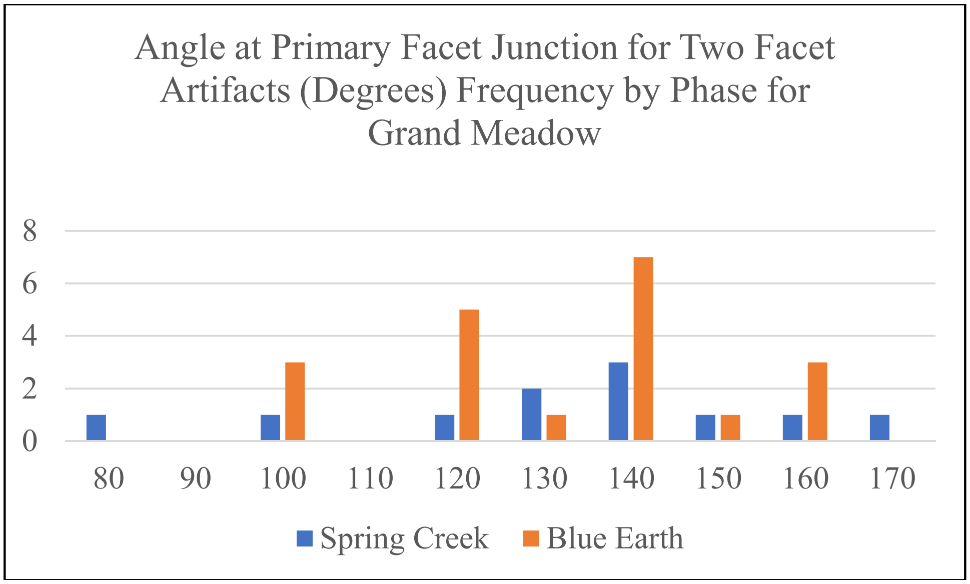

Figure 44: Histogram of Grand Meadow Chert end scraper primary facet junction angles for two-facet artifacts by phase (grand mean)

Table 58: Summary and associated F-test for Grand Meadow Chert end scraper primary facet angle (degrees) on one-facet artifacts by phase

Spring Creek Phase		Blue Earth Phase	
Grand Mean	21	Grand Mean	22.68421053
Median	27.5	Median	22
Mode	3	Mode	0
SD	13.02988019	SD	17.98472386
CV	0.620470485	CV	0.792830054
Range	32	Range	72
Minimum	3	Minimum	0
Maximum	35	Maximum	72
Sum	210	Sum	431
Count	10	Count	19
F	1.905139157		
P(F<=f) one-tail	0.162196028		
F Critical one-tail	2.960002534		

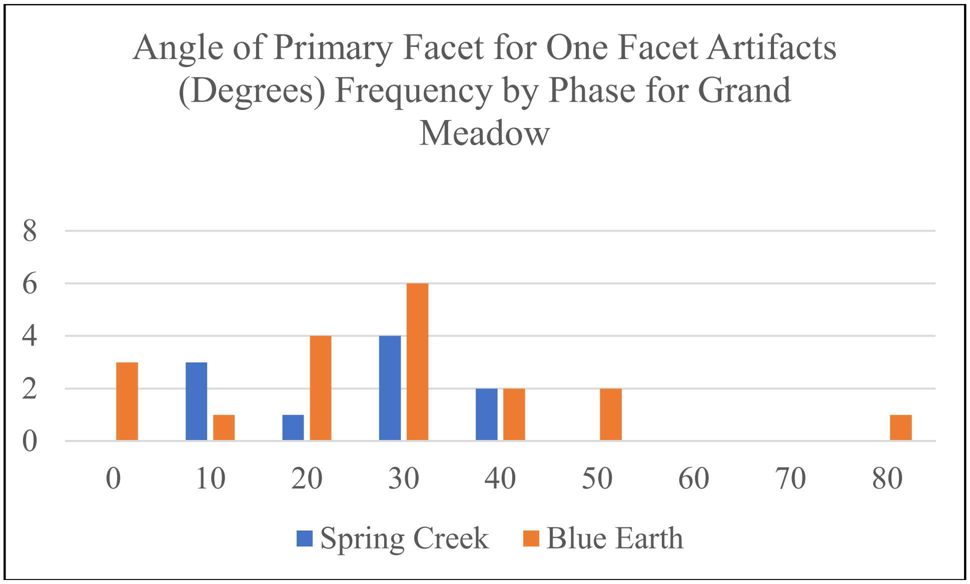

Figure 45: Histogram of Grand Meadow Chert end scraper primary facet angles for one-facet artifacts by phase (grand mean)

Grand Meadow Chert end scrapers from Blue Earth phase sites exhibit more diversity in terms of cross-section than those from Spring Creek phase sites, but, overall, the two phases are similar in terms of cross-section frequencies (Tables 59 and 60). In terms of the longitudinal location of maximum thickness, Grand Meadow Chert end scrapers from both phases have centered maximum thicknesses about 65 percent of the time (Table 61). Right and left oriented thicknesses occur with about equal frequency at sites associated with both phases. The maximum thickness occurs distally more often (about 71 versus 60 percent) on Grand Meadow Chert end scrapers from Spring Creek phase sites than those from Blue Earth phase sites, but the difference is not statistically significant (Table 62).

Table 59: Chi-squared test of cross-section counts for Grand Meadow Chert end scrapers by phase

Phase	Cross Section						
	Hemispherical	Rectangular	Trapezoidal	Triangular	Scalene	Total	P-Value
Spring Creek	5	0	14	6	12	37	0.502709785
Blue Earth	7	3	21	12	12	55	
Total	12	3	35	18	24	92	

Table 60: Chi-squared test of cross-section counts (Grouped) for Grand Meadow Chert end scrapers by phase

Phase	Cross Section				
	Hemi-spherical	Rectangular/ Trapezoidal	Triangular/ Scalene	Total	P-Value
Spring Creek	5	14	18	37	0.855443861
Blue Earth	7	24	24	55	
Total	12	38	42	92	

Table 61: Chi-squared test of longitudinal thickness orientation counts for Grand Meadow Chert end scrapers by lithic material

Phase	Longitudinal Thickness Orientation				
	Center	Left	Right	Total	P-Value
Spring Creek	25	6	7	38	0.864391347
Blue Earth	37	10	8	55	
Total	62	16	15	93	

Table 62: Chi-squared test of latitudinal thickness orientation counts for Grand Meadow Chert end scrapers by lithic material

Phase	Latitudinal Thickness Orientation				
	Distal	Middle	Proximal	Total	P-Value
Spring Creek	27	11	0	38	0.141649654
Blue Earth	33	17	5	55	
Total	60	28	5	93	

Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase contexts are broken at nearly equal rates, occurring about 34 to 35 percent of the time (Table 63). The orientation of breaks does differ between the phases, however, 92 percent of the broken Grand Meadow Chert end scrapers from Spring Creek phase sites having perpendicularly oriented breaks and about 47 percent of broken Grand Meadow Chert end scrapers from Blue Earth phase sites having perpendicularly oriented breaks (Table 64). About 42 percent of the broken Grand Meadow Chert end scrapers from Blue Earth phase sites have obliquely oriented breaks. No statistically significant difference exists between the phases with regards to the frequencies of breaks and break orientations.

Table 63: Chi-squared test of break presence counts for Grand Meadow Chert end scrapers by phase

Phase	Break Presence			
	Yes	No	Total	P-Value
Spring Creek	13	25	38	0.973338432
Blue Earth	19	36	55	
Total	32	61	93	

Table 64: Chi-squared test of break orientation counts for Grand Meadow Chert end scrapers by phase

Phase	Break Orientation					
	None	Perpendicular	Oblique	Multiple	Total	P-Value
Spring Creek	25	12	1	0	38	0.072460621
Blue Earth	36	9	8	2	55	
Total	61	21	9	2	93	

Fifty of the Grand Meadow Chert end scrapers from Blue Earth phase sites and 34 from Spring Creek phase sites have complete distal working-faces. The basic dimensions of distal working-faces are very similar between Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites. The mean width of the distal working-faces of Grand Meadow Chert end scrapers is about 18 mm for both phases (Table 65 and Figure 46), and the mean length of the distal working-faces of Grand Meadow Chert end scrapers is about 3.5 mm for both phases (Table 66 and Figure 47). The coefficient of variance is higher in both cases for Grand Meadow Chert end scrapers from Blue Earth phase sites (about 16 versus 14 percent for width and 38 versus 23 percent for length). The mean length to width ratio of the distal working-faces of Grand Meadow Chert end scrapers is also very similar between the phases, having a mean of about 0.2 in both cases (Table 67 and Figure 48), but the coefficient of variance is higher for Grand Meadow Chert end scrapers from Blue Earth phase sites (about 30 versus 21 percent). The location of the maximum length of the distal working-face relative to the width is fairly centered in both cases, Grand Meadow Chert end scrapers from Spring Creek phase sites having a mean maximum length location of about 0.51 and those from Blue Earth phase sites having a mean maximum length location of about 0.53 (Table 68 and Figure 49). The coefficient of variance with regards to the location of the maximum length of the distal working-face is slightly higher for Grand Meadow Chert end scrapers form Blue Earth phase sites than those from Spring Creek phase sites (about 18 versus 16 percent). No statistically significant difference exists between the phases with regards to the basic dimensions of the distal working-face. The edge of the distal working-face of Grand Meadow Chert end scrapers are undercut at a higher rate at Spring Creek phase sites than at Blue Earth phase sites: at least half of the edge of the distal working-face is undercut on about 21 percent of the Grand Meadow Chert end scrapers from

Spring Creek phase sites and 16 percent of those from Blue Earth phase sites (Table 69). The difference in undercutting between the phases is not statistically significant, however.

Table 65: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face width (mm) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	18.20588235	Mean	17.78
Median	19	Median	18
Mode	19	Mode	16
SD	2.459113067	SD	2.816061804
CV	0.135072446	CV	0.158383678
Range	12	Range	12
Minimum	10	Minimum	12
Maximum	22	Maximum	24
Sum	619	Sum	889
Count	34	Count	50
F	1.311376416		
P(F<=f) one-tail	0.207086441		
F Critical one-tail	1.72677088		

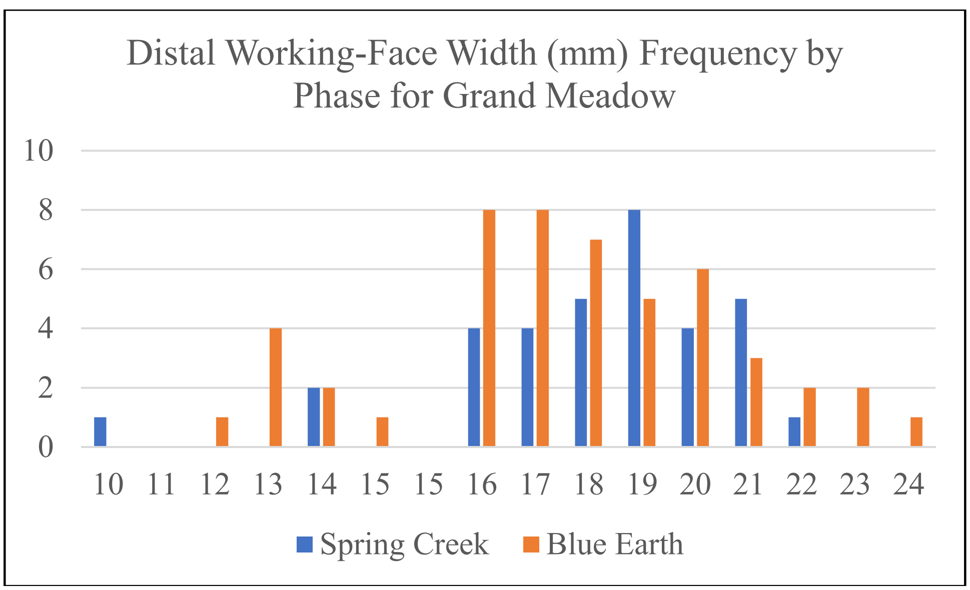

Figure 46: Histogram of Grand Meadow Chert end scraper distal working-face widths by phase

Table 66: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face length (mm) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	3.647058824	Mean	3.46
Median	4	Median	3
Mode	4	Mode	3
SD	0.848612163	SD	1.312576528
CV	0.23268398	CV	0.379357378
Range	4	Range	8
Minimum	1	Minimum	0
Maximum	5	Maximum	8
Sum	124	Sum	173
Count	34	Count	50
F	2.39238331		
P(F<=f) one-tail	0.004788882		
F Critical one-tail	1.72677088		

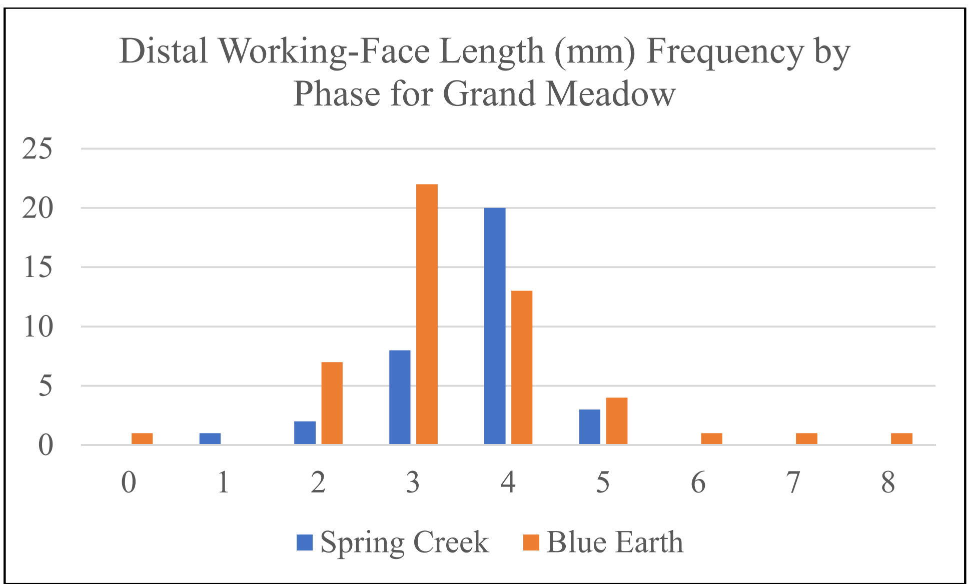

Figure 47: Histogram of Grand Meadow Chert end scraper distal working-face lengths by phase

Table 67: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face length to width ratio by phase

Spring Creek Phase		Blue Earth Phase	
Mean	0.200294118	Mean	0.1958
Median	0.205	Median	0.185
Mode	0.21	Mode	0.18
SD	0.042030674	SD	0.059387692
CV	0.209844774	CV	0.303307926
Range	0.18	Range	0.33
Minimum	0.1	Minimum	0
Maximum	0.28	Maximum	0.33
Sum	6.81	Sum	9.79
Count	34	Count	50
F	1.996458055		
P(F<=f) one-tail	0.019179696		
F Critical one-tail	1.72677088		

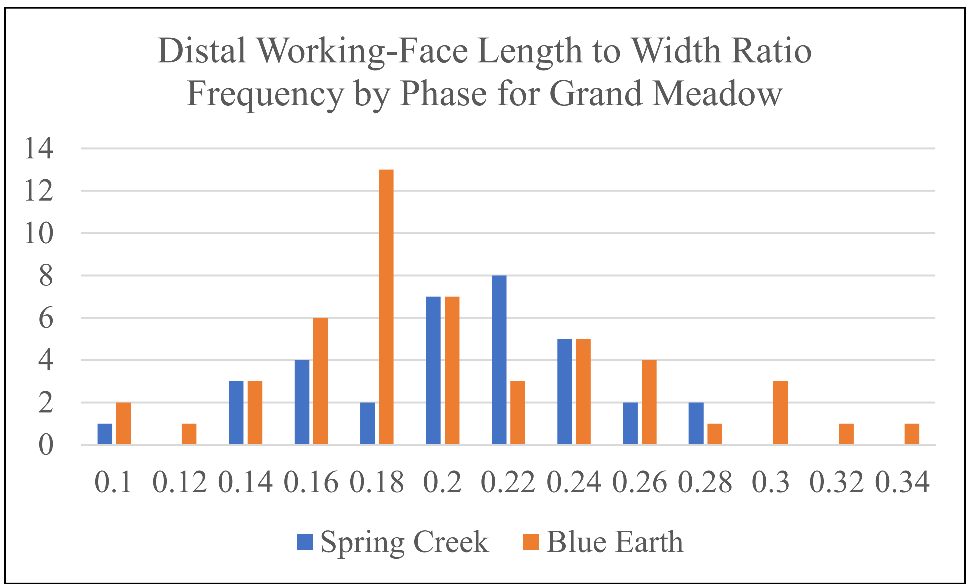

Figure 48: Histogram of Grand Meadow Chert end scraper distal working-face length to width ratios by phase

