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# LATE ARCHAIC TO EARLY WOODLAND LITHIC TECHNOLOGY AT THE KNOB CREEK SITE (12HR484), HARRISON COUNTY, INDIANA

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THESIS

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


Kyle Edward Mullen

Lexington, Kentucky


Director: Dr. Christopher Pool, Professor of Anthropology

Lexington, Kentucky

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ABSTRACT OF THESIS

# LATE ARCHAIC TO EARLY WOODLAND LITHIC TECHNOLOGY AT THE KNOB CREEK SITE (12HR484), HARRISON COUNTY, INDIANA


This study examines bifacial technology change at the Knob Creek site (12HR484) in Harrison County, Indiana, from the Late Archaic to Early Woodland periods. Through a statistical and attribute analysis of 2,620 lithic flakes it was possible to detect changes in the lithic reduction process over time. The analysis demonstrates that soft-hammer percussion becomes more prevalent during the Early Woodland component of the site. This is a significant change from the hard-hammer percussion industry of the Lower Late Archaic. The Terminal Archaic Riverton component in this study offers one of the few detailed flake-by-flake analyses for this poorly understood lithic tradition originally identified by Winters (1969) in the Wabash River Valley.



KEYWORDS: Lithic Technology, Riverton Culture, Caesars Archaeological Project, Archaic-Woodland Transition, Knob Creek Site



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July 25, 2013

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## Chapter 1 – Introduction, Geographic Location, Geology, and CAP Background

Most examinations of the Archaic-Woodland transition fail to consider the dynamic aspects of this important time in human history. Traditionally, the start of the Early Woodland period in the mid-continent was associated with the emergence of ceramic technology and the rise of sedentism among previously mobile groups. Unfortunately, the more research that is conducted in both the mid-continent and southeastern United States, the more archaeologists have come to realize that generalized evolutionary trajectories fail to hold. A more fruitful approach situates technological sequences in their micro-regional histories. This study attempts to compare the degree of bifacial reduction through time and by chert type in order to better understand how different types of stone were utilized from the Late Archaic (5500 BP) through the Early Woodland (2200 BP) periods at the Knob Creek site in Harrison County, Indiana (Figure 1.1).

This transition period in the prehistory at the Falls of the Ohio is not well understood. Sites at the Falls are oftentimes classified as simply Late Archaic/Early Woodland because it has been so difficult to distinguish between the two components. For example, diagnostic projectile points of the Early Woodland (Turkey-Tail and Dickson Cluster points) have appeared in pre-ceramic and Terminal Archaic sites (Stafford et al. 2007). Conversely, Terminal Archaic projectile points (Terminal Archaic Barbed Cluster points) continue to be found in Early Woodland contexts (Mocas 2006:3). Complicating the issue further is the fact that a fine-grained analysis of flaked stone technology for the Late and Terminal Archaic has been difficult to come by until now (Jefferies 2008:196). Late Archaic components are often found in plowzone contexts, making it difficult to say with confidence how lithic technology was organized at the Falls during this transition time. The Caesars Archaeological Project's (CAP) unmatched stratigraphy, precise dating, and lithic debris make it ideally suited for the type of fine-grained analysis that this thesis examines.

This analysis makes use of one of the most abundant, and mostly ignored artifact classes, in the archaeological record at ceramic sites, the common flake. On many archaeological projects debitage is discarded, oftentimes viewed as uninformative. In fact, through a flake-by-flake analysis of a debitage assemblage researchers can reconstruct the technological means through which stone tools were produced. Finished bifaces are the end product of a long sequence of individual decisions made by the knapper along the way. By limiting stone tool studies to only formal tools, the processes (and individual decisions) that created these tools are ignored. Where finished bifaces are classified into types that represent static categories associated with people of the past, a technological understanding of biface production can identify more subtle changes in a group's organization of technology, mobility, and economic organization.

One of the main goals of this project is to better understand how hunter-gatherer peoples of the past made stone tools. In this thesis I will apply both an attribute and descriptive analysis to a debitage assemblage in order to infer technological change at the Knob Creek site over the course of 3000 years. While the occupants of the Knob Creek site at this time were hunter-gatherers (and possibly experimenting with early cultivation), it is incorrect to assume that they remained in a static state.

This thesis begins by reviewing the geographic location of the Knob Creek site (12HR484). I examine the factors that made the Falls of the Ohio region such an attractive environment to hunter-gatherers of the distant past. I review the paleoenvironment and the processes that impacted change in the physical environment through time. I also discuss the regional geology to better understand how the distribution of raw material resources impacted hunter-gatherers. I then review the history of the Caesars Archaeological Project and describe the goals of the CAP and contextualize how this analysis contributes to the broader goals of the project. Next, the culture history of the Lower Ohio Valley is provided, most specifically in the Falls of the Ohio. I then proceed to provide a background for the types of lithic tools and debitage previously analyzed by the CAP. I consider how the debitage analysis can be used to make inferences about technological change over time. I conclude this chapter by considering the impact that raw material availability may have on debitage patterns in the archaeological record.

Chapter 2 reviews numerous theoretical perspectives associated with lithic reduction. In Chapter 3 I address the specific problem confronting this research and provide two working hypotheses. I outline the methods I used to specifically address my research questions in Chapter 4, including the kinds of flake measurements taken. In Chapter 5 I discuss the statistical analysis conducted surrounding descriptive statistics, an attribute analysis, and a principle component analysis. I make my closing arguments on what the data suggest and what this study contributes to what we already know about archaeology at the Falls of the Ohio in Chapter 6.

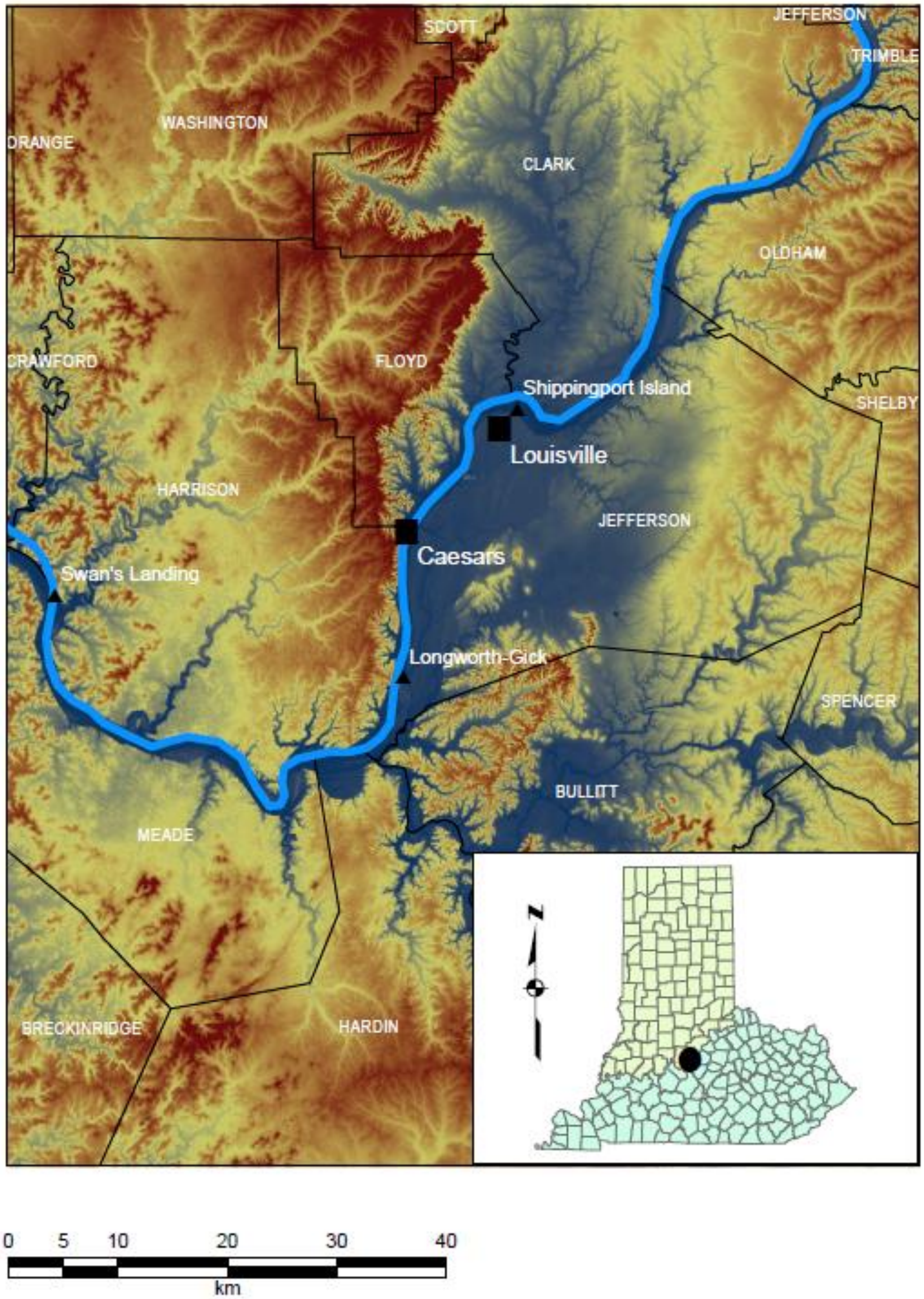


Figure 1.1: Map of the Falls of the Ohio Region. From Stafford et al. (2007:24).

## Location of the Knob Creek Site

Throughout the history of the United States the Ohio River has been socially, economically, and politically important. Throughout the 1800s, both the Mississippi and Ohio Rivers were main transportation and trade routes which led to the rise of river cities such as Cincinnati and Louisville. While considering the importance of the Ohio River in the context of recent American history, it should come as no surprise that the Ohio River was an important locus of activity to the lives of Native Americans prior to European contact.

The Knob Creek site is located along the Ohio River, adjacent to Bridgeport, Indiana (Figure 1.2). The site sits 16 km downriver from the Falls of the Ohio, a series of natural rapids that are important for a number of reasons. Prior to the damming of the Ohio River, the Falls stood as the only natural impediment to movement downriver (Jefferies 2008). Considering that the river runs for over 1600 km in total, this makes the Falls of the Ohio a significant geographic feature. Archaeological studies have suggested that throughout the course of prehistoric hunter-gatherer occupation, this was a culturally dynamic region of diversity and change. Numerous investigations in the region have suggested that the Falls constituted a natural cultural boundary, separating up- and downriver groups (Burdin 2004; Jefferies 1997).

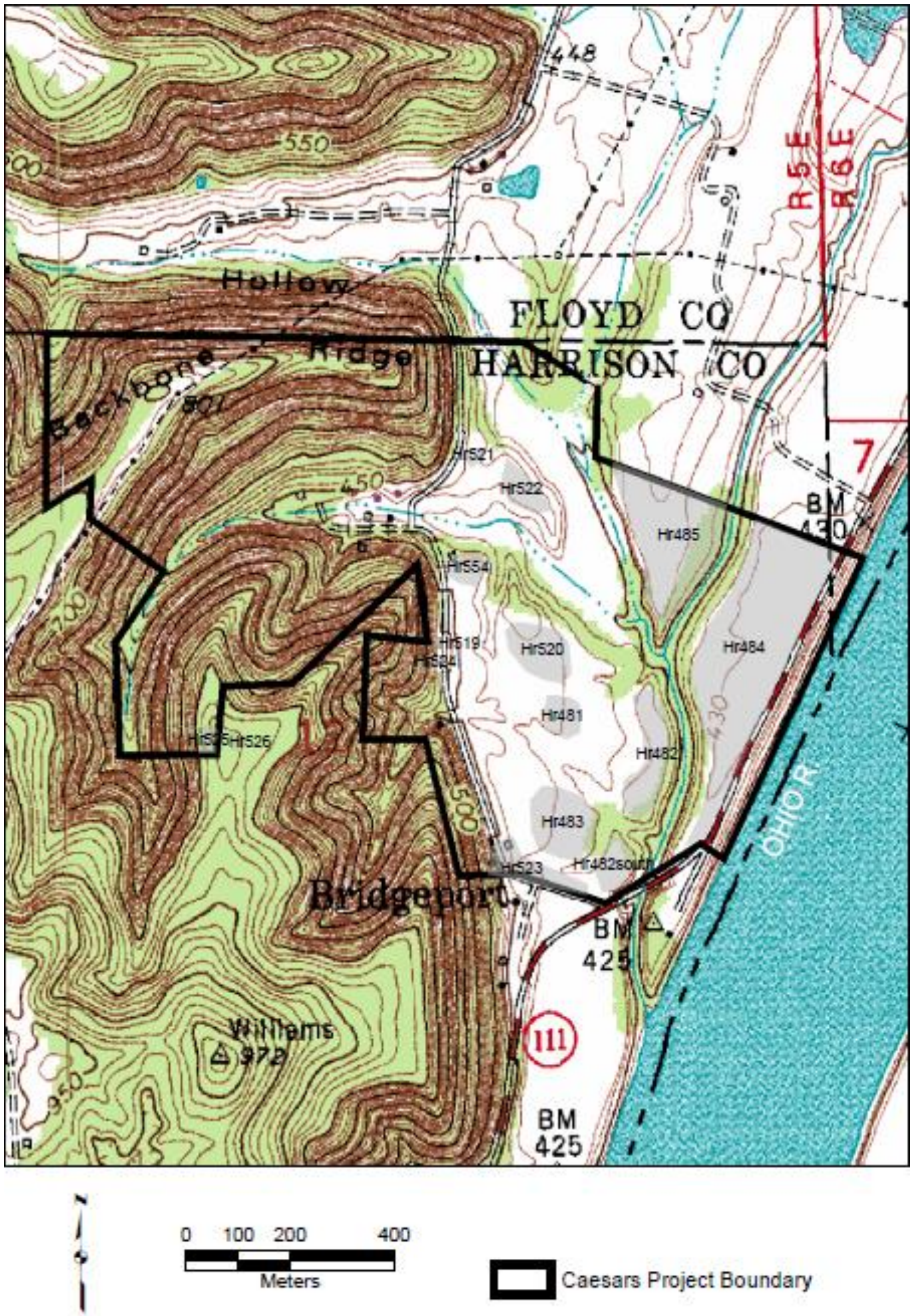


Figure 1.2: Map of CAP Boundary. The solid dark black line indicates the boundaries of the CAP area. From Stafford et al. (2007:25).

Prior to twentieth-century dam construction, the Falls of the Ohio extended for over 3 km, just outside Louisville. Over that distance the river elevation dropped eight meters. The formation of the Falls as a natural feature is due to glacial activity. Melting glacial water flooded the Ohio River's previous channel (now buried under modern Louisville) and filled it with thick layers of sand, gravel and clay. This geomorphological process rerouted the Ohio River across the underlying limestone formations, thus creating the Falls of the Ohio (Jefferies 2008:14).

The Falls of the Ohio region marks the easternmost boundary of the Lower Ohio River Valley. During the course of this vast river and drainage network, the Ohio River flows through a wide range of environmental and physiographic zones. The Lower Ohio River Valley's landscape is highly diverse, ranging from the Knobs of west-central Kentucky to the marshy Coastal Plains near the Mississippi River (Pollack 1990:7). The Lower Ohio River Valley includes the Salt, Green, Wabash, Saline Tradewater, Cumberland, Tennessee, and Cache river tributaries. This environment would have contained a variety of landforms, plants, animals, lithic outcrops, and water resources that formed over millions years.

## Paleoenvironment

Before the peopling of the Falls region, Wisconsin glaciation covered portions of the mid-continent north of the Ohio River. As Wisconsin glaciations retreated northward, large quantities of sediment runoff were created. Large amounts of clay, sand and gravel runoff was transported downstream, filling much of the Ohio River Valley with deep alluvial deposits. Lower Ohio River Valley tributary streams became flooded by backwater effects of glacial runoff creating slackwater lakes and filling Ohio River valleys with fine-gained silt (Jefferies 2008:21).

The Lower Ohio Valley flora has experienced many changes from the Pleistocene to the present day. Late Pleistocene boreal taxa transitioned to a deciduous forest in the Early Holocene period. Drier deciduous forests are found during the Middle Holocene while environmental conditions did not come to their modern state until the Late Holocene (Smith and Mocas 1995:18-19).

The most profound changes in vegetation occurred at the end of the Pleistocene, approximately 10,000 years ago. It is at the same time that megafauna began to disappear from the Lower Ohio River Valley as the environment begins to transition closer to its current state. As the ice sheets disappeared, conifer forests retreated northward, and were replaced by oak, hickory, ash, and elm trees throughout much of the Midwest and Southeast (Jefferies 2008:23; Jacobson et al. 1987:282). During the Early Holocene (12,500 to 8000 BP) a cooler, moister climate promoted a widespread expansion of mixed hardwood forests. Oak and hickory forests continued to dominate in the Southeast while elm, ash, and ironwood begin to disappear in the Midwest (Jacobson et al. 1987:282; Jefferies 2008:24). Oak and hickory forests were established during the this time in the western Lower Ohio River Valley while mixed hardwood forests grew south and east of the region (Muller 2009:50).

During the Middle Holocene (8000-4000 BP) temperature and precipitation changes led to widespread vegetation changes. By approximately 6,000 to 5,000 years ago, vegetation adapts to its modern conditions (Muller 2009:51). Increased warmth and dryness in the Great Plains due to the mid-Holocene Hypsithermal resulted in grasslands moving eastward (Deevy and Flint 1957). These dryer and warmer conditions led to increased surface erosion, decreased upland vegetation and aggraded floodplains (Jefferies 2008:24). Riverine shoal habitats that were created at this time set the stage for the expansion of shell-fish populations in the region. Backwater slough environments were also established during this time leading to the much greater increase in floodplain productivity for hunter-gatherers (Anderson 2001:158).

The Late Holocene (4000 BP to present) is marked by a period of stasis. Humans continued to impact the environment but the natural resources available to hunter-gatherers did not change dramatically (Muller 2009:51). In fact, human impact on the environment has only increased over the course of the last 5,000 years.

## Geological Occurrence of Cherts

Most of the lithic materials used by hunter-gatherers at the Knob Creek site were obtained locally. Cherts were especially prevalent in the region, with numerous types being of acceptable knapping quality. Hunter-gatherers at the Falls region utilized Wyandotte, Muldraugh, Allens Creek and various other quality cherts. Muldraugh and Allens Creek cherts were found in the Knobs region adjacent to the CAP. Wyandotte, a blue-gray high quality chert, can be found in western Harrison County, Indiana, approximately 35 kilometers away (Figure 1.3).

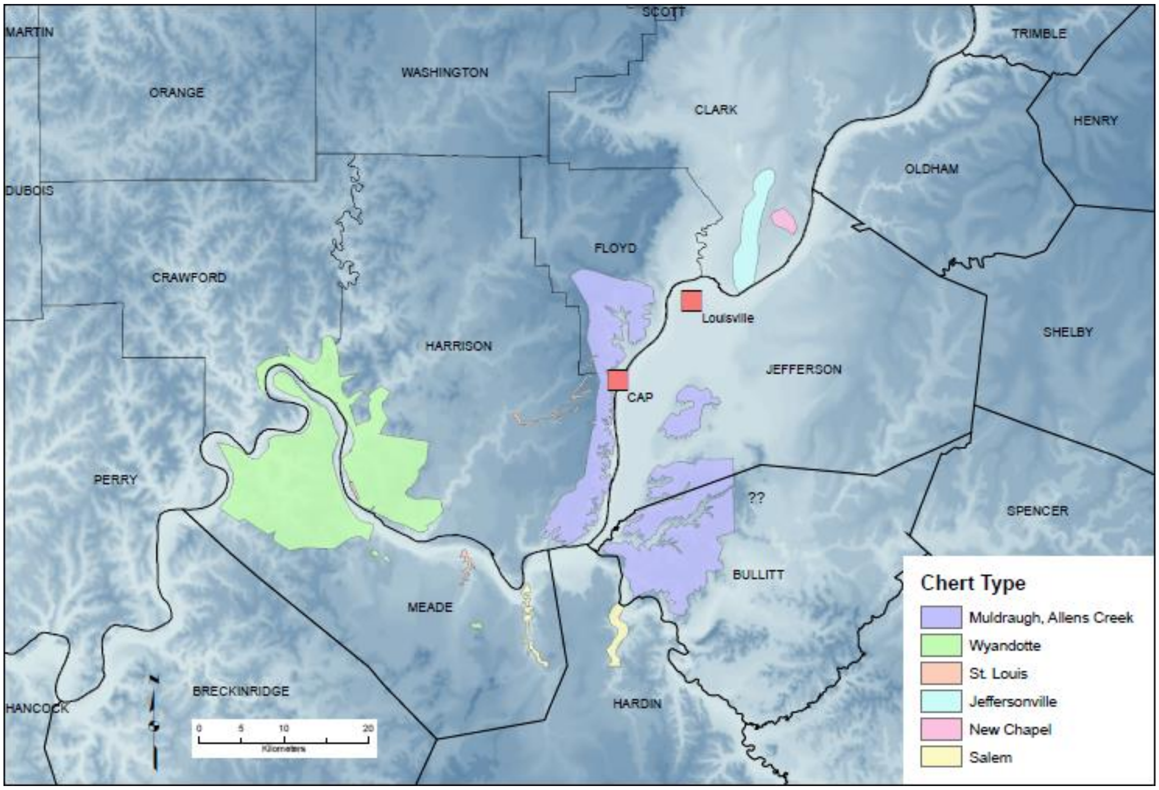


Figure 1.3: Lithic Sources in the Falls of the Ohio Region. Notice that Muldraugh and Allens Creek cherts outcrop adjacent to the site while Wyandotte chert can be found in western Harrison County. From Cantin et al. (2007:418).

Muldraugh

Muldraugh chert was the dominate chert type utilized at the Knob Creek site. It is likely that the Muldraugh outcrops in the bluffs behind the site played a role in making the CAP area attractive to hunter-gatherers. Muldraugh chert ranges in color from pastel brown to varying shades of gray (Cantin et al. 2007). It is quite similar to Allens Creek chert as the two locally grade into one another in the Knobstone Escarpment of Harrison County. Tabular beds of Muldraugh chert are exposed in various areas adjacent to the site. These beds are often greater than 30 centimeters thick and extend for tens of meters (Cantin et al. 2007:386). Due to its abundance, it is easy to find outcrops in the area where unweathered blocks of Muldraugh chert could have been procured easily.

The texture associated with Muldraugh chert ranges widely.  It is not uncommon to find beds in the area that display medium-coarse to very fine texturing.  Typical Muldraugh outcrops take on a medium texture though the same outcrop and bed can display varying textures in the span of just a few meters (Cantin et al. 2007).  While Muldraugh and Allens Creek cherts oftentimes grade into one another, Muldraugh is usually non-fossiliferous.  Fracturing qualities of Muldraugh range from fair to good conchoidally.  This allows for the production of flakes with sharp, soft edges (Ray 1982:8).

Allens Creek

As a subtype of Muldraugh, Allens Creek is found in the same alternating chert beds (Cantin et al. 2007:381).  Munson and Munson (1984:153) identified both bedded and nodular masses of Allens Creek chert.  Allens Creek is primarily distinguished from Muldraugh by its high fossil count.  Fossils are dominated by the crinoidal type with sponge spicules and fenestrate bryzoa types also common (Cantin et al. 2007:381).  Despite being highly fossiliferous, Allens Creek generally produces good conchoidal fractures with regular, sharp flakes (382).  The texture of Allens Creek chert ranges from coarse to coarse-medium (Cantin et al. 2007).

Wyandotte

The distribution of Wyandotte chert in the region is somewhat limited, but can be found in western Harrison County.  Wyandotte chert can occur in both nodule and tabular forms.  This chert tends to be relatively homogenous in color and is recognizable in shades of grays and blue-grays (Cantin et al. 2007:392).  Stream beds and residual exposures in western Harrison County provide large, high quality nodules.  These nodules are free of internal stress fractures and its fine cryptocrystalline structure allows for easy knapping. Cantin et al. (2007:393) observe that flaked Wyandotte cherts will often display a conchoidal fracture featuring both Hertzian cones and ripple marks.

Nodules found in river streams in western Harrison County traditionally have a well-developed cortex, usually 1-2 centimeters thick. Wyandotte is the only one of the three chert types in which cortex can be identified and recorded. Cortex is easily identified with its chalky, pale brown appearance that stands in stark contrast to the fine-textured, blue-gray chert.