Table 68: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face maximum length location to width ratio

Spring Creek Phase		Blue Earth Phase	
Mean	0.508235294	Mean	0.5274
Median	0.5	Median	0.51
Mode	0.5	Mode	0.5
SD	0.078873531	SD	0.097348731
CV	0.155190975	CV	0.18458235
Range	0.39	Range	0.44
Minimum	0.29	Minimum	0.37
Maximum	0.68	Maximum	0.81
Sum	17.28	Sum	26.37
Count	34	Count	50
F	1.523344144		
P(F<=f) one-tail	0.101926244		
F Critical one-tail	1.72677088		

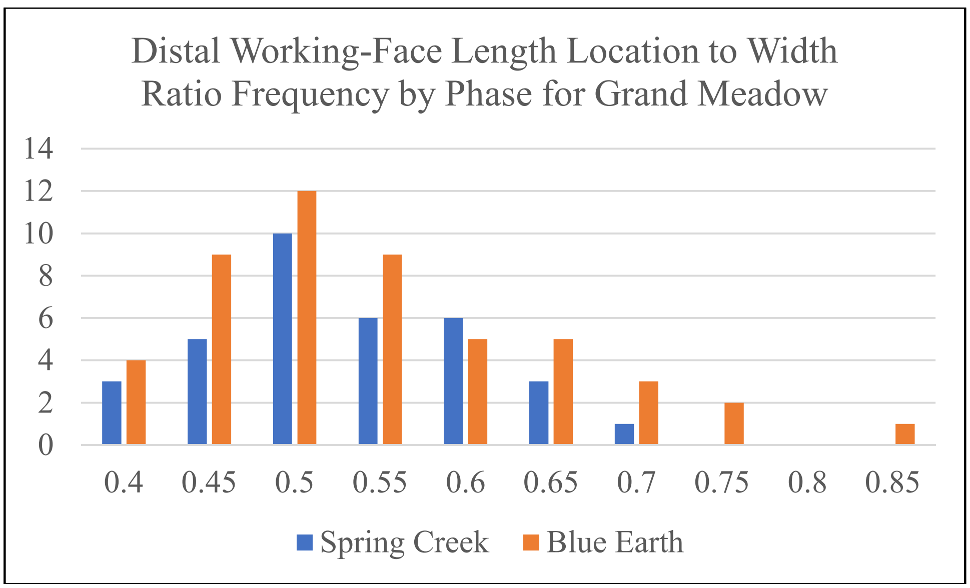

Figure 49: Histogram of Grand Meadow Chert end scraper distal working-face maximum length location to width ratios by phase

Table 69: Chi-squared test of distal edge undercutting presence counts for Grand Meadow Chert end scrapers by phase

Phase	Edge Morphology			
	Even	Undercut	Total	P-Value
Spring Creek	27	7	34	0.589928948
Blue Earth	42	8	50	
Total	70	16	86	

The angles and lengths of retouch on the distal-working face of Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites are similar. The grand mean of the lengths of retouch on the distal working-face is slightly larger (about 6.4 mm versus 5.8 mm) for Grand Meadow Chert end scrapers from Blue Earth phase sites than those from Spring Creek phase sites (Table 70 and Figure 50). The grand mean of the angles of retouch on the distal working-face of Grand Meadow Chert end scrapers, at about 67 degrees, is nearly equal between phases (Table 71 and Figure 51). For both grand means, the coefficient of variance is higher in the case of Grand Meadow Chert end scrapers from Blue Earth phase sites (about 28 versus 23 percent for length and 13 versus 11 percent for angle). The coefficients of variance of the retouch length and angle means that relate to the three individual points along the distal working-face measured are higher in every instance for Grand Meadow Chert end scrapers from Blue Earth phase sites, except in the case of retouch length on the left portion of the distal working-face (Tables 72 through 77 and Figures 52 through 53). Within phases, the portion of the distal working-face with the lowest coefficient of variance with regards to the length and angle of retouch is central in both instances. The central portion of the distal working-face also has the highest retouch length and angle means within phase in both instances.

Table 70: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face retouch length (mm) by phase

Spring Creek Phase		Blue Earth Phase	
Grand Mean	5.782941176	Grand Mean	6.3916
Median	5.87	Median	6.205
Mode	5.54	Mode	4.69
SD	1.313379932	SD	1.759495939
CV	0.227112795	CV	0.275282549
Range	6.16	Range	7.56
Minimum	3.04	Minimum	3.19
Maximum	9.2	Maximum	10.75
Sum	196.62	Sum	319.58
Count	34	Count	50
F	1.794716211		
P(F<=f) one-tail	0.039293032		
F Critical one-tail	1.72677088		

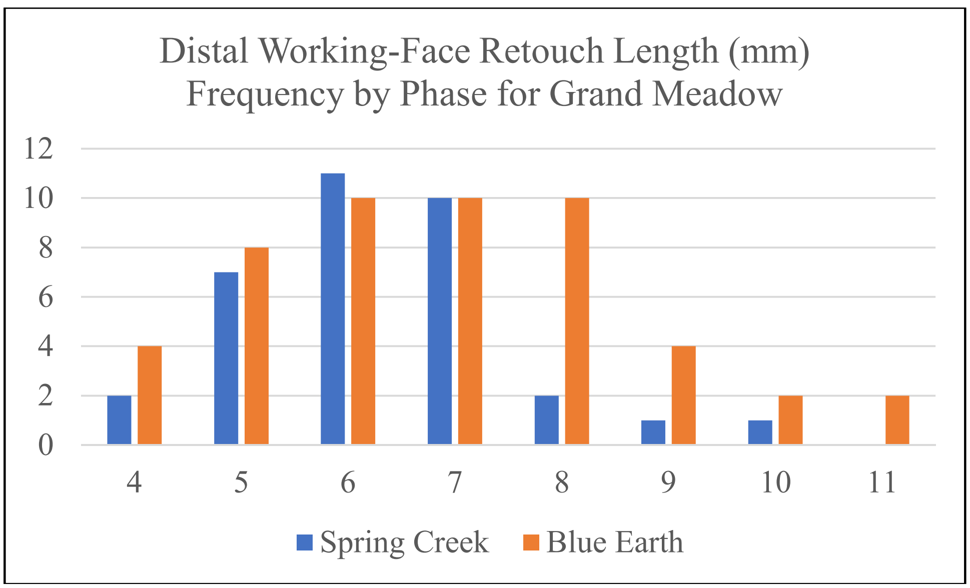

Figure 50: Histogram of Grand Meadow Chert end scraper distal working-face retouch lengths by phase (grand mean)

Table 71: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face retouch angle (degrees) by phase

Spring Creek Phase		Blue Earth Phase	
Grand Mean	67.44117647	Grand Mean	67.34
Median	67.5	Median	66.5
Mode	74	Mode	59
SD	7.118866	SD	8.726244721
CV	0.10555667	CV	0.129584864
Range	30	Range	45
Minimum	51	Minimum	49
Maximum	81	Maximum	94
Sum	2293	Sum	3367
Count	34	Count	50
F	1.502564557		
P(F<=f) one-tail	0.109475222		
F Critical one-tail	1.72677088		

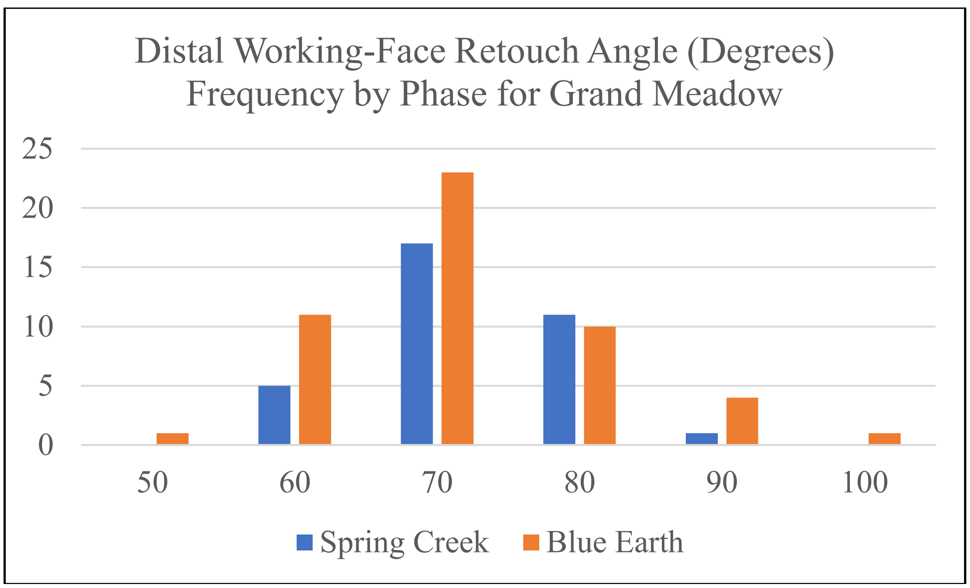

Figure 51: Histogram of Grand Meadow Chert end scraper distal working-face retouch angles by phase (grand mean)

Table 72: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face (left portion) retouch length (mm) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	5.480294118	Mean	5.9982
Median	5.35	Median	5.61
Mode	4	Mode	5.59
SD	1.595139369	SD	1.732429802
CV	0.291068205	CV	0.288824948
Range	6.94	Range	7.96
Minimum	2.45	Minimum	3.06
Maximum	9.39	Maximum	11.02
Sum	186.33	Sum	299.91
Count	34	Count	50
F	1.17954367		
P(F<=f) one-tail	0.311539537		
F Critical one-tail	1.72677088		

Table 73: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face (left portion) retouch angle (degrees) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	67.29411765	Mean	66.9
Median	67	Median	65
Mode	58	Mode	65
SD	8.864397335	SD	10.51772071
CV	0.131726184	CV	0.157215556
Range	38	Range	54
Minimum	51	Minimum	46
Maximum	89	Maximum	100
Sum	2288	Sum	3345
Count	34	Count	50
F	1.407812574		
P(F<=f) one-tail	0.15092009		
F Critical one-tail	1.72677088		

Table 74: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face (central portion) retouch length (mm) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	6.134117647	Mean	6.9344
Median	6.285	Median	7.105
Mode	6.5	Mode	7.98
SD	1.633397867	SD	2.000516423
CV	0.266280818	CV	0.288491639
Range	8.2	Range	8.83
Minimum	2.25	Minimum	2.92
Maximum	10.45	Maximum	11.75
Sum	208.56	Sum	346.72
Count	34	Count	50
F	1.500031136		
P(F<=f) one-tail	0.110430522		
F Critical one-tail	1.72677088		

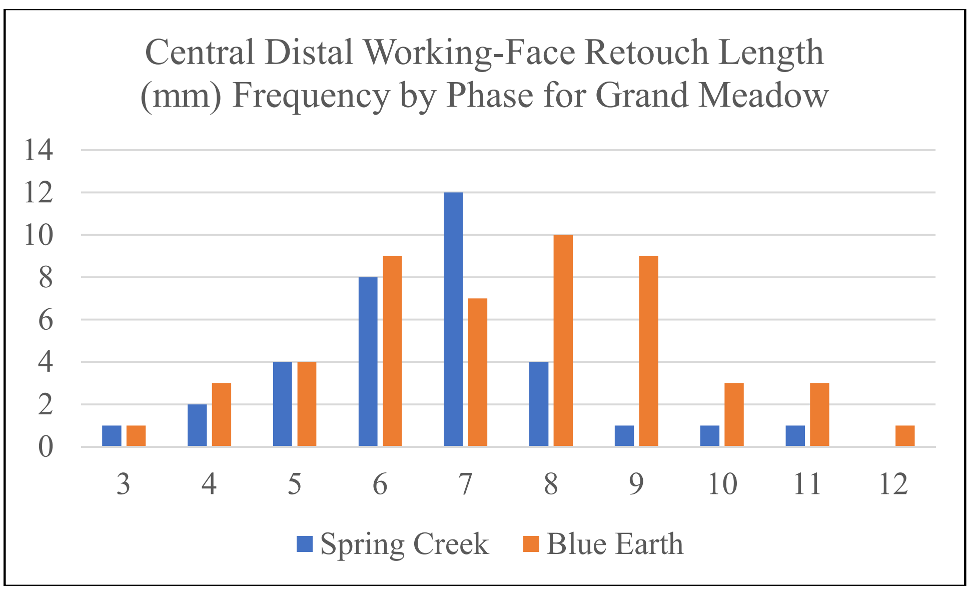

Figure 52: Histogram of Grand Meadow Chert end scraper distal working-face retouch lengths by phase (central portion)

Table 75: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face (central portion) retouch angle (degrees) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	71.70588235	Mean	68.92
Median	72	Median	67.5
Mode	77	Mode	60
SD	8.84386249	SD	9.432553272
CV	0.123335244	CV	0.136862352
Range	40	Range	46
Minimum	50	Minimum	51
Maximum	90	Maximum	97
Sum	2438	Sum	3446
Count	34	Count	50
F	1.137560676		
P(F<=f) one-tail	0.352117618		
F Critical one-tail	1.72677088		

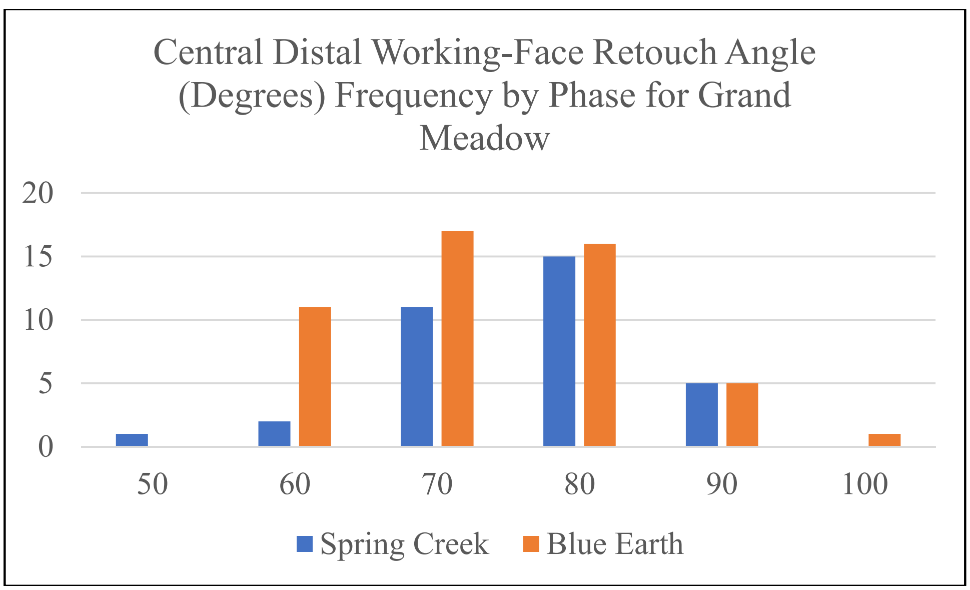

Figure 53: Histogram of Grand Meadow Chert end scraper distal working-face retouch angles by phase (central portion)

Table 76: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face (right portion) retouch length (mm) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	5.733235294	Mean	6.2434
Median	5.57	Median	5.97
Mode	N/A	Mode	N/A
SD	1.530422244	SD	2.198096217
CV	0.266938677	CV	0.352067178
Range	5.75	Range	9.72
Minimum	3.08	Minimum	2.42
Maximum	8.83	Maximum	12.14
Sum	194.93	Sum	312.17
Count	34	Count	50
F	2.062865244		
P(F<=f) one-tail	0.015156937		
F Critical one-tail	1.72677088		

Table 77: Summary and associated F-test for Grand Meadow Chert end scraper distal working-face (right portion) retouch angle (degrees) by phase

Spring Creek Phase		Blue Earth Phase	
Mean	64.20588235	Mean	67.04
Median	64.5	Median	67
Mode	63	Mode	67
SD	8.534349176	SD	11.25213812
CV	0.132921609	CV	0.167842156
Range	33	Range	58
Minimum	47	Minimum	38
Maximum	80	Maximum	96
Sum	2183	Sum	3352
Count	34	Count	50
F	1.738318265		
P(F<=f) one-tail	0.047996658		
F Critical one-tail	1.72677088		

Because of the overall similarity of Grand Meadow Chert end scrapers from Blue Earth phase and Spring Creek phase sites, end scrapers from the phases are combined in the following correlation matrices. Eighty-four of the Grand Meadow Chert end scrapers from sites associated with the two phases have complete distal working-faces. A correlation matrix of the lengths and angles of retouch on different portions of the distal working-face of Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites is presented in Table 78. The angles of retouch on the distal working-face of end scrapers are not strongly correlated with the lengths of retouch. The lengths and angles of retouch on the left and right portions of the distal working-face are more correlated with those measures for the central portion than with each other. The length of retouch on the right and left portions both have a correlation coefficient of about 0.7 with the length of retouch on the central portion, while having a correlation coefficient of about 0.54 with each other. The angle of retouch on the right and left portions have correlation coefficients of about 0.53 and 0.73, respectively, while having a correlation coefficient of about 0.3 with each other.