The Falls of the Ohio region is unique geomorphologically. For a large portion of the course of the Lower Ohio River, the valley is narrowly cut through the surrounding bedrock (Stafford 2007a:30). Throughout most of this stretch, the valley width ranges from 3.2 km to less than .8 km (Stafford 2007a; Ray 1974:4). The bottomlands of the valley sit below valley walls that reach up to more than 120 meters above the valley floor. The bedrock of the valley at the Falls of the Ohio is much wider (7.7 km) than many other parts of the Lower Ohio River (Stafford 2007a:32).

The pristine physical environment that hunter-gatherers entered in the Lower Ohio River Valley over 12,000 years ago was shaped by a series of dynamic processes that took place over the course of millions of years. After hunter-gatherer groups settled in the region, the environment continued to change. It became the environment that exists today by 5000 BP. The Falls region in particular stands as an attractive area to hunter-gatherer peoples of the past. A combination of forests, floodplains, and oxbow lakes in the vicinity allowed access to good hunting and fishing territories. As hunter-gatherer groups began to experiment with gardens, the fertile alluvium of the Ohio River allowed food production to intensify over time. The attractiveness of the physical environment makes it no surprise that the Falls region has been occupied by humans for at least the past 12,000 years.

Throughout the history of human occupation in the region, the Ohio River has served as an important mode of transportation and communication between groups, both u*p*- and downriver. Archaeological studies by Burdin (2004) and Jefferies (1997) suggest that the Falls region acted as a cultural boundary as well as a natural impediment to river travel in prehistoric times. The location of the Knob Creek site should be viewed as a sort of crossroads among various groups of hunter-gatherers through time.

Late Archaic to Early Woodland Culture History in the Falls of the Ohio Region

The term "Archaic Period", stretching for approximately 7,000 years from 10,000 BP to 3000 BP was first coined in the 1930s (Stoltman 1978). It was used by Ritchie (1932) to describe the prehistoric occupants of the Lamoka Lake Site. The term quickly entered the popular vocabulary of archaeologists to describe hunter-gatherer groups in North America who did not utilize ceramic technology (Stoltman 1978). Later, Willey and Phillips (1958:107) refined the concept even further to include "the stage of migratory hunting and gathering cultures continuing into environmental conditions approximating those of the present." Archaeologists have traditionally subdivided the Archaic Period into Early, Middle, and Late subperiods based upon changes in settlement patterns, technology, subsistence, and cultural complexity. The Early Archaic period in the mid-continent ranges from 10,000 BP to 8000 BP; the Middle Archaic from 8000 to 5000 BP; and the Late Archaic from 5000 BP to 3000 BP. While these divisions reflect their development at a time when cultural evolutionary schemes of the past dominated, they remain chronological markers today. As more research becomes available however, the subperiods that divide the Archaic Period are not as distinct as once thought. Instead, the boundaries between time periods have become blurred. For example, evidence suggests that Late Archaic peoples in some parts of the Ohio River Valley were practicing an early form of gardening, and beginning the plant domestication process (Smith 2008).

The Early Archaic (10,000-8000 BP) period encompasses a time of social changes amongst hunter-gatherer groups in the Falls of the Ohio region based primarily on the retreat of glaciers at the end of the Pleistocene Epoch (Jefferies 1996). Lithic tool-kits were similar to Late Paleoindian times, as were settlement patterns, mobility, and subsistence. One site near the Falls of the Ohio that has received great attention is the Longworth-Gick site. This Early Archaic occupation is located on a floodplain of the Ohio River and has evidence of at least eight occupation camps. These camps took place between late summer and winter when flooding of the Ohio River was least likely to occur (Collins and Driskell 1979:1024-1026). Based on what is understood, mostly through the examination of stone tools, the Early Archaic people at the Falls of the Ohio had a settlement pattern with high residential mobility (Binford 1980).

Around 9000 BP, the climate of the mid-continent began to change. These Hypsithermal climatic changes caused the Falls of the Ohio region to become warmer and drier. This change in climate affected plants, animals, and people for a few thousand years. By the Middle Archaic period (8000-5000 BP) regionally distinct cultures emerged throughout the eastern United States (Jefferies 1996:47). The impetus for this development may have been caused by changes that occurred in settlement, technology, and subsistence. The best evidence for the development of regionally distinct cultural traditions comes from changes that occurred in projectile points. At this time, few Middle Archaic period sites at the Falls of the Ohio have been studied.

Late Archaic Period (5500-3500 BP)

The areas surrounding the Falls of the Ohio were covered in dense forests during the Late Archaic (Jefferies 1996:64). This section of the Ohio River Valley had numerous floodplains and oxbow lakes that were ideal places for a reliable food supply for Late Archaic hunter-gatherers. The attractiveness of this locality at this time is demonstrated by the marked increase in sites from previous periods. Similar to the Green River sites of the Late Archaic, about one-third of all floodplain sites at the Falls have large middens of earth and shell (Collins and Driskell 1979). Sites located in the interior lowlands also have evidence of large, deep middens as well. Floodplain, interior lowland, and upland sites were all important locations for Late Archaic hunter-gatherers. These groups likely moved seasonally to exploit different micro-environments at different times of the year.

The Late Archaic period (5500 – 3500 BP) sees a variety of changes occurring from previous time periods. One of these changes is seen in Late Archaic settlement patterns that were distinct from those of the Early and Middle Archaic. The Late Archaic period is characterized by an increase in the number of sites and the overall size of sites across the Eastern United States (Jefferies 1996:54). This suggests that these changes may have accompanied basic changes in hunter-gatherer social organization. While Late Archaic groups of the Ohio River Valley were likely egalitarian in social structure, there is ample evidence of increased cultural complexity as seen in burials during this time. Some burials at this time contain exotic goods which may suggest preferential burial treatment of higher-status individuals (Winters 1968).

The Late Archaic also demonstrates evidence for change in stone tool technology. The Late Archaic toolkit continues to diversify to include a wide range of flaked stone, groundstone, and bone tools (Jefferies 1996:54). Large quantities of deer bone and hickory nuts in the archaeological record demonstrate their importance in the Late Archaic diet. While hunting and gathering continued to play an important role in subsistence, it is becoming clear that people as early as the Late Archaic were experimenting with small gardens (Chomko and Crawford 1978; Watson 1985). In many other parts of the Ohio River Valley however, Late Archaic sites still reflect relatively short-term occupations as they did in the Middle Archaic (Jefferies 1996:57).

Terminal Archaic (3500-2700 BP)

The Terminal Archaic period in the Lower Ohio River Valley is the most poorly understood period of those discussed in this thesis. Howard Winters' (1969) Riverton culture analysis remains the most extensive examination of this time period. Winters, working in the Lower Wabash River Valley, obtained radiocarbon dates from three sites that spanned from 3110 +- 120 to 3490 +- 200 BP (Winters 1969:105). A key feature of this culture is their distinct microtool technology. This aspect of the Riverton culture is directly related to this study as the Riverton debitage component would be expected to have smaller debitage characteristics based on this culturally specific microtool technology. Anslinger's (1986) extensive study of a Riverton component at the Wint site (12B95) in Bartholomew County, Indiana, yielded similar results to Winters (1969). That is, similar morphological attributes of small projectile points.

Part of what makes this study important is that a substantial Riverton occupation was uncovered at the Knob Creek site, consisting of seventy-nine Riverton features and 325 projectile points were recovered at Knob Creek. The Riverton component at Knob Creek was encountered during excavations in secure contexts directly underneath Early and Middle Woodland components. Radiocarbon dates taken for the Riverton component averaged to 3520 +-30 BP with the youngest date coming in at 3140 +-70 BP. These dates are at the older end of Riverton components found elsewhere in the Lower Ohio River Valley, but coincide nicely with the dates Winters obtained from Swan Island and Robeson Hills sites (Stafford and Cantin 2009:306).

### Early Woodland Period (2700-2200 BP)

The Early Woodland period (2700-2200 BP) marks an important transition in the cultural trajectories in the eastern United States. Like the term Archaic, the name Woodland came into use in the 1930s. This designation described prehistoric groups of people in the eastern United States who utilized pottery, constructed burial mounds, and lived a hunting-gathering-gardening way of life (Stoltman 1978). The Early Woodland period lasted from roughly 3000 BP to 2200 BP. This time period marked the first large scale introduction of pottery to the mid-continent and southeast. The Early Woodland period saw settlement patterns remain approximately the same from the preceding Late Archaic and Terminal Archaic periods. This is seen in the deep middens found at base camps and villages at the time. While there is much continuity from the end of the Archaic to the beginning of the Woodland, there are a few important differences. One includes the appearance of ritual sites away from village settlements. The sacred sites served the purpose of bringing groups of people together for ceremonies and burying the dead. It has been suggested elsewhere that the emphasis on ritual sites may in part be a side effect of territorial circumscription. Population densities in the region continued to increase from previous periods. It may have become necessary for groups to establish claims to certain territories that were key to hunting-gathering and gardening (Railey 1991; Seeman 1986).

The end of the Archaic and beginning of the Early Woodland marks a very important transition time in Ohio River Valley history. The first people to settle the Lower Ohio River did so in Paleoindian times (before 10,000 BP). Exact dates for when this occurred are hotly debated today; however, there is archaeological evidence that Paleoindians were living in the region by at least 12,000 BP. The Archaic begins approximately 10,000 BP with the extinction of megafuana and ice age flora. As the environment transformed to one closer to the one we experience today, Early Archaic peoples in the region maintained a similar nomadic lifestyle as enjoyed in the preceding Paleoindian period. The Middle Archaic Period (8000-5000 BP) sees the beginning of people becoming more adapted to the environment, a process that has been described as ‘settling in’. Distinct regional projectile point styles become the norm as home range area becomes smaller. It is during this time that the first evidence of long-distance trading is observed. By the Late Archaic (5500-3500 BP), the trends that began in the Middle Archaic are now even more pronounced. Evidence shows that Late Archaic peoples may have been experimenting with cultivation and rudimentary forms of pottery. This is precisely the reason why the research presented in this thesis is important. As broad-brushed perceptions of the past are now being refuted, a more nuanced look into the deep past is needed in order to understand the people at the Knob Creek site. It must not be assumed that the patterns found in one part of the Ohio River Valley will be the same throughout.

### Background on the Caesars Archaeological Project

The Falls of the Ohio is an important region in the prehistory of southern Indiana. In fact, all periods of Indiana prehistory are represented within the Falls region (Kellar 1983). The primary focus of past research at the Falls has centered on the numerous Wyandotte chert quarries and workshops in the area (Collett 1879; Fowke 1922; Cantin 1989). There have been three large survey projects undertaken in the Falls region. Seeman (1975) performed a survey of the chert quarries and discovered numerous other prehistoric sites within Harrison County, Indiana. The University of Kentucky performed an intensive survey at the Fort Knox Military Reservation (O'Malley et al. 1980). An extended version of this project documented a total of 172 components at 115 prehistoric sites. Lastly, numerous survey projects were conducted in the Bethlehem Bottoms of Clark County, Indiana (Mocas and Smith 1996, Stafford et al. 2007). This series of surveys identified 31 prehistoric sites in the Falls area.

The Falls of the Ohio section of the Ohio River has little in the way of Middle Archaic materials. In contrast, this section is well-known for having a large number of Late Archaic shell-midden sites (Stafford et al. 2007). Janzen's (1977) test-excavations at six shell-midden sites in the Falls region included four such sites in Harrison County, Indiana, near the CAP area. There has also been salvage excavation work done directly north of the CAP project area where Late Archaic deposits and human burials were found eroding from the edge of a riverbank (Burdin 2002).

Further upriver, other significant Late Archaic remains exist. Extensive faunal and burial remains with Late Archaic affiliation were recovered from the Railway Museum site (Anslinger et al. 1994). Late Archaic and Early Woodland components were recorded in the Falls Harbor project (McKelway 1995). The Arrowhead Farm site (Mocas 1976) is a dense Late Archaic midden site excavated on the Kentucky side of the Ohio River. Riverton cultural components, dating to the Terminal Archaic period, have been identified at both the Villier and Rosenberger sites in Jefferson County, Kentucky (Collins 1979). Downriver from the CAP area are deeply buried Early and Late Archaic components at the Poffey Creek site (Stafford and Cantin 1992).