Table 78: Correlation matrix of distal working-face retouch lengths and angles by portion for Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites

	Mean Length	Left Length	Central Length	Right Length	Left Angle	Central Angle	Right Angle	Mean Angle
Mean Length	1							
Left Length	0.8385	1						
Central Length	0.9153	0.6968	1					
Right Length	0.8642	0.5373	0.6957	1				
Left Angle	-0.0574	0.0188	0.0167	-0.1744	1			
Central Angle	-0.0584	-0.0501	-0.0043	-0.0974	0.7284	1		
Right Angle	-0.0182	-0.0738	0.0655	-0.0444	0.3034	0.5325	1	
Mean Angle	-0.0553	-0.0448	0.0315	-0.1286	0.8149	0.9054	0.7533	1

Sixty of the Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites are unbroken and have complete distal working-faces. A correlation matrix of distal working-face measurements and the basic dimensions of the 60 unbroken Grand Meadow Chert end scrapers is presented in Table 79. The length of retouch on the central portion of the distal working-face is most strongly correlated with artifact thickness, with correlation coefficient of about 0.78, while the angle of retouch on the central portion of the distal working-face is not strongly correlated with any of the other measurements. The width of the distal working-face is most strongly correlated (coefficient of about 0.94) with the width of the end scraper and the length of the distal working-face (coefficient of about 0.66). The location of the maximum length of the distal working-face is not strongly correlated with any of the other measurements. There are also no strong correlations amongst the basic dimensions of end scrapers. Artifact length is the basic dimension most strongly correlated with weight (coefficient of about 0.7504), while width and thickness are about equally correlated with weight (coefficients of about 0.6).

Table 79: Correlation matrix of distal working-face measurements and basic artifact dimensions for Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites

	Cent Dist Ret Leng	Cent Dist Ret Ang	Dist WF Width	Dist WF Leng	Dist WF Leng Loc	Art Leng	Art Width	Art Thick	Art Wght
Cent Dist Ret Leng	1								
Cent Dist Ret Ang	0.2045	1							
Dist WF Width	0.2638	0.1195	1						
Dist WF Leng	0.2307	-0.0148	0.6586	1					
Dist WF Leng Loc	-0.323	-0.3373	-0.1732	-0.2357	1				
Art Leng	0.059	0.1683	0.1809	0.2661	-0.1301	1			
Art Width	0.2845	0.2467	0.9374	0.6007	-0.1904	0.2891	1		
Art Thick	0.7811	0.334	0.2632	0.2545	-0.2934	0.2239	0.3334	1	
Art Weight	0.4253	0.2434	0.5057	0.5258	-0.2251	0.7504	0.6406	0.6297	1

Thirty-two Grand Meadow Chert end scrapers from the Spring Creek phase and Blue Earth phase sites have bulbs of percussion and complete platforms. A correlation matrix of bulb of percussion, platform, and ventral curvature measurements of the 32 Grand Meadow Chert end scrapers is presented in Table 80. Ventral curvature is not strongly correlated with bulb of percussion thickness or any of the platform measurements. A fairly strong correlation exists between platform area and bulb of percussion thickness (coefficient of about 0.65).

Table 80: Correlation matrix of platform, bulb of percussion, and ventral curvature measurements for Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites

	Platform Angle	Platform Area	Platform Thickness	Platform Width	Platform T-W	Bulb Thickness	Ventral Curvature
Platform Angle	1						
Platform Area	0.4469	1					
Platform Thick	0.4227	0.9642	1				
Platform Width	0.5003	0.9256	0.8261	1			
Platform T-W	0.1265	0.4844	0.6831	0.1721	1		
Bulb Thick	0.3306	0.6535	0.6805	0.5791	0.5016	1	
Ventral Curvature	0.0044	0.2751	0.2376	0.2725	0.1113	0.0891	1

Sixteen Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites have bulbs of percussion and complete eraillure scars. A correlation matrix of bulb of percussion, eraillure scar, and ventral curvature measurements of the 16 Grand Meadow Chert end scrapers is presented in Table 81. The strongest correlation between bulb of percussion, eraillure scar, and ventral curvature measurements is between eraillure scar area and bulb of percussion thickness (coefficient of about 0.49).

Table 81: Correlation matrix of eraillure scar, bulb of percussion, and ventral curvature measurements for Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites

	Eraillure Area	Eraillure Width	Eraillure Length	Eraillure W-L	Bulb Thickness	Ventral Curvature
Eraillure Area	1					
Eraillure Width	0.9582	1				
Eraillure Length	0.9065	0.8138	1			
Eraillure W-L	0.2095	0.4355	-0.1424	1		
Bulb Thickness	0.4947	0.3974	0.4204	0.1301	1	
Ventral Curvature	0.2348	0.1887	0.0982	0.0951	0.2733	1

Forty-one of the Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites have lateral retouch on both dorsal edges and are unbroken. A correlation matrix of dorsal lateral retouch measurements and basic artifact dimensions is presented in Table 82. The strongest correlation between dorsal lateral retouch and the basic dimensions of an end scraper occurs for artifact thickness and right lateral retouch length (coefficient of about 0.44), followed by artifact thickness and left lateral retouch length (coefficient of about 0.32).

Table 82: Correlation matrix of dorsal lateral retouch measurements and basic dimensions for Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites

	Left Ret Leng	Right Ret Leng	Left Ret Ang	Right Ret Ang	Left Ret %	Right Ret %	Art Leng	Art Width	Art W-L	Art Thick	Art Wgt
Left Ret Leng	1										
Right Ret Leng	0.2673	1									
Left Ret Ang	-0.128	-0.026	1								
Right Ret Ang	-0.127	-0.139	0.3139	1							
Left Ret %	0.1017	0.0114	-0.13	-0.062	1						
Right Ret %	0.1348	0.3066	0.2146	-0.029	0.2039	1					
Art Leng	-0.041	-0.198	-0.198	-0.178	-0.181	-0.252	1				
Art Width	-0.11	0.0089	0.0531	0.0316	-0.259	-0.196	0.1642	1			
Art W-L	-0.166	0.0709	0.1837	0.1931	0.1335	0.1501	-0.811	0.2854	1		
Art Thick	0.3177	0.4444	0.1652	0.2694	-0.185	-0.023	-0.002	0.3052	-0.04	1	
Art Wgt	0.0818	0.0829	0.0431	0.1901	-0.245	-0.223	0.6489	0.5803	-0.367	0.5901	1

Blue Earth Phase, Spring Creek Phase, and Woodland Tradition End Scrapers

A total of 14 comparative tests are made with end scrapers from Blue Earth phase, Spring Creek phase, and Woodland tradition. To achieve a 0.05 significance level for the data set, a corrected (Sidak) significance level of 0.003657 is used per individual comparison. A total of 145 end scrapers are compared in this section; 61 of which are from Blue Earth phase sites, 69 of which are from Spring Creek phase sites, and 15 of which are from Woodland tradition sites. Sixty-six of the Spring Creek phase end scrapers, 58 of the Blue Earth phase end scrapers, and 15 of the Woodland tradition end scrapers were complete enough to confidently assign a planview. In each case the majority of end scrapers are triangular in planview, followed by tapered, rectangular, and then ovate (Table 83). About 90 percent of all end scrapers are triangular or tapered in planview (Table 84). There is no statistically significant difference amongst the phases and tradition with regards to planview.

Table 83: Chi-squared test of planview counts for end scrapers by phase/tradition

Phase/	Planview					
Tradition	Ovate	Rectangular	Tapered	Triangular	Total	P-Value
Spring Creek	2	6	25	33	66	0.974119259
Blue Earth	1	7	20	30	58	
Woodland	0	1	6	8	15	
Total	3	14	51	71	139	

Table 84: Chi-squared test of planview counts (grouped) for end scrapers by phase/tradition

Phase/	Planview			
Tradition	Ovate/Rectangular	Tapered/Triangular	Total	P-Value
Spring Creek	8	58	66	0.753806508
Blue Earth	8	50	58	
Woodland	1	14	15	
Total	17	122	139	

Sixty-four end scrapers from Spring Creek phase sites, 49 from Blue Earth phase sites, and 14 from Woodland tradition sites are complete or lacking in breaks that impact the outline of the lateral edges. The angles from the distal-right corner to the proximal-right corner and distal-left corner to proximal-left corner of the artifacts planview are very similar for Spring Creek phase and Blue Earth phase end scrapers, both with means around 80 (left edge) and 77 (right edge) degrees (Tables 85 through 86 and Figures 54 through 55). The angles of the lateral edges are slightly narrower on the end scrapers associated with the woodland sites: the mean angle from the distal-right to proximal-right corner is about 76 degrees, and the mean angle from the distal-left corner to proximal-right corner is about 72 degrees. A similar pattern follows for the curvature of lateral edges: the means of the angles at the maximum protrusions (deviations) along the lateral edges of end scrapers from Spring Creek phase and Blue Earth phase sites are about 163 degrees for the left edge and 169 degrees for the right edge in both cases, while the means of the same measurements for Woodland tradition end scrapers are about 162 degrees for the left edge and 159 degrees for the right edge (Tables 87 through 88 and Figures 56 through 57). None of the differences amongst the Spring Creek phase, Blue Earth phase, and Woodland tradition in terms of lateral planview angles are statistically significant, however.

Table 85: Summary and associated one-way ANOVA test of distal corner to proximal corner angle (degrees) for the left edge planview of end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	79.84375	Mean	79.85714	Mean	75.57143	
Median	79	Median	80	Median	78	
Mode	79	Mode	84	Mode	90	
SD	8.779881	SD	7.390873	SD	10.17322	
CV	0.109963	CV	0.092551	CV	0.134617	
Range	37	Range	32	Range	32	
Minimum	62	Minimum	66	Minimum	58	
Maximum	99	Maximum	98	Maximum	90	
Sum	5110	Sum	3913	Sum	1058	
Count	64	Count	49	Count	14	
Source	SS	df	MS	F	P-value	F crit
Between	227.9922	2	113.9961	1.601964	0.205642	3.069286
Within	8823.866	124	71.16021			
Total	9051.858	126				

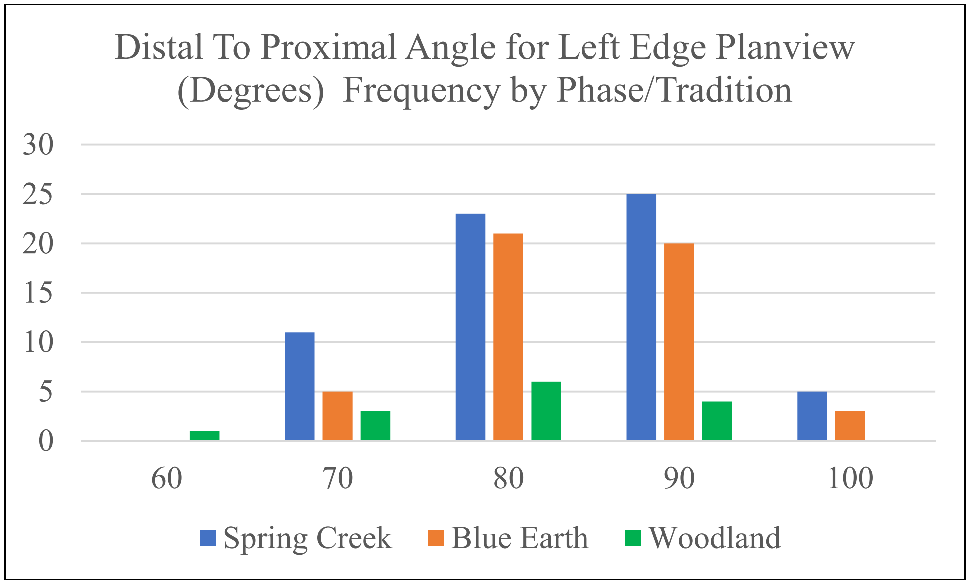

Figure 54: Histogram of distal to proximal angles for the left edge planviews of end scrapers by phase/tradition

Table 86: Summary and associated one-way ANOVA test of distal corner to proximal corner angle (degrees) for the right edge planview of end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	77.20313	Mean	77.12245	Mean	72.35714	
Median	75.5	Median	77	Median	71.5	
Mode	81	Mode	76	Mode	67	
SD	8.866165	SD	9.494807	SD	6.777873	
CV	0.114842	CV	0.123113	CV	0.093672	
Range	46	Range	41	Range	22	
Minimum	61	Minimum	55	Minimum	62	
Maximum	107	Maximum	96	Maximum	84	
Sum	4941	Sum	3779	Sum	1013	
Count	64	Count	49	Count	14	
Source	SS	df	MS	F	P-value	F crit
Between	288.4996	2	144.2498	1.811002	0.167788	3.069286
Within	9876.839	124	79.65193			
Total	10165.34	126				

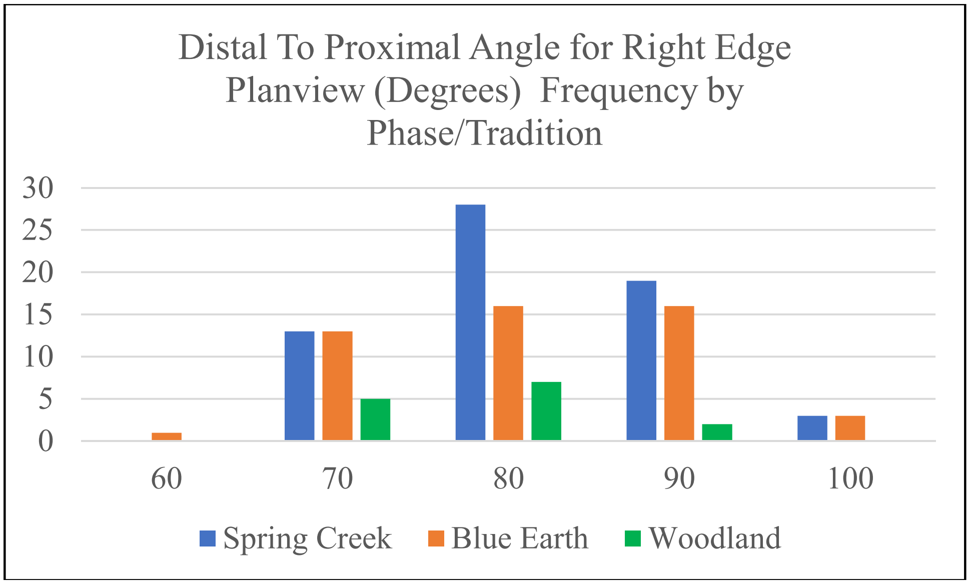

Figure 55: Histogram of distal to proximal angles for the left edge planviews of end scrapers by phase/tradition

Table 87: Summary and associated one-way ANOVA test of the angle (degrees) at the maximum deviation along the left edge of end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	163.5781	Mean	162.8367	Mean	162	
Median	163	Median	162	Median	159	
Mode	180	Mode	180	Mode	180	
SD	15.65583	SD	14.71868	SD	13.83418	
CV	0.095709	CV	0.090389	CV	0.085396	
Range	60	Range	49	Range	42	
Minimum	120	Minimum	131	Minimum	138	
Maximum	180	Maximum	180	Maximum	180	
Sum	10469	Sum	7979	Sum	2268	
Count	64	Count	49	Count	14	
Source	SS	df	MS	F	P-value	F crit
Between	34.92509	2	17.46255	0.076438	0.926454	3.069286
Within	28328.3	124	228.4541			
Total	28363.23	126				

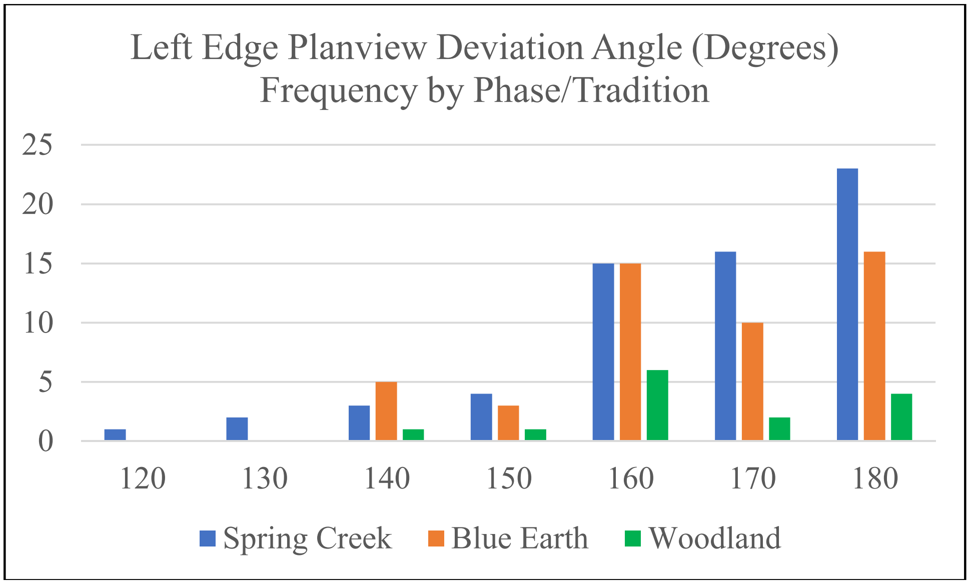

Figure 56: Histogram of angles at the maximum deviation along the left edge of end scrapers by phase/tradition

Table 88: Summary and associated one-way ANOVA test of the angle (degrees) at the maximum deviation along the right edge of end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	168.7813	Mean	169.0816	Mean	159.4286	
Median	176	Median	170	Median	153	
Mode	180	Mode	180	Mode	180	
SD	13.02192	SD	11.786	SD	14.35653	
CV	0.077153	CV	0.069706	CV	0.09005	
Range	52	Range	41	Range	37	
Minimum	128	Minimum	139	Minimum	143	
Maximum	180	Maximum	180	Maximum	180	
Sum	10802	Sum	8285	Sum	2232	
Count	64	Count	49	Count	14	
Source	SS	df	MS	F	P-value	F crit
Between	1122.685	2	561.3424	3.475104	0.034006	3.069286
Within	20030.04	124	161.5326			
Total	21152.72	126				

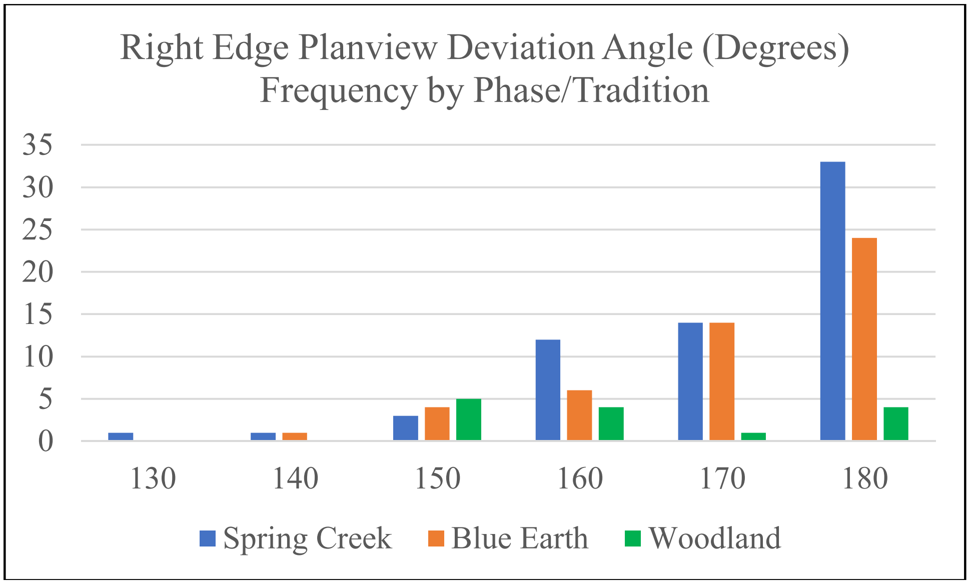

Figure 57: Histogram of angles at the maximum deviation along the right edge of end scrapers by phase/tradition

Retouch is present along at least one dorsal lateral edge of end scrapers about 90 percent of the time for the Spring Creek phase, Blue Earth phase, and Woodland tradition taken separately or together (Table 89). About 70 percent of the Woodland tradition and Blue Earth phase end scrapers have retouch present on both dorsal lateral edges, while the percentage is about 60 percent for Spring Creek phase end scrapers (Table 90). In neither case is the difference statistically significant. Forty-two of the Spring Creek phase, 38 of the Blue Earth phase, and 12 of the Woodland tradition end scrapers with dorsal lateral retouch have complete lateral edges. The percentage of edge retouched varies from about 60 to 80 percent for both dorsal lateral edges and all phases/traditions, and there is no statistically significant difference amongst the samples (Tables 91 and 92). When present, the length of lateral retouch usually ranges from about two to six millimeters for both dorsal lateral edges and all phases/traditions, and there is no statistically significant difference amongst the samples (Tables 93 and 94). The angles of dorsal lateral edge retouch on end scrapers from Spring Creek phase and Blue Earth phase sites both have grand means of about 60 degrees for both edges (Tables 95 and 96). The grand means for the left and right dorsal lateral edges of Woodland tradition end scrapers, at around 55 degrees apiece, are slightly more acute. The differences in dorsal lateral edge retouch angles are not statistically significant, however.

Table 89: Chi-squared test of dorsal lateral retouch presence (at least one edge) counts for end scrapers by phase/tradition

Phase/	Presence			
Tradition	Yes	No	Total	P-Value
Spring Creek	63	6	69	0.806197
Blue Earth	54	7	61	
Woodland	13	2	15	
Total	130	15	145	

Table 90: Chi-squared test of dorsal lateral retouch location counts for end scrapers by phase/tradition

Phase/	Edge					
Tradition	Both	Left	Right	None	Total	P-Value
Spring Creek	41	10	12	6	69	0.293724
Blue Earth	45	4	5	7	61	
Woodland	11	0	2	2	15	
Total	97	14	19	15	145	

Table 91: Summary and associated one-way ANOVA test of dorsal left lateral retouch percentage for end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	61.59524	Mean	76.13158	Mean	69.66667	
Median	80	Median	100	Median	100	
Mode	100	Mode	100	Mode	100	
SD	41.51289	SD	36.18509	SD	42.57258	
CV	0.673963	CV	0.475297	CV	0.61109	
Range	100	Range	100	Range	100	
Minimum	0	Minimum	0	Minimum	0	
Maximum	100	Maximum	100	Maximum	100	
Sum	2587	Sum	2893	Sum	836	
Count	42	Count	38	Count	12	
Source	SS	df	MS	F	P-value	F crit
Between	4229.742	2	2114.871	1.353745	0.263537	3.09887
Within	139039.1	89	1562.237			
Total	143268.9	91				

Table 92: Summary and associated one-way ANOVA test of dorsal right lateral retouch percentage for end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	75.2619	Mean	68.10526	Mean	81.41667	
Median	100	Median	91.5	Median	100	
Mode	100	Mode	100	Mode	100	
SD	37.40227	SD	37.95288	SD	30.67264	
CV	0.496962	CV	0.557268	CV	0.376737	
Range	100	Range	100	Range	100	
Minimum	0	Minimum	0	Minimum	0	
Maximum	100	Maximum	100	Maximum	100	
Sum	3161	Sum	2588	Sum	977	
Count	42	Count	38	Count	12	
Source	SS	df	MS	F	P-value	F crit
Between	1974.298	2	987.1492	0.726081	0.486645	3.09887
Within	121000.6	89	1359.557			
Total	122974.9	91				

Table 93: Summary and associated one-way ANOVA test of dorsal left lateral retouch length (mm) for end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
GrandMean	3.996078	GrandMean	4.538367	GrandMean	3.887273	
Median	3.54	Median	4.1	Median	3.56	
Mode	1.99	Mode	5.33	Mode	N/A	
SD	1.826198	SD	1.846304	SD	1.607595	
CV	0.456998	CV	0.406821	CV	0.413553	
Range	8.42	Range	7.78	Range	6.02	
Minimum	1.45	Minimum	1.45	Minimum	1.21	
Maximum	9.87	Maximum	9.23	Maximum	7.23	
Sum	203.8	Sum	222.38	Sum	42.76	
Count	51	Count	49	Count	11	
Source	SS	df	MS	F	P-value	F crit
Between	8.739061	2	4.36953	1.324777	0.270147	3.080387
Within	356.2179	108	3.298314			
Total	364.957	110				

Table 94: Summary and associated one-way ANOVA test of dorsal right lateral retouch length (mm) for end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	4.133019	Mean	4.4182	Mean	3.824615	
Median	3.96	Median	4.175	Median	3.03	
Mode	5.2	Mode	5.06	Mode	N/A	
SD	1.778313	SD	2.166561	SD	2.460588	
CV	0.43027	CV	0.490372	CV	0.643356	
Range	6.27	Range	9.33	Range	7.33	
Minimum	1.32	Minimum	1.01	Minimum	1.73	
Maximum	7.59	Maximum	10.34	Maximum	9.06	
Sum	219.05	Sum	220.91	Sum	49.72	
Count	53	Count	50	Count	13	
Source	SS	df	MS	F	P-value	F crit
Between	4.397201	2	2.198601	0.531877	0.588965	3.076574
Within	467.104	113	4.133664			
Total	471.5012	115				

Table 95: Summary and associated one-way ANOVA test of dorsal left lateral retouch angle (degrees) for end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	61.27451	Mean	58.14286	Mean	55.63636	
Median	61	Median	59	Median	56	
Mode	55	Mode	60	Mode	56	
SD	7.820686	SD	8.306624	SD	7.632467	
CV	0.127634	CV	0.142866	CV	0.137185	
Range	42	Range	43	Range	26	
Minimum	41	Minimum	38	Minimum	43	
Maximum	83	Maximum	81	Maximum	69	
Sum	3125	Sum	2849	Sum	612	
Count	51	Count	49	Count	11	
Source	SS	df	MS	F	P-value	F crit
Between	411.9643	2	205.9822	3.19963	0.044671	3.080387
Within	6952.702	108	64.37687			
Total	7364.667	110				

Table 96: Summary and associated one-way ANOVA test of dorsal right lateral retouch angle (degrees) for end scrapers by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	61.11321	Mean	59.26	Mean	54.61538	
Median	61	Median	61	Median	57	
Mode	67	Mode	62	Mode	57	
SD	8.679464	SD	8.939274	SD	9.482778	
CV	0.142023	CV	0.150848	CV	0.173628	
Range	43	Range	36	Range	33	
Minimum	41	Minimum	42	Minimum	35	
Maximum	84	Maximum	78	Maximum	68	
Sum	3239	Sum	2963	Sum	710	
Count	53	Count	50	Count	13	
Source	SS	df	MS	F	P-value	F crit
Between	450.1203	2	225.0601	2.853652	0.061795	3.076574
Within	8912.018	113	78.86741			
Total	9362.138	115				

Retouch along the ventral lateral edges is rare in the case of Spring Creek phase and Blue Earth phase end scrapers, occurring along at least one edge about five percent of the time in both cases (Table 97). Ventral lateral edge retouch is more common in the case of Woodland tradition end scrapers, occurring along at least one edge about 35 percent of the time. Although a low p-value was arrived at ($p<0.02$), the differences in the presence of ventral lateral retouch are not statistically significant.

Table 97: Chi-squared test of ventral lateral retouch presence (at least one edge) counts for end scrapers by phase/tradition

Phase/ Tradition	Presence			
	Yes	No	Total	P-Value
Spring Creek	4	65	69	0.012753
Blue Earth	3	58	61	
Woodland	4	11	15	
Total	11	134	145	

The location of the maximum length of the distal working-face tends to be centered to slightly off-centered-right for Spring Creek phase and Blue Earth phase end scrapers, while the same attribute tends to be centered to off-centered-left for those from Woodland tradition sites (Table 98 and Figure 58). The differences are not statistically significant, but a low p-value was arrived at ($p < 0.04$).

Table 98: Summary and associated one-way ANOVA test of end scraper distal working- face maximum length location to width ratio by phase/tradition

Spring Creek Phase		Blue Earth Phase		Woodland Tradition		
Mean	0.53127	Mean	0.526607	Mean	0.459286	
Median	0.52	Median	0.5	Median	0.47	
Mode	0.5	Mode	0.5	Mode	0.48	
SD	0.102603	SD	0.093464	SD	0.06627	
CV	0.193128	CV	0.177484	CV	0.14429	
Range	0.59	Range	0.44	Range	0.23	
Minimum	0.29	Minimum	0.37	Minimum	0.33	
Maximum	0.88	Maximum	0.81	Maximum	0.56	
Sum	33.47	Sum	29.49	Sum	6.43	
Count	63	Count	56	Count	14	
Source	SS	df	MS	F	P-value	F crit
Between	0.061656	2	0.030828	3.367047	0.037525	3.065839
Within	1.190247	130	0.009156			
Total	1.251902	132				

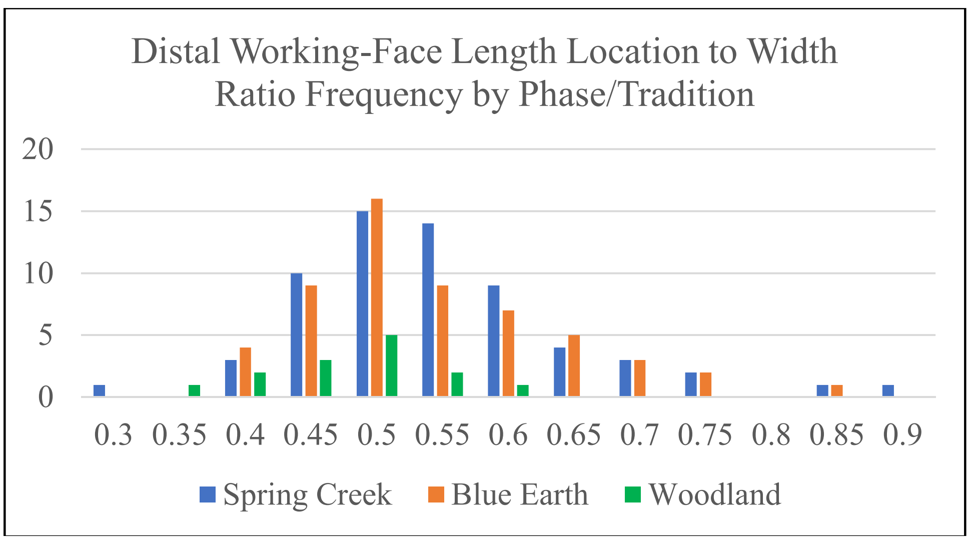

Figure 58: Histogram of Grand Meadow Chert end scraper distal working-face maximum length location to width ratios by phase

Chapter 6: Conclusions

Lithic Raw Materials

Grand Meadow Chert, a high-quality material that is known from a primary-source quarry (21MW8) located about 100 kilometers away from both the Blue Earth and Spring Creek phase sites, accounts for most, or about 68 percent, of the end scrapers studied in this thesis (see Bakken 2011 and Bakken in Morrow et al. 2016 for descriptions of the lithic materials discussed in this chapter). Consistent with Dobb's (1984) and Shane's (1982) observations, about 90 percent of the end scrapers included from Blue Earth phase sites are made of Grand Meadow Chert. A little over 50 percent of the end scrapers analyzed from Spring Creek phase sites are made from Grand Meadow Chert. Spring Creek phase sites are more like the Silvernale site (21GD3) with regards to the percentage of end scrapers made of Grand Meadow Chert than the Bryan site (21GD4), which has a percentage that more closely resembles that associated with Blue Earth phase sites (see Gibbon 1979 and Wendt 1985). The debitage profiles of the Silvernale and Bartron phase sites on the west side of the Mississippi River (see Fleming 2009) are more similar to Blue Earth phase sites than Spring Creek phase sites in terms of Grand Meadow Chert: Silvernale, Bartron, and Blue Earth phase sites typically have debitage assemblages that are 25 to 50 percent Grand Meadow Chert, while the percentage is closer to 10 percent for the Spring Creek phase (Koncur 2018).