The Early Woodland period at the Falls has been subject to less extensive study. There are numerous documented mounds in the region, which are often considered hallmarks of the Woodland Period. None, however, have been conclusively identified as being of Early Woodland cultural affiliation (Stafford et al. 2007). Previous surveys at the Falls region did include both Early and Middle Woodland cultural components. Seeman (1975), for instance, reported 45 Early Woodland components in his survey of

Harrison County, Indiana. The extended Fort Knox Military Reservation survey indicates 15 components that have been labeled Terminal Archaic/Early Woodland. The Bethlehem Bottom Survey conducted by Mocas and Smith (1996) also identified 15 sites with Terminal Archaic/Early Woodland components.

For the illustrious history of archaeological investigations at the Falls of the Ohio it is remarkable that only one extensive Early Woodland excavation has been undertaken (Stafford et al. 2007:5). This site, 12CL109 in the Clark Maritime Centre Archaeological District (CMCAD), contained dense middens along with a variety of features, high quantities of artifacts and botanicals, and a small amount of faunal remains. Early and Middle Woodland lithic manufacture and habitation sites were tested in the Titus Bottoms of Harrison County, Indiana (Cantin 1996; Cantin and Stafford 1997).

The Knob Creek site (12Hr484) was excavated as part of the large-scale, multiyear investigation of the CAP. This large-scale project investigated four prehistoric sites in Harrison County, Indiana (Figure 1.4). The project area is adjacent to Bridgeport, Indiana, approximately 16 kilometers downriver from the Falls of the Ohio.

Indiana State University began Phase I surface investigations in August, 1995. Field work consisted of pedestrian survey, shovel testing, backhoe trenching, and auger coring (Stafford et al. 2007). Extensive prehistoric deposits were discovered buried under as much as 3 meters of soil. These deposits were in contexts of alluvium associated with the present day Ohio River levee, early to mid-Holocene Ohio River terraces, and alluvium associated with Knob Creek (Stafford et al. 2007). Preliminary site boundaries were developed at this time after 13 prehistoric and historic archaeological sites were discovered.

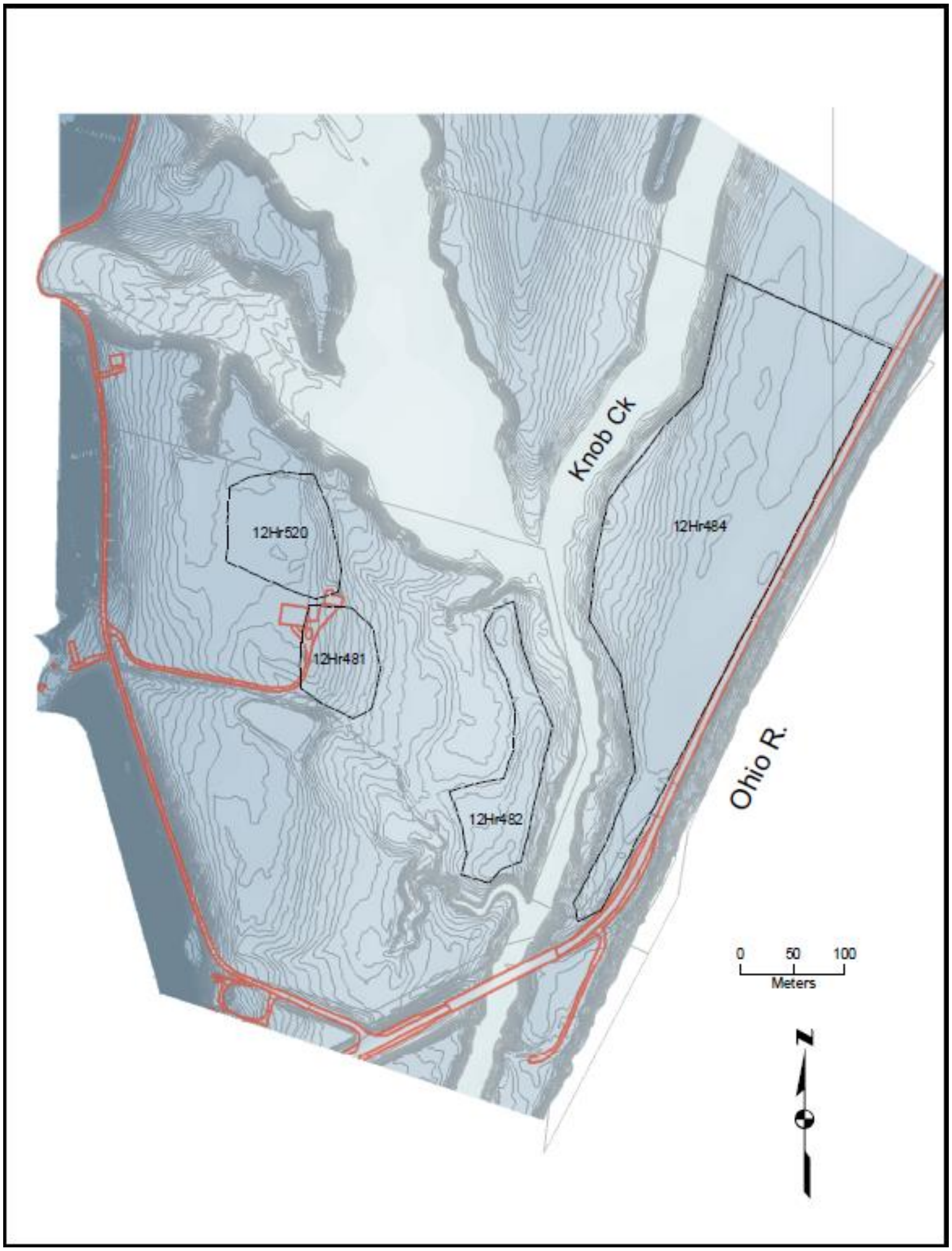


Figure 1.4: Boundaries of CAP and Four Archaeological Sites. The Knob Creek site (12Hr484) is the easternmost site within the project boundaries. From Stafford (2007c:157).

As a result of the preliminary Phase I analysis, it was determined that Phase II work should be conducted at six of the prehistoric sites, including the Knob Creek site (12Hr484). The Phase II work at the Knob Creek site accounted for a six percent sample of the entire site. Phase II testing included 2x2 meter hand-excavated units, mechanically stripped trenches and auger cores (Stafford et al. 2007:9).

A series of large-scale excavation blocks were spaced along the north-south axis of the site (Figure 1.5). The 100 and 200 level blocks were placed to sample Early and Middle Woodland cultural components. The Archaic components of the site were sampled by hand excavation in each of the four blocks. These components included Middle, Late, and Terminal Archaic components. Mechanical stripping accounted for the rest of the sampling that took place between excavation blocks. This occurred at five locations: 253N, 148N, 63N, 15N, and South Block.

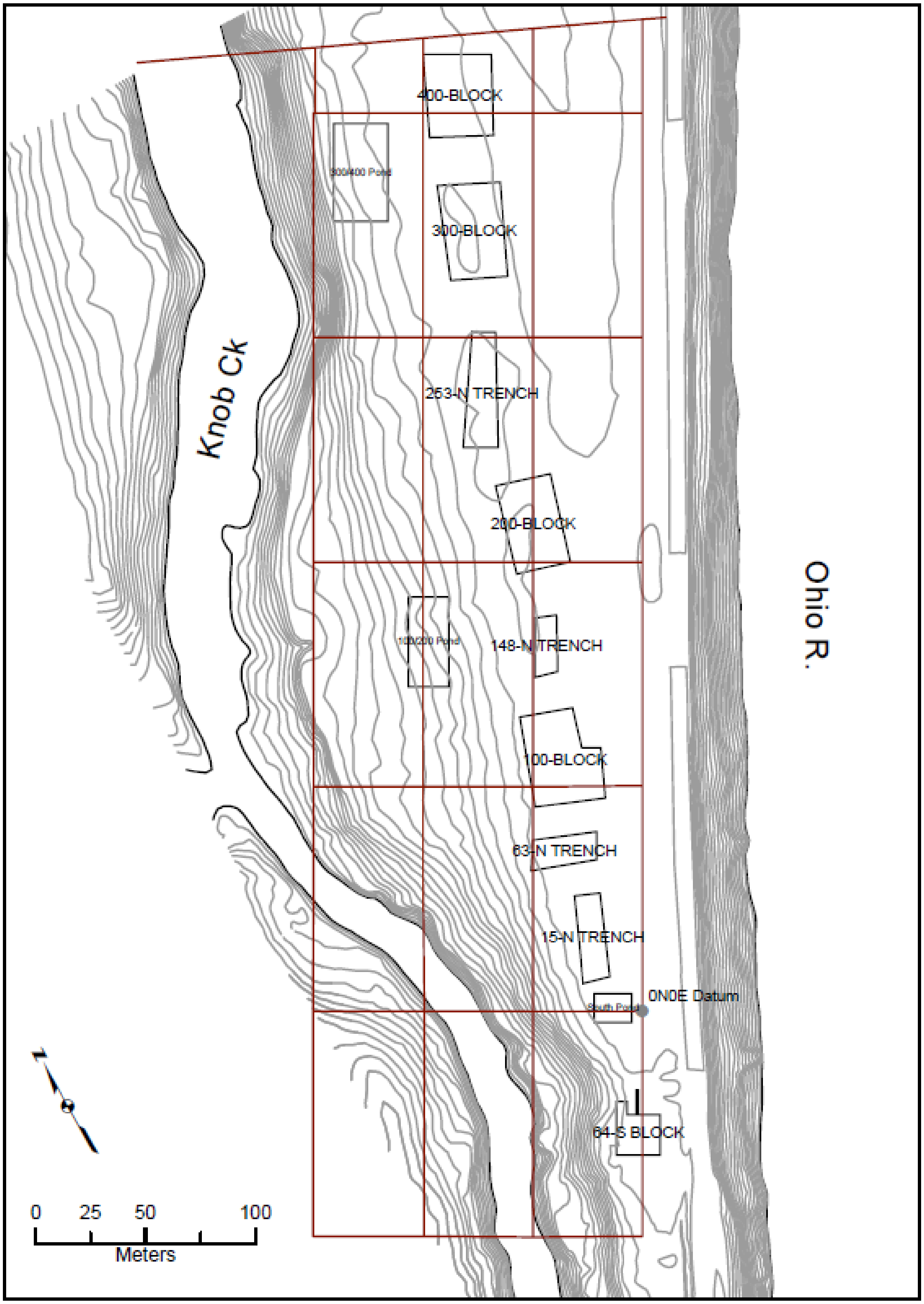


Figure 1.5: Excavation Blocks at Knob Creek Site (12Hr484). Stafford et al. 2007.

Site Layout at Knob Creek

The Lower Late Archaic component at Knob Creek provides a significant change in settlement type from the preceding Knob Creek phase. During the Lower Late Archaic, pits become the dominate feature type. Hearth-centered activities from the Knob Creek component are replaced by pit-centered activity areas (Stafford 2008b). Pits increase in frequency and become larger in volume. Lower Late Archaic pits clustered into large groups that appear to designate specific activity areas ranging between 6-10 meters in diameter.

In the Riverton component pit features decrease in volume but pit-hearth features increase in size. Pit-hearth features form a circular pattern during this time. Stafford (2008b:597) suggests that the change from pit-hearth clusters to pit-pit/hearth clusters from the LLA to the Riverton is part of a more general shift in settlement and subsistence strategies at this time. The spatial layout of the Knob Creek site changes due to a shift towards the bulk processing of subsistence materials during Riverton times (526).

The Early Woodland component is composed of 109 features (Mocas 2006:42). Pits, once again, are the most common feature type. Pit types include conical, basin, and steep-sided pits. Two conical pits found during this component contained large amounts of fire crack rock, pottery, and debitage. In contrast to previous components, two structures were uncovered. Both structures were identified by the presence of six post-molds. Post-molds show that the structures are unequal in size. Each of the structures found at Knob Creek were single-post, circular or semi-circular constructions (Mocas 2006:71). These constructions, along with the general increase in artifact density suggests that the Early Woodland occupants stayed at the site for a longer duration than their predecessors.

## Tools at Knob Creek

Excavations at the Knob Creek site recovered numerous types of artifacts, including various lithic tool types. Bifacial tools compose a significant portion of the lithic tools recovered during excavations at Knob Creek. Previous CAP analysis categorized bifaces into three stages that were meant to represent the final position of the artifact in the biface reduction sequence. Biface stage categories used by CAP were defined and developed by Callahan (1979). Callahan defined his biface stages based on a tool's degree of symmetry, sinuosity, cross-section, surface reduction, and retouch.