Projectile points, the next most common type of formal chipped-stone tool found at sites of both phases, are made from Grand Meadow Chert less often than end scrapers: about 20 percent of projectiles points from Spring Creek phase sites and 30 percent from Blue Earth phase sites are made of Grand Meadow Chert, while half or more from both phases are made of Prairie du Chien Chert (see Dobbs 1984 and Koncur 2018). This contrasts with Silvernale and Bartron phase sites on the west side of the Mississiippi River, which usually have more even amounts of Grand Meadow Chert and Prairirie du Chien Chert projectile points (Wendt 2000). Taking the percentages of projectile points and end scrapers made of Grand Meadow Chert in tandem, a clear preference for Grand Meadow Chert in the use and manufacture of end scrapers is evident for both the Spring Creek phase and Blue Earth phase. Further, when comparing lithic raw material frequencies for end scrapers and projectile points amongst the Blue Earth, Spring Creek, Bartron, and Silvernale phases, the factors associated with the preference appear to have increased in intensity or relevance between the earlier (i.e., Bartron and Silvernale) and later (i.e., Spring Creek and Blue Earth) phases. The preference for Grand Meadow Chert end scrapers may also extend further back in time, as the material is also the most represented amongst the Woodland tradition end scrapers included in this work, but, without corollary percentages for projectile points from the sites, the preference cannot be argued for as strongly. The preference for Grand Meadow Chert end scrapers likely relates to the quality of the material, the predictability of the source, and the economic pressures related to the use of end scrapers in hide-working. Further, the high proportion of end scrapers made of Grand Meadow Chert relative to other tool types suggests that end scraper manufacture was not expedient in terms of raw material selection or a biproduct of the creation of other stone tool-types but, rather, a discrete and specific (to the tool-type) process (see Ruth 2013).

Following Grand Meadow Chert, Prairie du Chien Chert is the next most commonly represented lithic raw material amongst the end scrapers from Spring Creek phase and Blue Earth phase sites. Prairie du Chien Chert accounts for a higher percentage of the end scrapers from Spring Creek phase sites than from Blue Earth phase sites, accounting for about 36 percent and 5 percent of the totals, respectively. Prairie du Chien Chert comprises the largest proportion of the lithic debitage assemblages associated with both phases, amounting to around half of the debitage from Blue Earth phase sites and about 80 percent of the debitage from Spring Creek phase sites (see Dobbs 1984 and Koncur 2018). Both primary and secondary sources of Prairie du Chien Chert are accessible within the Red Wing region, while only secondary deposits of the material are available within and between the Center and Willow Creek localities. Cherts collected from secondary deposits are typically of poorer quality than those mined from primary sources. That only one of the 13 Prairie du Chien Chert end scrapers with cortex associated with the Spring Creek phase appears weathered, suggests the Prairie du Chien Chert used for end scrapers at Spring Creek phase sites was most often from primary deposits. Although primary sources of high quality Prairie du Chien Chert have been located in the Spring Creek Valley, no quarries associated with the material have been discovered within the Red Wing region (Wendt 2014). Primary sources of Prairie du Chert are located about 30 kilometers north of the Willow Creek locality, around the junction of the Blue Earth and Minnesota rivers. The Prairie du Chien Chert utilized at the localities appears to have been acquired from gravel deposits within adjacent portions of the Blue Earth River Valley, rather than from primary sources to the north, however (see Ready in Dobbs 1984:85-86). None of the Blue Earth phase, Prairie du Chien Chert end scrapers analyzed had cortex present, making it difficult to directly address Ready's hypothesis in this work. If most of the Prairie du Chien Chert used at Blue Earth phase sites was from secondary deposits, it is comparable to the category of till-derived for Spring Creek phase sites.

About six percent of the Spring Creek phase end scrapers are made of a till-derived chert, which is about equal to the percentage of Blue Earth phase end scrapers made of Prairie du Chien Chert. The frequencies of end scrapers made of locally available materials at Spring Creek and Blue Earth phase sites reflect the outcomes of decisions based, partially, on the desirability of Grand Meadow Chert for end scraper manufacture, the cost of travel for quarrying activities, and the quality of locally available lithic materials. Low quality, locally available lithic materials (e.g., till-derived) were almost never used for end scrapers at Spring Creek or Blue Earth phase sites. Even when a lithic material of moderate to good quality was available locally (i.e., primary deposits of Prairie du Chien Chert within the Red Wing region), Grand Meadow Chert was still used most often in the manufacture of end scrapers. Further, in the case of the Blue Earth phase, primary deposits of Prairie du Chien Chert were more than three-times closer than those of Grand Meadow Chert but were never or hardly utilized for end scraper manufacture.

A small number (about three percent) of the end scrapers from Spring Creek phase sites are made of Galena Chert, a material found about 100 kilometers to the south-southeast of the Red Wing region. Galena Chert is a moderate to good quality lithic material and is distributed fairly widely throughout its source-area in southeastern Minnesota, in and near Fillmore County. The low frequency of Galena Chert end scrapers at Spring Creek phase sites is notable when compared to the frequency of Grand Meadow Chert end scrapers, as sources of Galena Chert are present along or near likely routes between the Red Wing region and Grand Meadow quarry (21MW8). Galena Chert debitage also occurs in very low numbers at Spring Creek phase sites: for example, only two pieces of Galena Chert debitage are associated with 21GD258 (Koncur 2018). This further supports that Grand Meadow Chert was preferred by the inhabitants of Spring Creek phase sites for the manufacture of end scrapers, even when compared to moderate to good quality non-local materials, and suggests, as well, that direct trips were made to and back from 21MW8 for the specific purpose of Grand Meadow Chert extraction.

One of the end scrapers (project number 74) associated with the Blue Earth phase for which a specific lithic raw material type was not identified is made of a highly fossiliferous material, likely originating from southwestern Iowa or adjacent areas in Missouri, Kansas, or Nebraska. The presence of the lithic material connects the Blue Earth phase to the expansion of the Oneota tradition into the Central Plains from the 13th through 14th centuries (Ritterbush 2002). The presence of one other distantly sourced raw material, Knife River Flint, in the sample of analyzed end scrapers is also notable. Slightly over a quarter of the included Woodland tradition end scrapers are made of Knife River Flint, which is a high quality lithic material that originates in western North Dakota. The high proportion of end scrapers made of Knife River Flint at 21NL30 and 21NLw/x is suggestive of a Middle Woodland component, as the regional exchange of the material peaked in this period (Clark 1984).

Grand Meadow versus Prairie du Chien End Scrapers from Spring Creek phase Sites

The only statistically significant difference found between Grand Meadow Chert and Prairie du Chien Chert end scrapers from Spring Creek phase sites relates to weight: Prairie du Chien Chert end scrapers are more than a gram heavier on average than Grand Meadow Chert end scrapers. Prairie du Chien Chert end scrapers are also longer, wider, and thicker on average than Grand Meadow Chert end scrapers. The differences between the lithic materials with regards to end scraper dimensions are not statistically significant, however, although low p-values were arrived at for some of the comparisons of variance. The coefficients of variance associated with the measurements of end scraper weight, length, width, and thickness are also higher in every case for those made of Prairie du Chien Chert. The difference between coefficients of variance for weight, at more than 20 percent, is the most pronounced.

No statistically significant differences were found between Grand Meadow Chert and Prairie du Chien Chert end scrapers from Spring Creek phase sites with regards to attributes that relate to initial reduction; however, some slight trends are evident. The platforms of Grand Meadow Chert end scrapers are ground at a higher rate (about 72 versus 55 percent) and are more varied in terms of faceting than those of Prairie du Chien Chert end scrapers. The bulbs of percussion and eraillure facets associated with Prairie du Chien Chert end scrapers are larger on average than those on end scrapers made of Grand Meadow Chert. The differences that relate to platform grinding and faceting, as well as bulb of percussion and eraillure facet sizes, might be the result of the materials being approached slightly differently and/or the different physical properties of the materials. Also, Prairie du Chien Chert end scrapers tend to have fewer primary facets, and the associated primary facets tend to be more level with the ventral surface than those on Grand Meadow Chert end scrapers. Differences in the number of primary facets and the associated angles might relate to differences in the shape of the raw materials: the flatter shape of some Prairie du Chien Chert nodules could result in end scrapers with fewer, as surface area increases with curvature, and more level facets. Overall, the general similarities between Grand Meadow Chert and Prairie du Chien Chert end scrapers with regards to attributes that relate to initial reduction may indicate that the residents of Spring Creek phase sites were selecting specific pieces of Prairie du Chien Chert (i.e., those that more closely resembled Grand Meadow Chert in terms of shape and consistency) for end scraper manufacture.

The smaller size of the Grand Meadow Chert compared to Prairie du Chien Chert end scrapers at Spring Creek phase sites may be, at least partially, related to a slightly more intensive/exhaustive (i.e., curative) use of the Grand Meadow Chert end scrapers. The angles of retouch on the distal working-faces of Grand Meadow Chert and Prairie du Chien Chert end scrapers are very similar, each having a grand mean of a little less than 70 degrees. However, Grand Meadow Chert end scrapers have undercut distal edges (about 21 versus 13 percent) and distally located maximum thicknesses (about 70 versus 56 percent) more often than Prairie du Chien Chert end scrapers, but the differences are not statistically significant. Prairie du Chien Chert end scrapers tend to be broken at a higher rate (about 48 versus 34 percent) and in more varied orientations than those made of Grand Meadow Chert, but the differences are, again, not statistically significant.

Grand Meadow Chert end scrapers from Spring Creek phase sites appear to be more curated than the Prairie du Chien counterparts by some measures (e.g., distal edge undercutting and latitudinal thickness orientation), and some trends are apparent with regards to attributes that relate to initial reduction (e.g., platform preparation, primary facets, bulb of percussion and eraillure scar sizes). However, none of the differences in terms of attributes that relate most directly to curation and initial reduction are statistically significant. As such, the difference in the sizes of end scrapers made from the two materials is likely most related to how the physical properties of the materials themselves impact initial reduction, rather than to a more thorough exhaustion of Grand Meadow Chert end scrapers through use or a drastic difference in the methods of initial reduction employed between the materials. Prairie du Chien Chert is more variable than Grand Meadow Chert in terms of quality, size, and shape: Prairie du Chien Chert occurs in tabular, spherical, and amorphous nodules up to about 30 cm thick, as well as boulders that are larger (see Figures 59 and 60), while Grand Meadow Chert occurs as spherical and cylindrical nodules up to about 25 cm thick, as well as pebbles that are smaller. Further, Prairie du Chien Chert often contains numerous faults, cavities, and cracks, while Grand Meadow Chert is typically free of internal flaws. The differences in the inherent properties of the materials appear to impact end scraper morphology generally, in terms of the magnitudes and variations of size, but not in any more descriptive ways that are consistent (e.g., planview and cross-section).

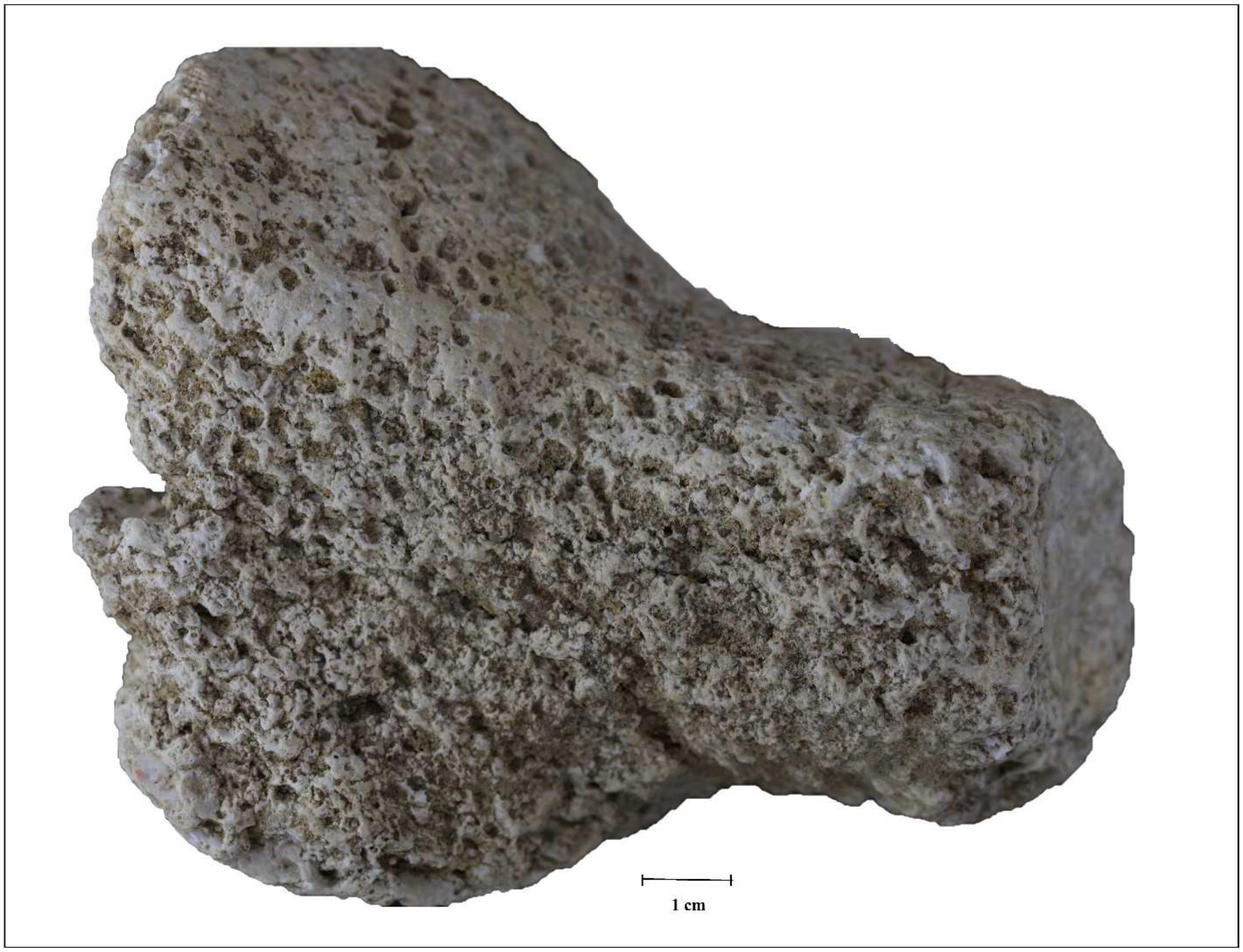

Figure 59: Amorphous nodule of Prairie du Chien Chert from the Blue Earth River Valley

Figure 60: Prairie du Chien Chert boulder from the Spring Creek Valley

Blue Earth Phase versus Spring Creek Phase Grand Meadow End Scrapers

The only statistically significant difference found between Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase sites relates to weight: Grand Meadow Chert end scrapers from Blue Earth phase sites are about a gram heavier than those from Spring Creek phase sites on average. The Grand Meadow Chert end scrapers from Blue Earth phase sites are also longer and thicker on average than those from Spring Creek phase sites, but the differences are not statistically significant, although low p-values were arrived at in some instances. The mean widths of Grand Meadow Chert end scrapers from both phases are very similar, differing by less than a millimeter. Grand Meadow Chert end scrapers from the Blue Earth phase sites have higher coefficients of variance in terms of length, width, thickness, and weight compared to Grand Meadow Chert end scrapers from Spring Creek phase sites. The lowest coefficients of variance for the basic dimensions of Grand Meadow Chert end scrapers occur for width in the case of both phases. Combined with the similarity in end scrapers widths between the phases, this suggests that fairly strong and similar constraints impacted end scraper widths from both phases (e.g., constraints associated with hafting).

No statistically significant differences were found between Grand Meadow Chert end scrapers from Blue Earth and Spring Creek phase sites in terms of measurements related to initial reduction. Platform and other initial reduction attributes, such as the number of primary facets, are very similar between the phases. Spring Creek phase end scrapers made of Grand Meadow Chert do have higher frequencies of ground platforms (about 72 versus 62 percent) compared to those from Blue Earth phase sites, but the difference is not statistically significant. Blue Earth phase end scrapers tend to have larger bulbs of percussion and eraillure facets, but the difference is also not statistically significant. Although a low p-value was arrived at for the difference in eraillure scar areas between the phases, the coefficient of variance exceeds 100 for the eraillure scar areas of Grand Meadow Chert end scrapers from Blue Earth phase sites, suggesting that this attribute requires larger sample-sizes to compare. Eraillure scars are slightly more common on end scrapers with bulbs of percussion from Spring Creek phase sites, occurring about 39 percent of the time compared to around 28 percent of time at Blue Earth phase sites. Heat treatment is rare in the case of Grand Meadow end scrapers, occurring about nine percent of the time at Blue Earth phase sites and three percent of the time at Spring Creek phase sites, but the difference is not statistically significant. However, as the low-temperature heat treatment of Grand Meadow Chert can be difficult to detect, heat treatment is likely underrepresented by the presented percentages (Dan Wendt, personal communication 2018). A notable, yet statistically insignificant, trend is also apparent with regards to cortex: cortex is present on about 58 percent of the Spring Creek end scrapers and 42 percent of the Blue Earth end scrapers. Further, of the end scrapers with cortex present, about a quarter of those from Spring Creek phase sites and 17 percent of those from Blue Earth phase sites are completely, excluding retouched edges, covered by cortex on the dorsal surface. All stages of reduction are represented for Grand Meadow Chert at Blue Earth and Spring Creek phase sites, as illustrated by the within-phase diversity in attributes such as interior platform angle, cortex presence, and primary facet counts. This, along with the high frequencies of Grand Meadow Chert artifacts in general, suggests that the residents of sites associated with both phases had direct access to the Grand Meadow Quarry (21MW8). Further, the initial reduction attributes are consistent with the transportation of un- or lightly modified nodules from 21MW8 to the respective sites, suggesting that trips were made to the quarry specifically for the raw material and little time was spent between the quarry and the Oneota sites studied in this work.

The angles of retouch on the distal working-faces of Grand Meadow Chert end scrapers are very similar between the phases, each having a grand mean of a little less than 70 degrees. Grand Meadow Chert end scrapers from Spring Creek phase sites are undercut at a slightly higher rate (about 21 versus 16 percent) than those from Blue Earth phase sites, however, but the difference is not statistically significant. No statistically significant difference exists between the phases with regards to the rate at which the maximum thicknesses of end scrapers are located distally, which is about 71 percent of the time for the Spring Creek phase and 60 percent of the time for the Blue Earth phase. Grand Meadow Chert end scrapers from both phases are broken about 35 percent of the time, but the orientations of breaks vary more for those from Blue Earth phase sites. A little over 90 percent of the Grand Meadow Chert end scrapers from Spring Creek phase sites are broken perpendicularly relative to the artifacts width, while the percentage is a little less than 50 for Grand Meadow Chert end scrapers from Blue Earth phase sites, which are broken obliquely at about the same rate. The difference in break orientations, however, is not statistically significant, although a low p-value was arrived at.

Although some differences exist that may suggest Grand Meadow Chert end scrapers from Spring Creek phase sites are more curated than those from Blue Earth phase sites, such as those that relate to distal-edge undercutting and the location of maximum thickness, none are statistically significant and, therefore, the differences in the sizes of Grand Meadow Chert end scrapers between the phases is not likely due to large variations in curation. Also, as all stages of reduction are represented for Grand Meadow Chert at sites of both phases, the differences in end scraper sizes are probably not due to variations in the degree to which Grand Meadow Chert was reduced between the quarry and sites associated with the phases. Other factors that may explain the differences in Grand Meadow Chert end scraper sizes between the phases include a conscious attempt to more conservatively reduce Grand Meadow Chert at Spring Creek phase sites, an unconscious tendency to more conservatively reduce Grand Meadow Chert at Spring Creek sites, or the selection of larger nodules of Grand Meadow Chert by residents of Blue Earth phase sites. If residents of Blue Earth phase sites were more selective in terms of Grand Meadow Chert nodule-size, a larger investment of time and effort into quarrying activities would be expected.

The tendency for Grand Meadow Chert end scrapers from Spring Creek phase sites to have ground platforms and eraillure facets more often than those from Blue Earth phase sites, as well as the typically larger bulbs of percussion and eraillure facets on Grand Meadow Chert end scrapers from Blue Earth phase sites, is consistent with a conscious or unconscious attempt at the conservation of Grand Meadow Chert at the Spring Creek phase sites. However, none of the differences are statistically significant, and, if Grand Meadow Chert was consciously reduced more conservatively at Spring Creek phase sites, an increase in the frequency of heat treatment relative to end scrapers from Blue Earth phase sites, which does not appear to be the case, might be expected. If there are conscious differences between residents of Spring Creek and Blue Earth phase sites in the way in which Grand Meadow Chert is reduced, the variations in attributes that relate to initial reduction are suggestive of the practice of a more specialized reduction technique, involving softer hammers and more deliberate applications of force, at Spring Creek phase sites compared to Blue Earth phase sites.

If residents of Blue Earth phase sites were more selective with regards to the size of Grand Meadow Chert nodules transported from 21MW8 (i.e., they selected larger nodules), cortex presence-frequencies and amount should be higher for the Spring Creek phase. This is, indeed, the case, but the differences are not statistically significant. An in-depth look at Grand Meadow Chert debitage from Blue Earth and Spring Creek phase sites would shed light on the question, but, because of differences in cataloging methodology, the assemblages of debitage from sites associated with the phases are not directly comparable at the present time. A quick comparison of the average weight of the pieces of Grand Meadow Chert debitage from 21FA2 (Blue Earth phase) and 21GD258 (Spring Creek phase), as presented in Dobbs (1984) and Koncur (2018), does show a large difference: the average weight of Grand Meadow Chert debitage from 21FA2 is about five and a half grams, while the average weight of Grand Meadow Chert debitage is about one and a half grams at 21GD258. However, without associated measurements of cortex presence and amount, the large difference in the average weight of Grand Meadow Chert debitage between the phases is consistent with both a conservation of the material at Spring Creek phase sites and the selection of larger nodules by the residents of Blue Earth phase sites.

If the differences between the phases with regards to Grand Meadow Chert end scrapers are related to both a more conservative use of the material by residents of Spring Creek phase sites and a selection of larger nodules by residents of Blue Earth phase sites, than it follows that Blue Earth phase groups invested more time/effort in quarrying activities and less of the same with regards to tool production (per individual tool) when compared to Spring Creek phase groups. This could relate to differences in travel costs: brief but frequent trips to the quarry may have been more imbedded in the lifeways of Spring Creek phase groups than in those of Blue Earth phase groups. It is also possible, however, that residents of sites associated with both phases typically made the same number of trips to the quarry in a given year (or that residents of Blue Earth phase sites made more trips), in which case the differences in nodule selection/material conservation, if they exists, might relate to a higher demand for large numbers of quality, quickly produced (when the material is at hand) end scrapers at Blue Earth phase sites compared to Spring Creek phase sites, indicating that the pressures/incentives associated with hide-products were stronger for Blue Earth phase groups. At minimum, the higher frequencies of Grand Meadow Chert end scrapers, projectiles, and debitage, as well as the larger size of the end scrapers and debitage made from the material, at Blue Earth phase sites when compared to Spring Creek phase sites suggests that larger quantities of Grand Meadow Chert were quarried, transported, and used by residents of Blue Earth phase sites. The differences in the quantity of Grand Meadow Chert at sites associated with both phases indicates that it is not likely that the 'travel costs' of going to the quarry were less for Spring Creek phase groups than for Blue Earth phase groups. As such, it may be that Blue Earth phase groups made more trips to the quarry every year than Spring Creek phase groups, indicating higher mobility on the part of the residents of Blue Earth phase sites.

Because Grand Meadow Chert end scrapers from Blue Earth phase and Spring Creek phase sites are so similar, measurements of end scrapers made of the material from sites associated with both phases are here combined in order to provide a general description of Grand Meadow Chert end scrapers from Oneota contexts in Southern Minnesota. The description provided in the proceeding paragraphs is synopsized in Table 99. Grand Meadow Chert end scrapers from Spring Creek and Blue Earth phase sites are typically about 15 to 20 mm long (though some are much longer), 16 to 20 mm wide, and 5 to 9 mm thick. The least variable of these measurements is width. The maximum thicknesses are typically located centrally and distally. Most of the Grand Meadow end scrapers from Spring Creek and Blue Earth phase contexts are tapered or triangular in planview and trapezoidal in cross-section, but triangular and scalene cross-sections are also common. Width to length ratios are most often one or a little less, indicating that the tools are often mostly expended.

Platform areas for Grand Meadow Chert end scrapers from Spring Creek and Blue Earth phase sites usually range from 10 to 50 mm^2, but most have areas of 20 to 30 mm^2. Most of the interior platform angles of Grand Meadow Chert end scrapers associated with the phases range from about 60 to 90 degrees, with the densest cluster of angles around 60 to 70 degrees. Platforms associated with Grand Meadow Chert end scrapers from Spring Creek and Blue Earth phase sites are most often ground, single-faceted, and centered to slightly off-centered relative to the artifacts width. The bulbs of percussion in the cases here of interest tend to be about four to eight millimeters thick, most of which are four to six millimeters thick. Eraillure facets are present on about half of the bulbs of percussion on end scrapers from Blue Earth and Spring Creek phase sites. The areas of eraillure scars vary widely, from about 10 to 160 mm^2, but most are about 20 to 30 mm^2.

About half of the Grand Meadow Chert end scrapers from Blue Earth and Spring Creek phase sites have some cortex present. When cortex is present, it is usually covers only a portion of the dorsal surface and is off-centered. The vast majority of the Blue Earth and Spring Creek phase Grand Meadow Chert end scrapers have one or two primary facets. The primary facets, when present, are always, at least in the sample studied, oriented parallel to the artifacts length. The angles of single primary facets, when only one is present, range from about 0 to 40 degrees on Grand Meadow Chert end scrapers associated with the phases, but most are around 20 degrees. The angles formed at the junction of two primary facets, when only two are present, range from about 100 to 160 degrees but are most often around 120 to 140 degrees.

The width of the distal working-face of Grand Meadow Chert end scrapers from Blue Earth and Spring Creek phase sites are usually equal to the artifacts width. The lengths of the distal working-faces range from about two to five millimeters and are most often three to four millimeters. The maximum lengths of the distal working-faces are typically centered and, if off-centered, are usually skewed right. Ratios of the length to width of the distal working-faces are most often about one-fifth. The grand means of the retouch angles on the distal working-face of Grand Meadow Chert end scrapers associated with the phases mostly range from 60 to 80 degrees, with most clustered around 70 degrees. The central portion of the distal working-face is most commonly the steepest portion with regards to retouch angle, as well as the least variable.

A fairly strong positive correlation exists between bulb of percussion thicknesses and platform areas, indicating that the two attributes may be similarly sensitive to certain reduction factors. A positive correlation also exists between eraillure scar areas and bulb of percussion thicknesses, but the correlation is less strong. There is a fairly strong positive correlation between the lengths and widths of the distal working-faces, indicating that the curvature of distal-working faces remained relatively constant regardless of changes to one of the dimensions. The angles of retouch on the distal working-faces of Grand Meadow Chert end scrapers from Blue Earth and Spring Creek phase sites are not strongly correlated with artifact lengths or thicknesses. This is notable because the relationship between the retouch angle of the distal working-face and curation (i.e., that steeper angles represent more heavily curated end scrapers) is premised on the notion that, as an end scraper is re-sharpened and its length shortened, the distal working-face is moved towards the thicker part of the artifact and it is thus more difficult to achieve the desired retouch angle. If this were the case with regards to Grand Meadow Chert end scrapers from the Oneota sites studied in this thesis, the retouch angles on the distal working-faces would be expected to get steeper with increases in artifact thicknesses and decreases in artifact lengths. The lengths of retouch on the distal working-faces of Grand Meadow Chert end scrapers are, however, strongly, positively correlated with artifact thicknesses. The angles of retouch on distal working-faces may have, thus, been kept relatively constant throughout the lives of end scrapers by increasing the length of retouch as the location of the tools maximum thickness moved distally. This suggests that, rather than distal working-face angles of around 70 degrees representing the maximum, functionally useful angle, angles around 70 degrees may have been desired throughout the life of an end scraper. In contrast, neither the length or angle of dorsal-lateral retouch is strongly correlated with artifact thickness.

Table 99: Typical values and ranges of measurements for Grand Meadow Chert end scrapers from Spring Creek phase and Blue Earth phase contexts

Attribute	Typical Value	Approximate Range
Artifact Length	15 to 20 mm	10 to 50 mm
Artifact Width	16 to 20 mm	15 to 25 mm
Artifact Thickness	5 to 9 mm (maximum located distally and centrally)	3.5 to 11 mm
Artifact Weight	2 to 6 g	1 to 12 g
Artifact Width to Length Ratio	0.8 to 1	0.5 to 1.5
Planview	Tapered or Triangular	N/A
Cross-Section	Trapezoidal (Scalene and Triangular forms also common)	N/A
Platform Area	20 to 30 mm^2	10 to 55 mm^2
Interior Platform Angle	60 to 70 deg	45 to 90 deg
Other Platform Attributes	Most are ground, single-faceted, and centered to slightly off-centered	N/A
Bulb of Percussion Thickness	4 to 6 mm	2.5 to 9 mm
Eraillure Scar Presence	Present on about 50% of the bulbs of percussion	N/A
Eraillure Scar Area	20 to 30 mm^2	10 to 160 mm^2
Cortex	Present on about 50% of end scrapers (usually partial and off-centered)	N/A
Primary Facet Count	1 or 2 (always oriented parallel to the length of the end scraper)	N/A
Primary Facet Angle for 1 Facet Artifact	20 deg	0 to 40 deg
Primary Facet Junction Angle for 2 Facet Artifact	120 to 140 deg	100 to 160 deg
Distal Working-Face Width	Same as artifact width	N/A
Distal Working-Face Length	3 to 4 mm (maximum located centrally or slightly off-centered to the right)	0 to 8 mm
Distal Working-Face Length to Width Ratio	0.2	0 to 0.3
Distal Working-Face Retouch Angle	70 deg (central portion steepest and least variable)	50 to 100 deg

Blue Earth Phase, Spring Creek Phase, and Woodland Tradition End Scrapers

No statistically significant differences were identified amongst end scrapers from Blue Earth phase, Spring Creek phase, and Woodland Tradition sites. However, some trends, indicated by low p-values, are evident. Although there are no significant differences amongst the phases and tradition with regards to planview (most from all the sites are tapered or triangular), the Woodland tradition end scrapers have, on average, slightly more acute distal-corner to proximal-corner angles (i.e., the Woodland tradition end scrapers are slightly more 'triangular'): the distal-corner to proximal corner angles for the left and right edges of end scrapers from the Spring Creek and Blue Earth phases are around 80 degrees, while the corresponding angles of Woodland tradition end scrapers are about 70 to 75 degrees. The difference between these angles is not statistically significant, however, and the p-values are not particularly low. The right lateral edges of the Woodland tradition end scrapers also tend to be more 'shouldered' than those of Blue Earth and Spring Creek phase end scrapers: the mean angle at the right lateral edge deviation is around 170 degrees for the Blue Earth phase and Spring Creek phase, while the same measurement has a mean of about 160 degrees for the Woodland tradition sites. Although the difference is not statistically significant, a low p-value was arrived at. The angles at the deviation on the left lateral edge have similar means, which are all a little over 160 degrees, amongst the phases and tradition. Note that 180 degree represents a lateral edge without a deviation. A number of the end scrapers from the two included Woodland tradition sites are presented in Figure 61.