### Lower Late Archaic

Stone tools and their debris are least abundant during the Lower Late Archaic. Overall, 158 stone tools were recovered from Lower Late Archaic contexts at Knob Creek. The diversity of tools during this time included cores, bifaces, points, and retouched tools and flakes. The Lower Late Archaic differentiates itself from later times through the component's emphasis on hard-hammer tool industries. Despite this emphasis, approximately one-third of the assemblage is composed of bifacial tools. Stage III bifaces form the majority group during this time composing 71% of all bifaces (n=36) (Stafford 2008a:424). Stage III bifaces are generally narrow and thick with contracting bases and pointed proximal ends (Figure 1.6). Stage I forms account for 12% (n=6) of bifaces at this time, while Stage II forms account for 18% (n=9) of bifaces.

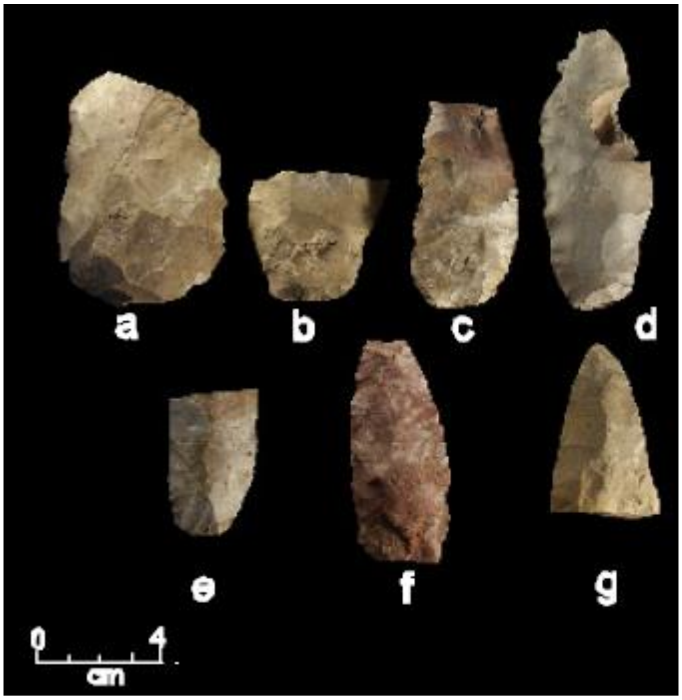


Figure 1.6: Lower Late Archaic Bifaces. Photo from Stafford (2008a:459).

Muldraugh chert dominates the assemblage during the Lower Late Archaic accounting for 70% of manufactured bifaces. Wyandotte chert accounts for the second most bifaces, composing only 16% of the assemblage. Stafford (2008a) notes that bifaces show less chert diversity in their manufacture when compared with other stone tool types during this time. Stafford suggests this is due to the need for high-quality chert to bring a biface blank through the biface reduction sequence. Chert quality then, may serve to limit a blank's reduction potential.

It is important to emphasize here that the Lower Late Archaic occupants of the Knob Creek site placed a greater emphasis on hard-hammer percussion tools and cores than later times. Hardstone artifacts accounted for 10% of the total lithic tool assemblage (Stafford 2008a:426). Additionally, there is generally less stone tool diversity than both the Riverton and Early Woodland components. This, combined with the low density of lithic tools, leads Stafford to argue that the site was used as a short-term, special function site during this time (2008a:430).

Riverton

Twice as many lithic tools were recovered from the Riverton component compared with the Lower Late Archaic. Additionally, the 1,057 Riverton lithic tools demonstrate greater variation in form. Bifaces are the dominant tool type comprising 42% of all stone tools. Stage III bifaces are the most common biface form, comprising 72% of excavated bifaces. The most standardized form at this time is a small (4-5 cm. long), leaf-shaped biface that likely was used as a preform for Riverton points (Figure 1.7) (Stafford 2008b:603). These preforms are similar to those described at Riverton sites by both Winters (1969) and Anslinger (1986). Stage I and II bifaces share approximately equal frequencies. As in the Lower Late Archaic, Stage III bifaces are made primarily of high-quality Muldraugh and Wyandotte cherts (61%). Meanwhile, high-quality cherts rank second in frequency for Stage II bifaces, and third for Stage I bifaces. These numbers suggest that raw material quality played an important role in determining how far in the biface reduction sequence a tool progressed. The Riverton assemblage sees a reduction in hardstone artifact (3.1%) frequencies from Lower Late Archaic times.

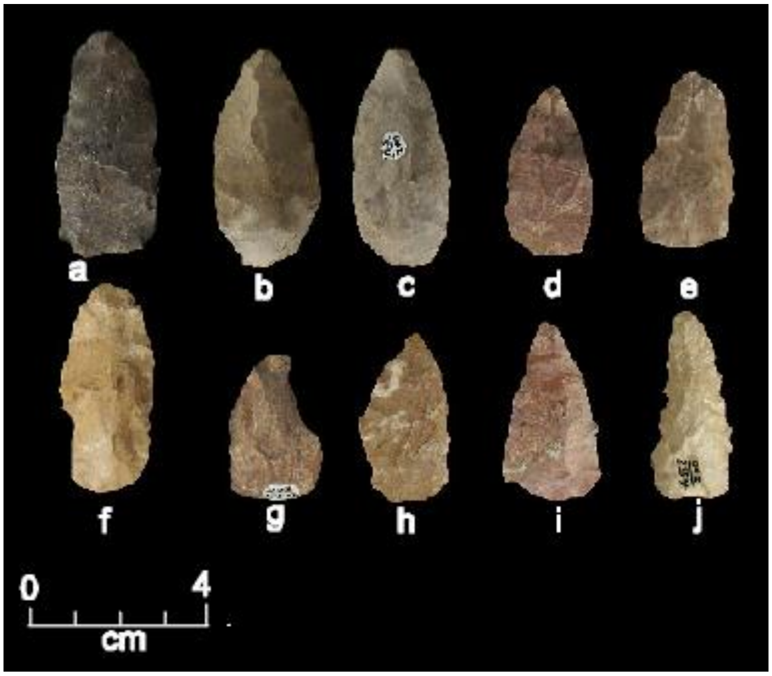


Figure 1.7: Riverton Stage III Bifaces (Stafford 2008a:471).

Early Woodland

Formal tools during the Early Woodland were primarily manufactured with Wyandotte chert. Early Woodland component projectile points primarily consist of those in the Early Woodland Contracting Stemmed points with a strong frequency of Turkey-tail points (Mocas 2006:145). Biface fragments (n=1,302) excavated during the Early Woodland component are once again primarily of the Stage III variety (n=770, 60%) (Figure 1.8). Stage II bifaces (n=347, 27%) are the second most-represented biface type, while only 13% of bifaces fall into the Stage I category (n=159). The small frequency of Stage I bifaces suggests that initial reduction and decortification were only minor components of the lithic reduction process at Knob Creek (Mocas 2006:171). This suggests that the Early Woodland site was not a workshop site. Instead, the high proportion of Stage III shows extensive manufacture and maintenance of formal tools during this time.

Muldraugh and Allens Creek cherts comprise 50% of Stage I bifaces (Mocas 2006:176), while 42% were manufactured from Wyandotte. For Stage II bifaces, Wyandotte chert accounts for 53% of the group with Muldraugh and Allens Creek accounting for 44%. For Stage III bifaces, 70.7% were manufactured with Wyandotte chert. The increase in the percentage of high-quality Wyandotte chert through biface stages suggests that chert quality played an important role in determining the biface reduction process.

Only 18 cores were recovered during the Early Woodland component. This means that most Wyandotte chert entered the site in reduced form as Stage I bifaces or quarry blanks (Mocas 2006:200). Moderate amounts of retouch on Wyandotte flakes appear to suggest that some effort was made to conserve the raw material because of the distance it took to obtain the high-quality chert.

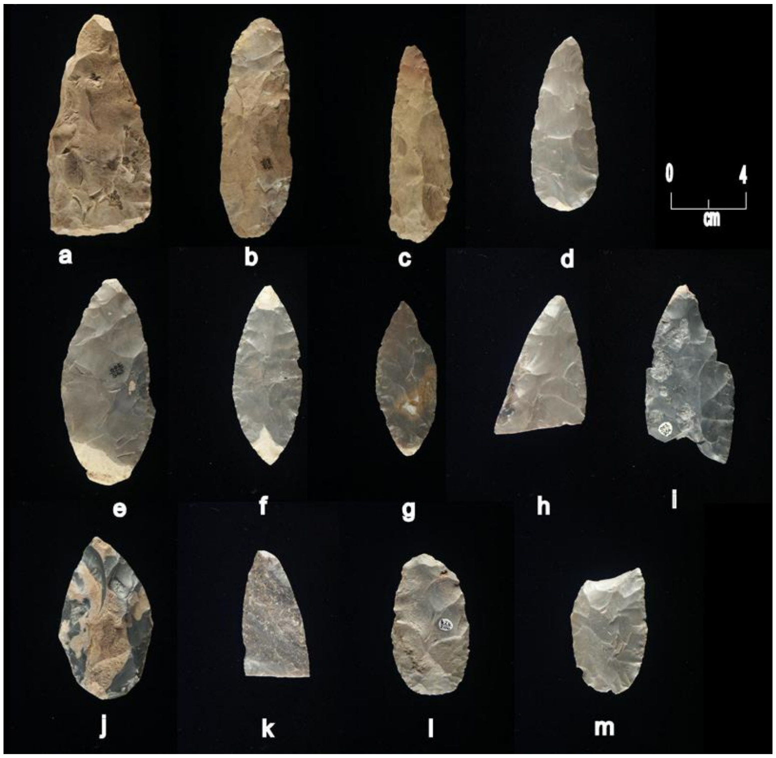


Figure 1.8: Early Woodland Stage II and Stage III Bifaces (Mocas 2006:371).

Previous Debitage Research at 12HR484

What makes analyzing the debitage at the Caesar's Archaeological Project so enticing is what has been found thus far through preliminary analytical methods. A total count for the debitage recovered at the CAP is unobtainable due to the large quantity. Estimates range in the millions. More than 1000kg of debitage have been recovered from the combined sites while one unit yielded over 30,000 pieces of debitage in a 10 cm level of a 2x2 m unit. The quantity of CAP debitage is by all means extraordinary. The overarching goal of the preliminary mass analysis was to identify relative degrees of tool reduction by examining size grades based on raw material type (Stafford 2007b:445). The presence or absence of cortex was recorded for Wyandotte chert debitage as an additional measure of relative reduction. Muldraugh and Allens Creek cherts lack cortex due to their bedded nature.

The results from this preliminary analysis have demonstrated some intriguing patterns. Debitage density nearly doubles in unit contexts from the Middle Archaic to the Late Archaic. Late Archaic (5500-3500 BP) flake ratios tend toward the early stages of the reduction sequence in both unit and feature contexts (Stafford 2007b:455). When broken down by chert type, both Muldraugh and Allens Creek cherts tend heavily toward the early stages of reduction in both units and features. Wyandotte chert debitage from units shows a strong early stage emphasis as 65% of flakes had cortex present. Only 29% of Wyandotte flakes from feature contexts had cortex present (Stafford 2007b:455). It is likely that trash disposal behaviors account for this difference as larger, early-stage reduction flakes were more likely to be removed from activity areas and disposed of in pits.

The Riverton component (3500-2700 BP) of the Terminal Archaic has the highest density of debitage recovered from any Archaic component (Stafford 2007b:456). Muldraugh chert dominates the lithic assemblage during this time. Trash disposal behavior again appears to be a factor as unit contexts show late stage reduction of Muldraugh chert while feature contexts show early stages of reduction. Wyandotte chert in unit contexts tend to trend towards the later stages in the reduction process. Cortical frequencies for Wyandotte chert are substantially less than all other Archaic components. Feature data, however, tells a different story, as cortical flakes (62%) and large flakes dominate. Allens Creek chert continues to have debitage densities approaching three to four times those of Wyandotte chert. As in previous components however, Allens Creek is far less prevalent than Muldraugh (Stafford 2007b:456). Allens Creek and all other chert types display a clear trend toward the early stages of reduction. These preliminary numbers suggest that, unlike in the Late Archaic, there is variation in lithic stage reduction based on raw material type.

While the Riverton component saw the highest density of debitage of any Archaic component, the amount of Early Woodland debitage is more than double the Riverton assemblage. This coincides with a general trend of population increase in the region. For the first time at the Knob Creek site, Muldraugh chert, with its convenient outcrop in the adjacent bluffs, is not the most abundant chert type. Wyandotte chert, making up 43% of the Early Woodland debitage assemblage, shows pronounced late stage reduction in both unit and feature contexts (Stafford 2007b:457) with fewer than 50% of flakes displaying cortex. Allens Creek and "Other cherts" continue to represent early stages of reduction. The switch to the semi-local Wyandotte chert in the Early Woodland period may suggest a change in lithic technology or a change in the size of the bifaces produced at Knob Creek.

## Summary

Bifacial technology during the Late Archaic to Early Woodland transition remains poorly understood in the Falls of the Ohio region. Recall that many sites in the region can be identified only as Late Archaic/Early Woodland as the two components are often indistinguishable. Additionally, Late Archaic materials in the area are commonly found in plowzone contexts. The CAP is well-suited for a bifacial lithic technology analysis for this time period. The Knob Creek site (12HR484) contains well-dated Late Archaic, Terminal Archaic, and Early Woodland components in secure contexts. Debitage flakes from Knob Creek alone number in the millions. Over thousands of years, the occupants of Knob Creek were able to make use of abundant, and local, Muldraugh and Allens Creek chert found in the bluffs beyond the site. These sources provided the Knob Creek occupants with medium to high-quality raw material for stone tools. By the Early Woodland, Wyandotte chert became the dominant raw material type as Stage III biface frequencies declined. Through a detailed flake-by-flake debitage analysis, I attempt to shed greater light on lithic technological change during this transitional time in the prehistory of the Falls of the Ohio.

## Chapter 2 - History of Lithic Analysis

Among hunter-gatherer groups of the distant past, formal stone tools and lithic byproducts are the most abundant artifact types. While hunter-gatherers utilized other forms of material culture (e.g. basket-making, cordage), lithic materials are all that remain from many Archaic Period sites in the Ohio River Valley. Lithic materials are ideally suited to examine issues of mobility, site function, and economic organization among Ohio River Valley peoples of the Late Archaic to Early Woodland transition.

One of the first researchers to attempt a systematic study of ancient stone tools was William Henry Holmes (1894). His goals were similar to archaeologists studying stone tools today. Holmes argued that lithic studies should be undertaken for use as chronological markers, to understand the evolution of forms and function, and to understand the processes of stone tool production. Formal lithic tool types are considered diagnostic traits of many cultures around the world. Archaeologists have also inferred the function of prehistoric archaeological sites based on the stone tools found at a given site (Bordes 1961; Goodyear 1974; Harold 1993).

The replication of stone tool forms beginning in the 1950s by Don Crabtree and Francois Bordes stimulated interest in the investigation of lithic tool production. These controlled experiments helped develop techniques for reduction sequence analysis and tool refitting analysis. George Frison (1968) was the first to explicitly state that stone tool shapes change throughout their uselife. Since tool morphology changes throughout uselife, it changed the way lithic researchers thought about static stone tool typologies as diagnostic cultural indicators. As a consequence of Frison (1968), researchers have begun to conceptualize stone tools as a dynamic, ever-changing entity that is directly related to mobility, economy, scheduling and exchange (Andrefsky 1998:4).

The early reproduction work of Crabtree (1967) and Bordes and Crabtree (1969) was heavily criticized as unscientific. These tended to focus more on the craft of flintknapping than the science of the lithic reduction process. Early flintknappers were able to draw attention to the range of lithic production variability but did so in non-controlled experiments (Thomas 1986; 1989). As reproduction experiments moved towards focusing on the by-products of stone tool manufacture, rather than the finished tool, this began to change. These experiments were seen as more scientific and gained greater acceptance within the archaeological community to provide behavioral information to lithic studies (Andrefsky 1986; 1998).

Debitage

Debitage is the most abundant artifact class in the archaeological record for the Late Archaic/Early Woodland transition in the Ohio River Valley. Analyzing debitage requires a number of different techniques implemented at varying scales. Due to the time constraints facing many researchers, debitage analyses today are predominately carried out as a part of a mass analysis at the population level (Ahler 1989). These aggregate analyses of debitage are conducted by stratifying an entire assemblage by a uniform criterion, most often size. By comparing relative frequencies between strata, a rough sketch of the debitage at a site can be observed in a time- and cost-effective manner (Ahler and VanNest 1985). The benefits of this type of study are obvious. Extremely large quantities of debitage can be processed quickly regardless of the size or shape of individual flakes. While aggregate studies have greatly advanced the field of debitage analysis by allowing for faster analysis, these studies mask much of the variation within any assemblage.

Typological approaches to lithic studies allow for the researcher to make immediate behavioral inferences about an archaeological site based upon individual flakes.  For example, if a bifacial thinning flake is recovered at a site, the researcher immediately can state with confidence that bifaces were thinned at the site even if no formal bifacial tools are recovered (Raab et al. 1979).  The idea that a single piece of debitage contains significant behavioral information about people of the distant past is an important reason why typological approaches must be utilized alongside aggregate methods (Andrefsky 1998).  Andrefsky (1998:134) makes the important argument that there is no ‘cook-book’ formula for studying a debitage assemblage.  This thesis follows Andrefsky’s lead in suggesting that the most convincing debitage arguments make use of both aggregate and flake-by-flake analyses.

Parry and Kelly’s (1987) landmark technological study demonstrates the importance of debitage in making behavioral inferences about the past.  In their study, the proportion of bifacial thinning flakes found in the total assemblage changes through time. They convincingly argue that the changes in biface technology relate to changes in mobility.  As groups become more sedentary, biface technology is replaced by more expedient forms of lithic tools.

The Biface Trajectory Model

Bifacial trajectory models are possible due to the fact that formal tools tend to have standardized forms (Johnson 1989:121). The standardization found in many formal tools is produced through a specific trajectory based on a sequence of stages. The biface trajectory begins when a knapper establishes a bifacial edge on a raw material. After the edge is established, the remaining cortex is removed, forming a 'preform'. A preform is a broad term used to describe the stage in which a complete biface edge is straightened. A preform in its early stages will then undergo thinning. The final stage of the biface trajectory comes when a thinned preform is reduced to a symmetrical and flat form. In its final formation, the biface will be used and retouched until it is discarded. Throughout this trajectory, the biface's length, width, and thickness progressively reduces. It is because of this continuous reduction that debitage can be utilized to approximate the trajectory length of a production sequence model.

By connecting a detailed debitage analysis to the finished bifacial products of a site it is possible to recreate the biface reduction system of the past. Through this recreation, it may be possible to understand a site's function due to the site's place in the bifacial reduction trajectory. Both flake size and attributes have been used to place debitage within biface production trajectories (Jefferies 1976; Ahler 1975). Raab, Cande and Stahle (1979) plotted distributions of debitage sizes and convincingly argued that that the length of a site's bifacial trajectory is related to site type. They found that long bifacial trajectories were more common with maintenance activity sites. Short bifacial trajectories were associated with short term special-extraction sites.

Site Function Models and Lithic Materials

Lewis Binford's (1977, 1978, 1980) work with the Nunamiut was groundbreaking in the sense that it brought human organizational factors to the forefront for archaeologists interested in studying prehistoric site function. Binford (1980) recognizes two kinds of hunter-gatherer organization that he viewed on a continuum. He writes that "logistical and residential variability are not to be viewed as opposing principles (although trends may be recognized) but as organizational alternatives which may be employed in varying mixes of different settings" (Binford 1980). For Binford, the difference between foragers and collectors (on opposite ends of the continuum) had to do with the type of mobility a group practiced. Mobility, likewise, was viewed by Binford as part of a continuum, placing residential and logistical mobility organizations at opposite ends of the continuum. When practicing residential mobility, the entire group moved from one location to the next. Logistically mobile groups had certain individuals or small groups of individuals move to certain locations for a specific purpose and then return to the main camp when the task is complete. Foragers practiced greater residential mobility while logistical mobility played only a minor role. Collectors make few residential moves, but make greater use of logistical mobility. While Binford's mobility models offer a convenient dichotomy, the diversity found amongst ethnographically known hunter-gatherers must not be forgotten (Kelly 1995). Binford's model must be interpreted as a continuum with foragers and collectors falling on opposite ends of the spectrum.

Assemblage Diversity and Site Function

Chatters (1987) utilized Binford's mobility models and expanded them to evaluate types of sites based on stone tool assemblage diversity. Chatters suggests that tool diversity will be high at base and residential camps while field camps, designed to process a specific resource, will be reflected by a lower number of specialized tools (1987:340). Chatters' reasoning makes sense as people who remain in a single place for a longer period time would likely be performing a wider array of tasks in that location.

Robert Kelly's (1983; 1995) work has brought much-needed attention to the issues of diversity within hunter-gatherer populations. He argues successfully that human mobility can be measured in many different ways. Kelly's studies demonstrate that residentially mobile groups of people move in different frequencies, at different average distances per move, and in overall distance traveled in an annual cycle. Shott (1986) similarly gathered ethnographic data from over a dozen hunter-gatherer groups in order to better understand the relationship between artifact diversity and group mobility. He found that artifact diversity was found to have an inverse relationship with residential mobility. As mobility increases, artifact diversity decreases. The forager-collector model theorizes different types of residences in a variety of combinations. Both types of hunter-gatherers utilize mobility strategies in different ways. Utilizing artifact diversity within a site's assemblage, it should be possible to reconstruct different site types. This thesis attempts to do so through a debitage analysis. In the case of debitage, it is expected that a wide variety of debitage sizes and flake types will be recovered at residential base camps, while special extraction sites will likely produce more homogenous flake types.

## Sedentism and Lithics

Sedentism in human populations has been a key issue in archaeological history. It develops alongside other major political and economic changes in a culture. In evolutionary trends, there has often been a connection between the transition to sedentism and the move form egalitarian to non-egalitarian, ascribed leadership, craft specialization, etc. That being said, sedentism, like mobility, is difficult to define (Kelly 1995:148). Generally speaking, sedentism is defined as when a population remains in the same location year-round (Andrefsky 1998:212). This becomes complex however when some of the population moves while others stay put. Most people would view our society today as a very sedentary society owing to the fact that most people remain in a place of residence year-round for years at a time. It is interesting to note however, that Americans are in fact extremely mobile people. We drive 30 miles to work, 5 miles to the grocery store, another 20 miles to the mall, etc. As you can see, even seemingly sedentary people do not remain in the same place during the course of the day. In many ways, people today are much more mobile than the residentially mobile hunter-gatherers of the past we study. Sedentism, like mobility, must never be conceptualized as an absolute state but instead on a continuum.

## Lithic Production Process

When thinking about sedentism, it must also be kept in mind that human groups are always complex entities. Even within a group of hunter-gatherers, it is very likely that some persons are more mobile while others are more sedentary. Lithic studies have played an important role in understanding sedentism in the past. A number of studies relate stone tool technology to residential sedentism (Andrefsky 1991; Henry 1989;

Morrow and Jefferies 1989; Parry and Kelly 1987; Shott 1986). These studies have demonstrated a link between the amount of energy expended upon the production process and the settlement strategies used by the tool makers. There is an important distinction between tools made with more effort (formal tools), and those produced through less energy-intensive processes (informal tools).

A key difference between expedient and formal stone tools is a matter of energy expenditure. The amount of energy expended upon stone tools tells the analyst much about the culture that produced it. Tools that are produced with little to no effort are expediently manufactured while, tools that took great amounts of energy are formal (Binford 1979; Kelly 1988). Formalized tools, such as a biface, go through a sequence of production stages (Callahan 1979; Whittaker 1994).

Formal tools take a greater amount of energy to produce and are manufactured to conform to a preconceived shape. This means that the formal tool could be produced from start to finish in one sitting, or it may pass through several resharpening episodes. The consistency of a tool's form is also a defining characteristic of formal tools, while informal tools are made with little regard for form. Formal tools have the advantage of being very flexible in use, can be easily rejuvenated when dull, and have the possibility for redesigning as different functions arise (Goodyear 1979:4). In fact, Parry and Kelly (1987) have demonstrated that more sedentary populations will have far fewer retouched flakes in the archaeological record. Archaeological sites created by more mobile populations will have more retouched flakes due to the importance of rejuvenation and conservation of raw materials. An easy example of a formal tool is a projectile point.

When archaeologists find a projectile point in the archaeological record they witness the end product of hundreds of individual decisions that went into the construction process, formal tools are often produced in anticipation of events that will occur in the future, but not always. For another example, consider prismatic blade technology. Prismatic blades are an example of a formal tool type in which great energy is expended and there is an emphasis on the replication of tool form. Prismatic blade production differs in that energy is expended in the preparation of a core.