Figure 61: End scrapers from 21NL30 and 21NLw/x (template created by Cory Nowak)

The vast majority, or about 90 percent, of the end scrapers from each of the phases and tradition have dorsal retouch present on at least one lateral edge. Dorsal retouch occurs on both lateral edges about 70 percent of the time for Blue Earth phase and Woodland tradition end scrapers and about 60 percent of the time for Spring Creek phase end scrapers. The difference between Blue Earth phase/Woodland tradition and Spring Creek phase end scrapers with regards to dorsal lateral retouch presence is not statistically significant. When dorsal retouch is present on the lateral edges, it covers, on average, all or most of the edge (about 60 to 80 percent) on end scrapers associated with both phases and the tradition. The lengths of dorsal lateral retouch when present, which range from about two to six millimeters, are similar for both edges and all phases/tradition. The mean angles of dorsal lateral retouch are about 60 degrees for both edges and phases. The mean angles of dorsal lateral retouch on Woodland tradition end scrapers are slightly more acute, at about 55 degrees for both edges. Although the differences in the retouch angles of the dorsal lateral edges are not statistical significant, low p-values were arrived at for the comparisons of measurements. The high rate of dorsal lateral retouch on end scrapers from both phases and the tradition suggests that the widths of the tool were intentionally narrowed due to some constraint (e.g., hafting).

Retouch on the ventral lateral edges of end scrapers from Spring Creek phase and Blue Earth phase sites is extremely rare, occurring about five percent of the time. Ventral lateral retouch on the Woodland tradition end scrapers, however, is fairly common, occurring about 35 percent of the time. When ventral lateral retouch is present on a Woodland tradition end scraper, it is often extensive (see Figure 62). Although the differences with regards to ventral lateral retouch presence are not statistically significant, a low p-value was arrived at for the comparison. The location of the maximum length of the distal working-face tends to be centered to slightly off-centered right for end scrapers from Blue Earth phase and Spring Creek phase sites, while the location of the maximum distal working-face length tends to be slightly off-centered left in the case of the Woodland tradition end scrapers. The difference in the location of the maximum distal working-face length is not statistically significant; however, a low p-value were arrived at for the comparison.

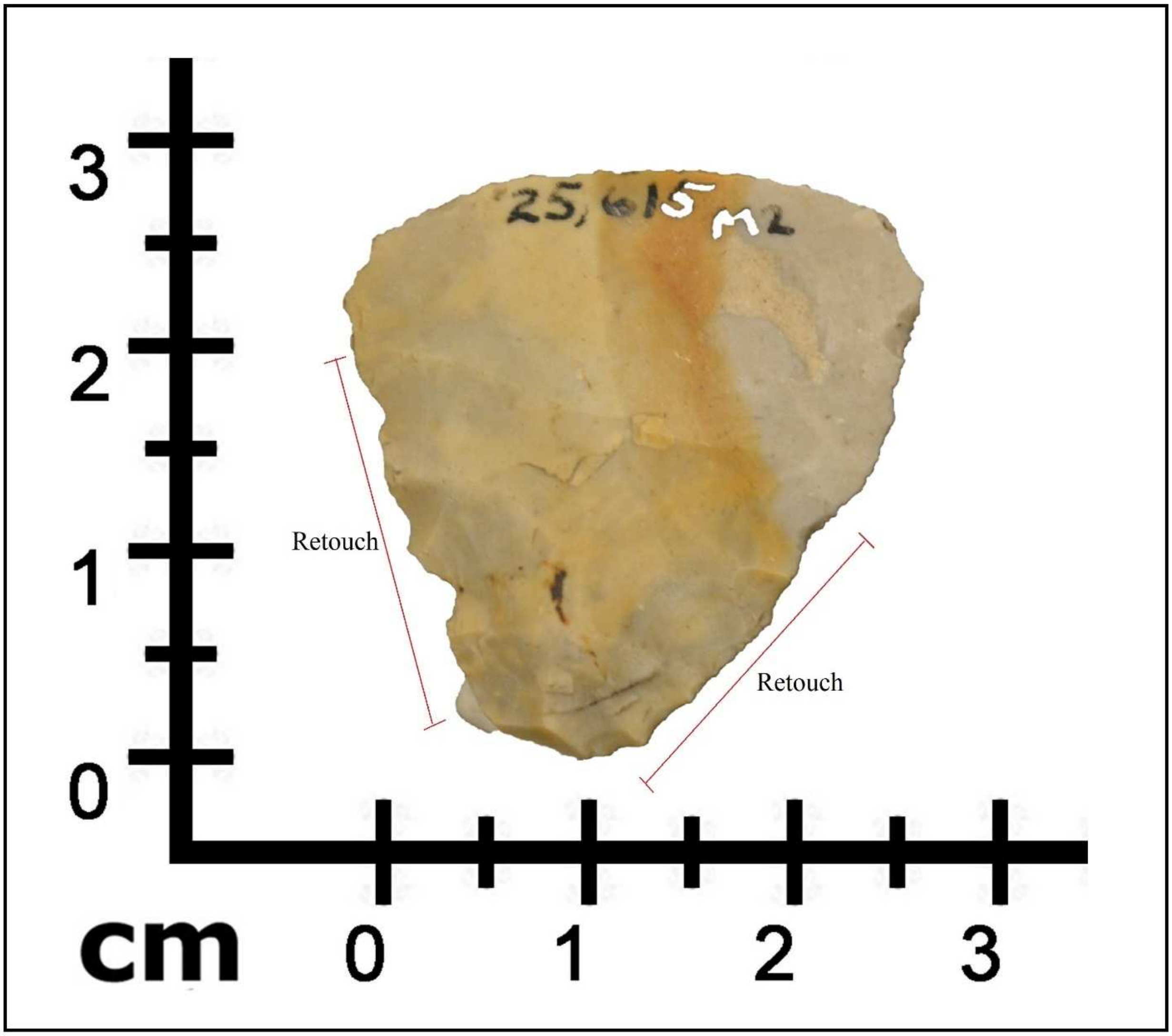

Figure 62: Ventral lateral retouch on a Woodland tradition end scraper (project number 65)

Although no statistically significant differences amongst Blue Earth phase, Spring Creek phase, and Woodland tradition end scrapers were found, several of the trends may be important. The much higher incidence of ventral lateral retouch on Woodland tradition end scrapers when compared to those from Blue Earth and Spring Creek phase sites suggests that greater constraints impacted the ventral surfaces of the Woodland tradition end scrapers in terms of ventral flatness and artifact thickness, which may relate to how the tools were hafted (i.e., the Woodland tradition end scrapers were hafted to a flatter surface). The tendency for Woodland tradition end scrapers to be slightly more triangular, shouldered, and to have more acute dorsal lateral retouch angles when compared to those from Spring Creek and Blue Earth phase sites may also suggest that the constraints impacting the lateral edges of end scrapers differed between the phases and tradition. Further, the difference in the location of the maximum length of the distal-working edge may relate to interwoven variations in the ways end scrapers are hafted and used (e.g., the angles at which the end scrapers are applied to and moved against a hide). Overall, although no statistically significant differences are present amongst the Spring Creek phase, Blue Earth phase, and Woodland tradition with regards to attributes that reflect end scraper hafting, the trends present indicate that Blue Earth phase and Spring Creek phase end scrapers are more similar to each other in this regard than either are to the Woodland tradition end scrapers.

Recommendations for Future Research

Detailed analyses of specific stone tool-types are time consuming and, by definition, specialized. Due to this, such analyses are often impractical in terms of cost effectiveness. Advances in 3D imaging and analysis will likely render the methods employed in this thesis and other specialized studies of stone tools obsolete within the near future, as well as decrease the cost and increase the frequency of such studies (see, for example, Gilboa et al. 2012; Grosman et al. 2008; Sholts et al. 2012). However, until that time, several attributes that are not typically measured on end scrapers within general analyses of assemblages may be worth consideration.

The length, width, thickness, and weight of end scrapers are amongst the standard measurements taken of the tool-type, and, as this research illustrated, such measurements are valuable in comparing assemblages. Within the sample of end scrapers analyzed for this work, width appears to be most related to lateral hafting constraints. The high proportion of end scrapers with lateral retouch along the dorsal edges supports this. The relationship of the width of an end scrapers and dorsal lateral retouch to hafting is not necessarily universal to the tool-type, however, and hafting constraints are not constant for end scrapers across time and space. As such, dorsal lateral retouch might be an attribute that is worth including in more general studies, especially as noting the presence/absence of it is methodologically simple. The presence/absence of ventral lateral retouch is also easy to determine and, as the attribute could be valuable in distinguishing between Woodland and Oneota tradition assemblages, may be worth including in general analyses as well. In terms of the overall shape of end scrapers, comparisons of the angles of the lateral edges relative to the distal edge did not reveal any definitively meaningful differences. It appears, thus, that the methodologically simpler measurement, planview shape, suffices to capture variations in this attribute.

Several attributes measured in this study remained fairly consistent across phases and traditions, such as the angle of retouch on distal working-faces and the length-to-width ratio of distal working-faces. The consistency of these attributes suggests that fairly strong constraints, likely related to function, were in operation with regards to these attributes. Said constraints appear to have been relatively constant with regards to the end scrapers here studied, and, therefore, large deviations away from the values arrived at for these attributes within other assemblages of end scrapers would be significant. A final end scraper attribute that may be worthy of inclusion in more general studies is the presence/absence of a platform. This attribute is valuable, not so much in what it reveals in and of itself, but in terms of denoting that other, more specific measurements can be taken on that particular artifact: the presence of platforms allows for the confident determination of the presence/absence of bulbs of percussion and eraillure facets, as well as the measurement of platform angles and other platform attributes (i.e., those relating to platform preparation).

Most of the end scrapers included in this study are made of Grand Meadow Chert. Due to the quality, consistency, and discrete source-area of the material, as well as the use of the material throughout southern Minnesota and adjacent areas over an extended period of time (Bakken 2011; Morrow et al. 2016), a study that focused on variations amongst Grand Meadow Chert end scrapers from different contexts in southern Minnesota would be valuable. Structuring a study of end scrapers within a specific lithic raw material type, especially one that has such consistent physical properties, would allow for the control of one of the main factors that impacts end scraper morphology (i.e., lithic raw material type). As such, the environmental and social factors that impact end scraper morphology would be more easily isolated and studied. The fact that the Grand Meadow Chert end scrapers from the Blue Earth phase and Spring Creek phase sites here studied are very similar suggests that any patterned differences found in such a study would be meaningful.

Patterns in the variations of end scrapers across broad spatial and temporal scales, much less smaller scales (e.g., between related phases or within a single site), have rarely been explicated in-depth. Although such patterns have been demonstrated in individual studies (e.g., Wendt 1985), no overall system exists within which these patterns can be compared. The dearth of knowledge with regards to end scraper pattering across time and space is starkly evident when compared to projectile points. As such, in order to form a foundation from which meaningful comparisons can be made amongst end scrapers from closely related assemblages, an analysis and comparison of end scrapers that are from widely separated, in terms of time and space, contexts would be valuable. Such a study would, ideally, begin by comparing end scrapers from very different contexts (e.g., Paleoindian west of the Rockies versus Eastern Woodland) and proceed by incorporating end scrapers from less and less disparate sources. In this way, broad patterns could be identified at large scales of comparison and progressively narrowed. A system thus formed would result in a better understanding of how social, environmental, temporal, and spatial factors impact end scraper variation, allowing for detailed analyses of individual end scraper assemblages to be conceptualized within a larger, more encompassing framework.

Bibliography

Ahler, S. A.

1989 Mass Analysis of Flaking Debris: Studying the Forest Rather Than the Tree. In *Alternative Approaches to Lithic Analysis*, edited by D. Henry and G. Odell, pp. 85-118. Archeological Papers, no. 1. American Anthropological Association, Arlington.

Anfinson, Scott

1984 Annual Report for the Minnesota Municipal and County Highway Archaeological Reconnaissance Study. The Minnesota Historical Society, St. Paul.

1985 Annual Report for the Minnesota Municipal and County Highway Archaeological Reconnaissance Study. The Minnesota Historical Society, St. Paul.

1986 Annual Report for the Minnesota Municipal and County Highway Archaeological Reconnaissance Study. The Minnesota Historical Society, St. Paul.

1997 Southwestern Minnesota Archaeology: 12,000 Years in the Prairie Lake Region. The Minnesota Historical Society Press, St. Paul.

Bakken, Kent E.

2011 Lithic Raw Material Use Patterns in Minnesota. Ph.D. Dissertation, Department of Anthropology, University of Minnesota, Minneapolis.

Barton, Michael C.

1990 Beyond Style and Function: A View from the Middle Paleolithic. American Anthropologist 92(1):57-72.

Benn, David W.

1989 Hawks, Serpents, and Bird-Men: Emergence of the Oneota Mode of Production. The Plains Anthropologist 125(34):233-260.

Bergervoet, Michael

2007 A Monument Mosaic: Merging Indian Oral Tradition and Scientific Method. Unpublished Master's Thesis, Minnesota State University, Mankato.

Berres, Thomas E.

2001 Power and Gender in Oneota Culture: A Study of a Late Prehistoric People. Northern Illinois University Press, Dekalb.

Beyries, Sylvie and Veerle Rots

2008 The Contribution of Ethnoarchaeological Macro- and Microscopic Wear Traces to the Understanding of Archaeological Hide-Working Processes. Proceedings of the Congress "Prehistoric Technology: 40 Years Later. Functional Studies and the Russian Legacy":21-28.

Birk, D.
1970 Field Notes of Excavations at the Bryan Site. Copy on File, Minnesota Historical Society, St. Paul.

Blades, Brooke S.
2003 End Scraper Reduction and Hunter Gatherer Mobility. American Antiquity 68(1):141-156.

Boszhardt, Robert F. and Joelle McCarthy
1999 Oneota End Scrapers and Experiments in Hide Dressing: An Analysis from the LaCrosse Locality. Midcontinental Journal of Archaeology 24(2):177-199.

Brower, Jacob
1903 Minnesota: Discovery of its Area: 1540-1665. Minnesota Historical Society, St. Paul.

Brown, Gary M.
1991 Embedded and Direct Lithic Resource Procurement Strategies on Anderson Mesa. Kiva 56(4):359-384.

Callahan, Errett
1979 The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts. Archaeology of Eastern North America 7(1):1-180.

Christopher, Kelly J.
2004 North Umpqua End Scrapers: Allometry, Discard, and Residual Utility. M.A. Thesis, Interdisciplinary Studies, Oregon State University, Corvallis.

Clark, Frances
1984 Knife River Flint and Interregional Exchange. Midcontinental Journal of Archaeology 9(2):173-198.

Collins, Michael B.
1999 Clovis Blade Technology: A Comparative Study of the Keven Davis Cache, Texas. Austin: The University of Texas Press.