Informal tools are on the opposite end of the spectrum in that little energy is expended and little emphasis is placed on standardization of form. Informal tools include those that have been expediently made. Binford (1979) characterizes expedient tools as situational gear. Situational gear is used in response to specific needs an individual encounters.

Parry and Kelly (1987) relate hunter-gatherer populations' stone tool technology with sedentism (Parry and Kelly 1987). They suggest that informal tools will be mostly associated with sedentary populations while formal tools will dominate in more mobile groups. The logic to this hypothesis is that highly mobile groups cannot risk running out of raw materials. Therefore, because they do not know definitively when they may next be able to procure materials, they will likely maximize the raw materials in their possession. The tools they will carry will need to be multifunctional, modifiable, and easily portable (Andrefsky 1998:214), each of these is a characteristic of formal tools. Sedentary populations are less likely to expend as much energy on the tool-making process because the uncertainty of not being able to find raw materials is not a problem.

Relatively sedentary groups then can manufacture and discard tools when situations arise and have no reason to be concerned about raw material availability. All of this assumes that local stone materials are readily available. Sedentary populations in areas with little in the way of knappable material will have to trade for raw materials. In this case, it is possible that sedentary populations would utilize technologies that maximize raw material usage as well.

### Raw Material Variability

The variability in lithic raw material sources can also have important effects on lithic tool production and mobility patterns. This variability most importantly includes how raw resources are distributed across a region and the quality of the raw materials. It is for these reasons that the identification of the raw material sources are of such importance to archaeologists. Geochemical techniques have advanced in recent years that determine the elemental composition of lithic artifacts. The importance of these techniques should not be overlooked, as elemental analyses offer important insights when macroscopic techniques are inadequate to determine an artifacts origin. The vast majority of raw material identification in this study, however, is based on macroscopic criteria.

### Summary

By identifying the types of lithic raw materials utilized, the quantities in which these raw materials were used, and where these raw materials are found in relation to an archaeological site, it is possible to begin to examine changes in hunter-gatherer groups over time. As Binford (1979) argues, tools are differently designed, used, and discarded based upon their intended role in the group's organization of technology. Two factors that influence a group's organization of technology are: 1) their settlement strategy and the resulting mobility patterns; as well as 2) the spatial distribution and quality of raw materials in the region.  Patterns that emerge in the debitage data may reflect variability in these two factors.  It is important to emphasize that these are not the only factors that affect how technology is produced in a society.  In fact, technological choice may be influenced by social aspects related to the production process and various other practical considerations of daily life.

## Chapter 3 - The Problem

This study attempts to compare the degree of bifacial reduction at the Knob Creek site by time period and chert type in order to better understand how different types of stone were differently utilized over the course of a three-thousand year period from the Late Archaic (5500 BP) through the Early Woodland (2200 BP). The transition from the Late Archaic to the Early Woodland has long been understood in cultural evolutionary terms. Archaic period peoples are typically portrayed as hunter-gatherers with high group mobility. As the Archaic progresses, hunter-gatherers become more adapted to their environment as group mobility slowly decreases by the end of the Archaic. The beginning of the Woodland period is marked by the sudden emergence of ceramic technology, sedentism, and the origins of gardening with domesticates. As more data have been collected in recent decades, these models do not hold. In fact, Late Archaic groups were experimenting with gardens. Additionally, Early Woodland groups continued to practice the same settlement patterns as their Late Archaic predecessors and projectile point types overlap these time periods. This transition from Archaic to Woodland is especially not well understood in the Falls of the Ohio region. Sites in the Falls region are oftentimes only classified as "Late Archaic/Early Woodland" due to the general difficulty in separating these two chronological assignments (Stafford 2007a). Early Woodland diagnostic points, Turkey-tail Dickson cluster points in particular, have recently been found in pre-ceramic sites. Conversely, Terminal Archaic Barbed Cluster points continue to be used well into the Early Woodland. Because these broad evolutionary trajectories do not hold, this thesis argues that archaeologists need to begin focusing on micro-regional perspectives to better understand the past.

The main objective of this study is to provide a fine-grained debitage analysis at the Archaic/Woodland transition to better make sense of this complicated transition in the Falls region. The stratigraphic sequencing at Knob Creek is ideal for such a study as it allows for the researcher to explore both changes in chert type and debitage size over time. In addition, this thesis also explores three other under-researched aspects of archaeology at the Falls of the Ohio.

Late Archaic sites of the Lower Ohio River Valley have long drawn the attention of scholars, however the dominant focus of this research has been almost exclusively on residential camp sites that have visible shell middens. Largely ignored until this point have been the shorter-term, pi*t*-centered occupations that have been found at the Knob Creek site. The Terminal Archaic, represented largely by the Riverton component at the Knob Creek site also is of significant interest. Winters' (1969) *The Riverton Culture* still stands as the most thorough analysis of this understudied culture. While Winters' Riverton component was defined in the Wabash Valley of Illinois, the Knob Creek site offers the first large sample of artifacts and features of secure context at the Falls of the Ohio. Excavations at the Knob Creek site yielded 300 Riverton projectile points and 79 features. An in-depth study of the Terminal Archaic Riverton component at the Knob Creek site can serve as an interesting comparison to Winters' shell-midden sites along the Wabash River. Lastly, there has been only one other extensive Early Woodland excavation in the Falls region. Detailed analysis of the Knob Creek site can add to this under-researched time period.

Objective

This study attempts to compare the degree of bifacial reduction by time period and chert type in order to better understand how different types of stone were utilized over the course of a three-thousand year period from the Late Archaic (5500 BP) through the Early Woodland (2200 BP).

Hypothesis 1: The debitage assemblage at Knob Creek will show change in technology through time. Technological change will occur between the Lower Late Archaic and Riverton components and between the Riverton and Early Woodland components.

If Hypothesis 1 is supported, I will expect to see differences in flake dimension variance and central tendency through time and by chert type. Additionally, I would expect to see changes in the frequencies and presence of non-metric attributes, most specifically bulb of percussion and platform lipping. Numerous studies have linked these two attributes to the identification of soft or hard hammer percussion (Crabtree 1972:74; Frison 1968:149). Fracture studies suggest that flakes with small bulb of percussion and pronounced lip are the result of bending forces during the flake's removal from the objective piece (Lawrence 1979; Tsirk 1979). If Hypothesis 1 is supported, I expect flake attributes to display varying frequencies over time and chert type.

Hypothesis 1a: The Riverton debitage assemblage at the Knob Creek site will show a similar microtool biface technology as Winters' Riverton component of the Wabash Valley (Winters 1969). I expect this due to the commonality previously observed between Riverton points at Knob Creek and Winters' sites in the Wabash Valley in Illinois.

If Hypothesis 1a is supported I will expect to see a general decrease in variance of flake dimensions during the Riverton component. When Winters identified this microtool tradition elsewhere in the mid-continent, he argued that the Riverton people created a bipolar percussion technological system based on the small size of chert river nodules in the region. The Knob Creek site differs in that high and medium-quality raw materials are abundant in the bluffs above the site. If the Riverton technological complex found in the Wabash Valley was merely a functional response to limited raw material availability, I would expect to see a different pattern at Knob Creek. If raw material availability was the limiting factor in the Wabash Valley, I would expect to Knob Creek flake variance to be comparable to both the Lower Late Archaic and Early Woodland components.

## Conclusion

The Caesar's Archaeological Project stands unmatched in its enormous quantity of debitage materials, estimated to be in the millions. Additionally, the stratigraphic sequencing allows for a fine-grained debitage analysis as clear delineations can be found and dated between Late Archaic, Terminal Archaic, and Early Woodland time periods. By examining chert use, flake dimensions, and flake attributes it is possible to better understand technological change through time.

# Chapter 4 - Methods

In order to address the objectives of this study I examined a sample of 2,620 complete flakes from the Knob Creek site. An appropriate sized sample was needed for each period that could be deemed statistically significant when analyzed. Hampering this process was the fact that the occupants of Knob Creek used the site to varying intensities from the Late Archaic through the Early Woodland. A proportional sampling strategy was utilized.

The flakes collected from the CAP number in the millions. A detailed flake-by-flake analysis has not been conducted prior to this study. Characteristics of the population of debitage from the site are known from a mass analysis that was conducted by Russell Stafford (2007b). A detailed review of the results of the debitage mass analysis was covered in Chapter 1.

## Methods for this Study

A total of 2,620 flakes were selected as a sample for this study. In choosing the flakes to study for this analysis it was important to keep a number of things in mind. For example, because the previous mass analysis discovered that debitage densities of the Early Woodland were double that of the Riverton component, a sample was taken in which there were roughly double the amount of Early Woodland flakes to Riverton flakes. Next, context was also a major consideration when selecting a sample for analysis. Previous mass analysis demonstrated that feature contexts displayed larger debitage sizes than hand-excavated unit contexts. This is likely due to cleanup behavior as Knob Creek's prehistoric occupants would easily pick up and dispose of the largest debitage flakes while small flakes escaped their reach. Approximately half of all flakes, for each time period and chert type, came from each kind of context. This does not represent a proportional sampling strategy because it is unknown if equal amounts of flakes came from features and units during excavations. The last major consideration prior to taking the sample was how to ensure representativeness. A systematic sample was randomized with a random number generator to determine which flakes would be selected from a given context. I wanted to make sure that each flake within a sampling stratum had an equal chance of being selected.

As part of the mass analysis, flakes from each provenience were divided and bagged according to chert type (Muldraugh, Wyandotte, Allens Creek, and Other) and size (2", 1", ½", ¼"). The sample for this study was taken only from proveniences that have already been mass analyzed. With the help of Russell Stafford, I was able to specifically target features and units that contained debitage from the three time periods of interest.

When a feature or unit was selected through randomly generated numbers, all bags (of all chert types and sizes) from the provenience were emptied and laid out on a table. Then, a randomized systematic sample was conducted as a random number generator was again used to select a number between 1 and 5. I then counted down the line of flakes and selected the one that the number dictated. No matter what the original random number was, I then selected every fifth flake and placed them in separate bags. For the purposes of this study only complete flakes were used. When the debitage piece to be selected for the study was an incomplete flake, the next immediate whole flake in line was selected for analysis. The five count would then start at the flake that was selected. No matter how many or few flakes happened to be in a bag for the selected provenience, each flake had an equal opportunity of being selected.

After the sample had been selected the next consideration was what attributes to measure on the selected flakes? The goal of this study is to examine changing patterns in debitage size and technology. This allowed for two different options. The first option was to analyze the debitage assemblage utilizing a typological analytical approach. This stage approach lumps flakes into a small number of categories in the biface reduction process. These categories often include: initial biface reduction flakes, biface thinning flakes and biface finishing flakes. The stage approach is acceptable if the goal of the analysis is to simply reconstruct the tools and techniques that were used at a given site. However, the stage approach masks a great deal of variability in a debitage assemblage by lumping flakes into only few different categories. When a more precise measure of the lithic reduction at a site is desired, as it is in this case, a continuum approach is better suited.

The continuum approach is the driving force behind this study. Rather than masking variation within categories of flakes, the continuum approach allows the researcher to not place flakes into artificially made categories. In the continuum approach, metric attributes of flakes are recorded. A statistical analysis can then be performed in order to compare one time period, or raw material, type against another.

In order to obtain the needed flake morphological characteristics to carry out a metric study of lithic reduction, six variables were selected for measurement. The goal in choosing these variables was to obtain measurements that best represented overall flake size. Each of the 2,620 flakes were measured for ratio scale data of flake length, width, and thickness to the nearest hundredth of a millimeter. Additionally, platform width and platform thickness dimensions were recorded to the nearest hundredth of a millimeter. Lastly, flake weight was recorded to the nearest tenth of a gram. These measurements were taken for each flake and recorded in an Excel spreadsheet.

*T*-Test, *F*-Test, and ANOVA

Quantitative methods, including the Analysis of Variance (ANOVA), *t*-test, and *F*-test were utilized in order to compare variation resulting from the numerous flake variables (e.g. flake length, width, etc.). The two sample *t*-test is the most common statistical tool used for hypothesis testing. This test evaluates the probability that two independent datasets have mean value differences at a statistically significant level. The difficulty with applying a two-sample *t*-test to this project is the provision that datasets must be normally distributed. Histograms are an easy way to evaluate whether or not a dataset is normally distributed. In the histograms I present below, I will demonstrate that the simple, two-sample *t*-test to evaluate means is not appropriate for the purposes of this study. However, after *F*-tests are performed, it is possible to perform a series of *t*-tests that do not assume equal variance between datasets.