Connolly, Loris
1999 Listen to Grandmother Earth. Minnesota History Magazine 56(6):322-327.

Crabtree, Don E.
1972 An Introduction to Flintworking. Occasional Papers No. 28. Idaho State University Museum, Pocatello.

Dibble, Harold L.
1995 Middle Paleolithic Scraper Reduction: Background, Clarification, and Review of the Evidence to Date. Journal of Archaeological Method and Theory 4(2):299-368.

Dobbs, Clark A.
1984 Oneota Settlement Patterns in the Blue Earth River Valley, Minnesota. Ph.D. dissertation, Department of Anthropology, University of Minnesota, Minneapolis.
1985 An Archaeological Survey of the City of Red Wing, MN. Reports of Investigations No. 2, Institute for Minnesota Archaeology, Minneapolis.
1986a A Phase One Archaeological Reconnaissance of a Proposed Dredged Material Disposal Site at Prairie Island, Minnesota. Reports of Investigations No. 17, Institute for Minnesota Archaeology, Minneapolis
1986b A Preliminary Report on Investigations at the Energy Park Site (21GD158). Institute for Minnesota Archaeology, Minneapolis.
1987 Archaeological Investigation of the Bryan Site (21GD4), Goodhue County, Minnesota: 1983-1984. Reports of Investigations No. 8, Vol. 1-3, Institute for Minnesota Archaeology, Minneapolis.
1988 Outline of Historic Contexts for the Prehistoric Period (CA. 12,000 B.P.—A.D. 1700). The Institute for Minnesota Archaeology, Minneapolis.
1990 A Phase Two Evaluation of Ancient Native American Sites in Portions of the Spring Creek Valley, City of Red Wing, Minnesota. Reports of Investigations No. 83, Institute for Minnesota Archaeology, Minneapolis.
1991 Cataloging and Preliminary Analysis of Archaeological Materials Obtained from the Bryan Site (21GD4), Goodhue County, Minnesota. Reports of Investigations No. 63, Institute for Minnesota Archaeology, Minneapolis.
1992 A Pilot Study of High Precision Radiocarbon Dating at the Red Wing Locality. Reports of Investigations No. 228, Institute for Minnesota Archaeology, Minneapolis.
1993 The Mounds of Red Wing. Reports of Investigations No. 251, Institute for Minnesota Archaeology, Minneapolis.

Dobbs, Clark A. and Orrin Shane III
1982 Oneota Settlement Patterns in the Blue Earth River Valley, Minnesota. In Oneota Studies. Guy Gibbon, ed. Pp. 55-68. University of Minnesota Publications in Anthropology, No. 1. University of Minnesota Anthropology Department, Minneapolis.

Fleming, Edward P.
2009 Community and Aggregation in the Upper Mississippi River Valley: The Red Wing Locality. Ph.D. dissertation, Department of Anthropology, University of Minnesota, Minneapolis.

Gibbon, Guy E.

1972 Cultural Dynamics and the Development of the Oneota Life-Way in Wisconsin. American Antiquity 37(2): 166-185.

1979 The Mississippian Occupation of the Red Wing Area. Minnesota Prehistoric Archaeology Series No. 13. Minnesota Historical Society, St. Paul.

2012 Archaeology of Minnesota. University of Minnesota, Minneapolis.

Gilboa, Ayelet, Ayellet Tal, Ilan Shimshoni and Michael Kolomenkin

2012 Computer-Based, Automatic Recording and Illustration of Complex Archaeological Artifacts. Journal of Archeological Science.

Grosman, Loere, Oded Smikt and Uzy Smilansky

2008 On the Application of 3-D Scanning Technology for the Documentation and Typology of Lithic Artifacts. Journal of Archaeological Science.

Guthe, Carl E.

1937 The Indianapolis Archaeological Conference. Committee on State Archaeological Surveys, Division of Anthropology and Psychology. National Research Council.

Hanks, Margaret

1976 Excavations at the Durkee Site (21FA50). On file, Winnebago Area Museum, Winnebago.

Harvey, Kyle G.

2012 Who Needs a Plow Zone: Using a Common Site Mapping Method in a New Way at the Silvernale Site (21GD03). Unpublished Master's Thesis, Department of Anthropology, Minnesota State University, Mankato.

Hay, Conran A. and Robert Rogers

1978 A Method for Determining Polyhedral Core Sizes from Prismatic Blade Debitage. Lithic Technology 7(3):46-52

Jennings, Thomas A.

2011 Experimental Production of Bending and Radial Flake Fractures and Implications for Lithic Technologies. Journal of Archaeological Science

Johnson, Eldon

1991 Cambria and Cahokia's Northwestern Periphery. In *New Perspectives on Cahokia: Views from the Peripheries*, edited by James B. Stoltman, pp. 307-318. Monograhs in World Archaeology 2. Prehistoric Press, Madison.

Johnson, Jay K.

1997 Stone Tools, Politics, and the Eighteenth-Century Chickasaw in Northeast Mississippi. American Antiquity 62(2):215-230.

Ketz, Anne
2010 Preliminary Phase I Archaeological Survey for Select Portions of the Buffalo Lake Energy Discharge Pipeline, Martin and Faribault Counties, Minnesota. The 106 Group Ltd., St. Paul, Minnesota. Submitted to Barr Engineering, Minneapolis.

Koncur, Jasmine
2018 The McClelland Site (21GD258) and the Oneota Tradition in the Red Wing Region. Unpublished Master's Thesis, Department of Anthropology, Minnesota State University, Mankato.

Kopischke, Earl D.
1982 A Blue Earth River Village Site in Minnesota. Minnesota Archaeologist 24:74-82.

Lofstrom, Ted
1979 Archaeological Survey of Blue Earth and Faribault Counties. Minnesota Historical Society, St. Paul.
1981 Minnesota Statewide Archaeological Survey Summary: 1977-1980. Submitted to the Minnesota Legislature. Minnesota Historical Society, St. Paul.

Marwick, Ben
2007 What Attributes are Important for the Measurement of assemblage Reduction Intensity? Results from an Experimental Stone Artefact Assemblage with Relevance to the Hoabinhian of Mainland Southeast Asia. Journal of Archaeological Science 35:1189-1200.

McAndrews, John H.
1966 *Postglacial History of Prairie, Savanna, and Forest in Northwestern Minnesota.* Memoirs of the Torrey Botanical Club Vol. 22, edited by Theodore Delevoryas. The Torrey Botanical Society.

McCall, Grant S.
2012 Ethnoarchaeology and the Organization of Lithic Technology. Journal of Archaeological Research 20(2):157-203.

McElrath, Dale L. and Thomas E. Emerson
2000 Toward an "Intrinsic Characteristics" Approach to Chert Raw Material Classification: An American Bottom Example. Midcontinental Journal of Archaeology 25(2): 215-244.

McLoughlin, Patrick
2007 Section 106 Cultural Resources Review. Natural Resources Conservation Service.

Morrow, Juliet
1997 End Scraper Morphology and Use-Life: An Approach for Studying Paleoindian Technology and Mobility. Lithic Technology 22(1):167-191

Morrow, Toby et al.
2016 Stone Tools of Minnesota. Office of the Minnesota State Archaeologist, St. Paul.

Musser, Kimberly, Scott Kudelka, and Richard Moore
2009 Minnesota River Basin Trends. Water Resources Center, Minnesota State University, Mankato.

Neumann, Michelle K.
2017 A Stylistic Analysis Using Multivariate Statistics of Oneota Pottery from the Upper Mississippi, Blue Earth, and St. Croix River Valleys. Unpublished Master's Thesis, Department of Anthropology, Minnesota State University, Mankato.

Nystuen, D.
1970 Field Notes of Excavations at the Bryan Site. Copy on File, Minnesota Historical Society, St. Paul.

Odell, George H.
1981 The Morphological Express at Function Junction: Searching for Meaning in Lithic Tool Types. Journal of Anthropological Research 37(4):319-342.
2000 Stone Tool Research at the End of the Millennium: Procurement and Technology. Journal of Archaeological Research 8(4):269-331.
2001 Stone Tool Research at the End of the Millennium: Classification, Function, and Behavior. Journal of Archaeological Research 9(1):45-100.

Ojakangas, Richard W. and Charles Matsch
1982 Minnesota's Geology. University of Minnesota Press, Minneapolis.

Quade, Henry
2000 Blue Earth River Major Watershed Diagnostic Report: Blue Earth River Basin Implementation Framework. Water Resources Center, Minnesota State University, Mankato. Submitted to South Central Minnesota County, Comprehensive Water Planning Project, Joint Powers Board. MPCA Clean Water Partnership Project No. 1943.
2000 Le Sueur River Major Watershed Diagnostic Report: Le Sueur River Basin Implementation Framework. Water Resources Center, Minnesota State University, Mankato. Submitted to South Central Minnesota County, Comprehensive Water Planning Project, Joint Powers Board. MPCA Clean Water Partnership Project No. 951-1-194-07.
2000 Watonwan River Major Watershed Diagnostic Report: Blue Earth River Basin Implementation Framework. Water Resources Center, Minnesota State University, Mankato. Submitted to South Central Minnesota County, Comprehensive Water Planning Project, Joint Powers Board. MPCA Clean Water Partnership Project No. 1943.

Peterson, Leslie D.
1975 The Minnesota Trunk Highway Archaeological Reconnaissance Survey Annual Report for 1974. Minnesota Historical Society, St. Paul.
1976 The Minnesota Trunk Highway Archaeological Reconnaissance Survey Annual Report for 1975. Minnesota Historical Society, St. Paul

Ritterbush, Lauren W.
2002 Drawn by the Bison: Late Prehistoric Prehistoric Native Migration into the Central Plains. Great Plains Quarterly, Fall:259-270.

Rozen, K. C., and A. P. Sullivan III
1989 The Nature of Lithic Reduction and Lithic Analysis: Stage Typologies Revisited. American Antiquity 54(1):179-184.

Ruth, Susan
2013 Women's Toolkits: Engendering Paleoindian Technological Organization. Ph.D. dissertation, Department of Anthropology, University of New Mexica, Albuquerque.

Sackett, James R.
1982 Approaches to Style in Lithic Archaeology. Journal of Anthropological Anthropology 1:59-112
2008 Style, Function, and Assemblage Variability: A Reply to Binford. American Antiquity 51(3):628-634.

Sanockl C.A. and T.A. Winterstein
1999 Physical Characteristics of Stream Subbasins in the Cannon River Basin, Southeastern Minnesota. Prepared in Cooperation with the Minnesota Department of Transportation. United States Geological Survey, Department of the Interior.

Schirmer, Ronald C.
2002 Plant-use Systems and Late Prehistoric Culture Change in the Red Wing Locality. Ph.D. dissertation, Department of Anthropology, University of Minnesota, Minneapolis.
2016 Radiocarbon Dating Early Oneota Sites in Southern Minnesota. Report of Investigation, Minnesota State University, Mankato.

Schultz, Jack M.
1992 The Use-Wear Generated by Processing Bison Hides. Plains Anthropologist 141(37):333-351.

Sholts, Sabrina B., Dennis J. Stanford, Louise M. Flores and Sebastian K.T.S. Warmlander
2012 Flake Scar Patterns of Clovis Points Analyzed with a New Digital Morphometrics Approach: Evidence for Direct Transmission of Technological Knowledge Across Early North America. Journal of Archaeological Science.

Shott, Michael J.
1994 Size and Form in the Analysis of Flake Debris: Review and Recent Approaches. Journal of Archaeological Method and Theory 1(1):69-110.
1996 An Exegesis of the Curation Concept. Journal of Anthropological Research 52:259-280.

Sidak, Zbynek
1967 Rectangular Confidence Regions for the Means of Multivariate Normal Distributions. Journal of the American Statistical Association 318(62):626-633.

Siegel, Peter E.
1984 Functional Variability within an Assemblage of End Scrapers. Lithic Technology 13(2):35-51.

Sims, P.K. and G.B. Morey (editors)
1972 Geology of Minnesota: A Centennial Volume. The Minnesota Geological Survey, University of Minnesota, St. Paul.

Spector, Janet D.
1993 What this Awl Means: Feminist Archaeology at a Wahpeton Dakota Village. Minnesota Historical Society Press, Saint Paul

Strachan, Richard and Kathleen A. Roetzel
1989 An Archaeological Survey of Four Specified Areas Within the Swan Lake Project, Nicollet County, Minnesota. Submitted to the Minnesota Department of Natural Resources.

Sundstrom, Linea
2002 Steel Awls and Stone Age Plainswomen: Rock Art, Religion, and the Hide Trade on the Northern Plains. Plains Anthropologist 181(47):99-119.

Theler, James L. and Robert F. Boszhardt
2006 Collapse of Crucial Resources and Culture Change: A Model for the Woodland to Oneota Transformation in the Upper Midwest. American Antiquity 71(3):433-472.

Trow, Thomas
1981 The Grand Meadow Quarry Site. Paper presented at the 1981 Annual Council for Minnesota Archaeology Symposium, St. Paul.

USDA, NRCS

2007a Rapid Watershed Assessment Cannon River (MN) HUC: 07040002. United States Department of Agriculture, Natural Resources Conservation Service.

2007b Rapid Watershed Assessment Rush-Vermillion (MN/WI) HUC: 07040001. United States Department of Agriculture, Natural Resources Conservation Service.

2009 Rapid Watershed Assessment Resource Profile Middle Minnesota (MN) HUC: 07020007. United States Department of Agriculture, Natural Resources Conservation Service.

Weedman, Kathryn J.

2006 An Ethnoarchaeological Study of Hafting and Stone Tool Diversity among the Gamo of Ethiopia. Journal of Archaeological Method and Theory 13(3):189-238.

Wendt, Dan

1985 An Analysis of End Scrapers from the Bryan Site. Institute for Minnesota Archaeology Reports of Investigations.

2000 A Late Prehistoric Boundary at the Mississippi River: Triangular Projectile Point Variation in the Red Wing Locality of Pierce County, Wisconsin and Goodhue, Minnesota. Reports of Investigations No. 602, Institute for Minnesota Archaeology, Minneapolis.

2014 PDC Group Chert Resources of the Upper Mississippi River Valley in South-eastern Minnesota and Far Western Wisconsin. The Minnesota Archaeologist, The Minnesota Archaeological Society, St. Paul.

Wilke, Philip, Gayle Carlson and John Reynolds

2002 The Late Prehistoric Percussion-Blade Industry of the Central Plains. Central Plains Archaeology 9(1):1-21.

Willey, Gordon R. and Philip Phillips

1958 Method and Theory in American Archaeology. University of Chicago Press, Chicago.

Wilford, Lloyd A.

1941 A Tentative Classification of the Prehistoric Cultures of Minnesota. American Antiquity 6:231-249.

1945a Three Village Sites of the Mississippi Pattern in Minnesota. American Antiquity 11:32-40.

1945b The Humphrey Village Site. On file, Wilford Laboratory of Archaeology, University of Minnesota, Minneapolis.

1952 The Vosburg Site. On file, Wilford Laboratory of Archaeology, University of Minnesota, Minneapolis.

1957 The Bryan Site. Unpublished Report on File, Wilford Laboratory of Archaeology, University of Minnesota, Minneapolis.

Winchell, Newton H.
1910 Extinct Pleistocene Mammals of Minnesota. Bulletins of the Minnesota Academy of Natural Sciences 1892-1910 (4):414-422.
1911 The Aborigines of Minnesota. Minnesota Historical Society, St. Paul.

Winchell, Newton H. and Warren Upham
1884 *The Geology of Minnesota*. Final Report of the Geological and Natural History Survey of Minnesota Vol. 1, 1872-1882. Johnson, Smith & Harrison, Minneapolis.
1888 *The Geology of Minnesota*. Final Report of the Geological and Natural History Survey of Minnesota Vol. 2, 1882-1885. Pioneer Press, St. Paul.

Yourd, William J.
1983 An Archaeological Assessment Study of Proposed MNDOT Project S.P. 2514-71, T.H. 61: Reconnaissance and Limited Excavation at the Bryan Site, Goodhue County, Minnesota. Minnesota Trunk Highway Archaeological Reconnaissance Survey. Minnesota Historical Society, St. Paul.