The ANOVA is built upon the *F*-distribution and provides a conceptual framework to compare means (VanPool and Leonard 2011:153). A Model II ANOVA is utilized here as differences found in the dataset are not introduced experimentally, but can be empirically observed. Differences in debitage size may reflect various forms of raw material use and discard. It is possible to test the difference in variable means by setting up a null hypothesis based on time period H0: μLLA = μRiv = μEW or chert type H0: μMuld = μWy = μAC = μOth. To do this, the ANOVA compares population variance amongst groups. To perform an ANOVA, the average variance within groups must first be calculated by averaging the difference from each variate to its own group's mean. If the null hypothesis is true, then the average of the within group variance should be an appropriate estimate of the population variance. Another estimate of the population variance is the referred to as the variance among means. Variance among means reflects the variation of means around the grand mean (VanPool and Leonard 2011:157). By calculating the variance within groups and the variance among groups, both estimates for the population variance of a dataset, it is then possible to evaluate the null hypothesis. If the null hypothesis is true, then both population variance estimates should be roughly similar. For example, if mean flake length values are equal between time periods, then both population variance estimates should be roughly the same. If there is a great degree of difference between population variance estimates, the null hypothesis is likely not supported. Greater among-group variance over within group variance suggests that variable means are more greatly dispersed. By measuring the population variance of the dataset we are actually examining the relationship of means.

The *F*-distribution provides a method for evaluating whether the among-group variance and within-group variance reflect the same population (VanPool 2011:160). The *F*-distribution is constructed based on the idea that both calculated variances are roughly equal. When one sample variance is divided by the other, the resulting *F*-distribution should have an average close to 1. The normal *F*-distribution allows for the measure of probabilities associated with the relationship between two variances (VanPool and

Leonard 2011:161). If the ratio of two variances deviates greatly from 1, the null hypothesis can then be rejected. The larger the sample size, the closer the ratio between two variances should approach a value of 1.

While the driving force of this study is a metric analysis, it was also beneficial to record nominal and ordinal scale data as well. When conceptualizing methods to analyzing debitage, continuum and typological approaches should not be seen as mutually exclusive. Instead, when possible, these two approaches should be used to complement one another. The most convincing lithic studies make use of both. For example, nominal scale data can be important in informing the researcher about certain types of behavior. It can also offer clues as to the general stage in the reduction process a given flake was removed. The presence of cortex is likely to be found on initial reduction flakes, platform lipping is oftentimes found on biface thinning flakes, and abraded platforms will be found on biface finishing flakes. Flake attribute data can offer a researcher a wealth of potential information. These data were recorded for each flake as follows.

Bulb of percussion was measured for each flake on an ordinal scale of 1 to 5. Flakes defined with a value of 1 had no visible bulb of percussion. Bulbs with a value of 2 had only a very small bulb. Values of 3 were considered medium bulbs with values of 4 having large bulbs. Values of 5 were reserved for only the largest bulbs. The presence or absence of platform lipping was recorded as was the presence or absence of cortex. Distal termination was examined and each flake was recorded as either feathered (smooth termination), hinged (when force rolls away from the objective piece), or plunging (when impact force rolls towards objective piece). Platform type, also a nominal scale of measurement, follows Andrefsky's (1998) definitions. Platform types were recorded as cortex, flat, complex, or abraded. Finally, flake type was recorded based on the researcher's interpretation of the entirety of variables. Flake types include initial reduction flakes, biface reduction flakes, biface thinning flakes, and biface finishing flakes (Table 4.1).

Possible Limitations

One issue that must to taken into account while analyzing this sample of the assemblage is the role disposal behaviors played in the site formation processes. All features that are analyzed in this study are garbage-filled pit features. Debitage found in secondary contexts such as these cannot be compared directly to those found at activity area locations. The size of the flakes likely plays an important role in whether or not it was picked up and thrown into a trash pit in the first place. I expect to find that activity areas display smaller debitage size when compared to feature contexts.

Another issue that that must be considered in this analysis is Winters' (1969) documentation of a microtool technology associated with the Riverton culture. The focus of this study is based entirely on bifacial reduction. If the Riverton occupants of Knob Creek were using bipolar percussion to maximize raw materials, it will not be included in this study. It is important to be aware of Winters' (1969) results in order to make better interpretations in this study.

Conclusions

A proportional sample of flakes was taken with regard to time period and raw material type. I utilized a randomized systematic sampling strategy by using a random number generator in order to determine which flake to select first from a given sampling stratum. From there, every fifth flake was selected and bagged as part of the sample. Metric variables were recorded in order to best capture flake size while nonmetric and attribute data were recorded as a method to supplement the continuum approach.

Table 4.1: Definitions of Flake Types.

| Flake Type | Description |
|---|---|
| Initial Reduction Flake | Produced from hard-hammer percussion; thick; display cortex on dorsal surface; large, flat or cortex platforms. |
| Biface Reduction Flake | Produced from hard- or soft-hammer percussion; thick; may display dorsal cortex; flat platforms; display more dorsal scars than initial reduction flakes. |
| Biface Thinning Flake | Produced from soft-hammer percussion; no cortex; thin; have small, complex or abraded platforms; curved profile; multi-directional dorsal scars. |
| Biface Finishing Flake | Produced from pressure flaking; smaller and thinner than biface thinning flakes; produced during the edge preparation of a biface tool; abraded platforms. |

# Chapter 5 - Data Results

All data were analyzed using the IBM SPSS Statistics 19 package. A total of 2,620 complete flakes were measured as part of this study. This chapter discusses the results of attribute, descriptive, and principle component analyses undertaken on the dataset.

## Non-Metric Data

In order to better understand technological change through time, non-metric data were collected for the presence of lipping and prominence of the bulb of percussion for each flake. The presence of cortex could not be used to analyze the assemblage as it was only recognizable for Wyandotte chert. The presence of lipping has been used elsewhere to infer the nature of direct percussion (i.e. hard-hammer percussion vs. soft-hammer percussion) (Crabtree 1972:74; Frison 1968:149). Experimental research in lithic technology has demonstrated that the degree of bulb of percussion is also related to the nature of percussion. Hard hammer percussion flakes are generally understood to produce flakes with lower frequencies of lipping along with larger bulbs of percussion when compared to soft hammer percussion flakes. The following section reviews the data generated in this study, focusing on these two non-metric flake attributes.

### Lipping

All 2,620 flakes analyzed in this study were examined for the presence or absence of platform lipping. Table 5.1 shows the presence or absence of lipping based on time period. Because different time periods in this study have different sample sizes, it is inappropriate to look simply at the raw frequencies. Instead, I chose to highlight the percentages of lipping presence during each time period. It is interesting to note that the presence of lipping increases through time. The presence of lipping is found on 27.2% of Lower Late Archaic flakes, 34.3% of Riverton flakes, and 42.4% of Early Woodland flakes (Table 5.1).

Table 5.1: Lipping Data by Time Period. Notice the increase in lipping presence through time.

| Period | N | Lipping | Frequency | Percent |
|---|---|---|---|---|
| Lower L. Archaic | 547 | - | 398 | 72.8 |
| | | + | 149 | 27.2 |
| | | | | |
| Riverton | 755 | - | 496 | 65.7 |
| | | + | 259 | 34.3 |
| | | | | |
| E. Woodland | 1318 | - | 759 | 57.5 |
| | | + | 559 | 42.4 |

Lipping data was also analyzed to determine if there was variation between unit and feature contexts. The results are presented in Table 5.2. Context appears to matter little in both the Riverton and Early Woodland components as there is approximately only a 2% difference in lipping presence between contexts. The Lower Late Archaic component is different as lipping presence for feature contexts is at 23.5%, while presence for units is 31.4%. Additionally, unit contexts show greater lipping presence in the Lower Late Archaic and the Early Woodland. The Riverton component shows the opposite trend as feature contexts have a slightly greater lipping presence.

Table 5.2: Lipping Data by Time Period and Context.

| Period | Context | N | Lipping | Frequency | Percent |
|---|---|---|---|---|---|
| Lower L. Archaic | Features | 289 | - | 221 | 76.5 |
| | | | + | 68 | 23.5 |
| | Units | 258 | - | 177 | 68.6 |
| | | | + | 81 | 31.4 |
| Riverton | Features | 363 | - | 234 | 64.5 |
| | | | + | 129 | 35.5 |
| | Units | 392 | - | 262 | 66.8 |
| | | | + | 130 | 33.2 |
| E. Woodland | Features | 649 | - | 382 | 58.9 |
| | | | + | 267 | 41.1 |
| | Units | 669 | - | 377 | 56.3 |
| | | | + | 292 | 43.6 |

Table 5.3 provides lipping data broken down by time period and flake type. It is not surprising to see generally low frequencies of lipping associated with initial reduction flakes. Most initial reduction flakes are removed by hard hammer percussion in an effort to remove cortex or reduce a chert nodule into a manageable size and shape. Table 5.3 shows that biface reduction, thinning, and finishing flakes all show increased lipping through time. In fact, in the Early Woodland period, over 50% of thinning and finishing flakes have lipping present.

Table 5.3: Lipping Data by Flake Type.

| Period | N | Flake Type | Lipping | Frequency | Percent |
|---|---|---|---|---|---|
| Lower Late Archaic | 547 | Initial | - | 63 | 94 |
| | | | + | 4 | 6 |
| | | Reduction | - | 158 | 78.6 |
| | | | + | 43 | 21.4 |
| | | Thinning | - | 135 | 62.5 |
| | | | + | 81 | 37.5 |
| | | Finishing | - | 42 | 66.7 |
| | | | + | 21 | 33.3 |
| | | | | | |
| Riverton | 755 | Initial | - | 46 | 85.2 |
| | | | + | 8 | 14.8 |
| | | Reduction | - | 198 | 75.3 |
| | | | + | 65 | 24.7 |
| | | Thinning | - | 179 | 58.9 |
| | | | + | 125 | 41.1 |
| | | Finishing | - | 73 | 54.5 |
| | | | + | 61 | 45.5 |
| | | | | | |
| E. Woodland | 1318 | Initial | - | 97 | 89 |
| | | | + | 12 | 11 |
| | | Reduction | - | 316 | 72.1 |
| | | | + | 121 | 27.7 |
| | | Thinning | - | 258 | 44.3 |
| | | | + | 324 | 55.7 |
| | | Finishing | - | 88 | 46.3 |
| | | | + | 102 | 53.7 |

Table 5.4 presents lipping data based on time period and chert type. Muldraugh chert is the dominant raw material at the Knob Creek site, showing up in the greatest quantities. Wyandotte chert is the most utilized raw material during the Early Woodland period. Not surprisingly then, the presence of lipping for both Muldraugh and Wyandotte

chert increases through time. In fact, lipping presence for Muldraugh and Wyandotte chert closely mirrors the general increase in lipping by time period seen in Table 5.1.

Table 5.4. Lipping Data by Chert Type.

| Period | N | Chert Type | Lipping | Frequency | Percent |
|---|---|---|---|---|---|
| Lower L. Archaic | 547 | Muldraugh | - | 242 | 72.7 |
| | | | + | 91 | 27.3 |
| | | Wyandotte | - | 35 | 70 |
| | | | + | 15 | 30 |
| | | Allens Creek | - | 64 | 74.4 |
| | | | + | 22 | 25.6 |
| | | Other | - | 57 | 73.1 |
| | | | + | 21 | 26.9 |
| | | | | | |
| Riverton | 755 | Muldraugh | - | 396 | 64.7 |
| | | | + | 216 | 35.3 |
| | | Wyandotte | - | 30 | 65.2 |
| | | | + | 16 | 34.8 |
| | | Allens Creek | - | 50 | 75.8 |
| | | | + | 16 | 24.2 |
| | | Other | - | 20 | 64.5 |
| | | | + | 11 | 35.5 |
| | | | | | |
| E. Woodland | 1318 | Muldraugh | - | 282 | 56.8 |
| | | | + | 213 | 43 |
| | | Wyandotte | - | 347 | 55.2 |
| | | | + | 282 | 44.8 |
| | | Allens Creek | - | 111 | 70.3 |
| | | | + | 47 | 29.7 |
| | | Other | - | 19 | 52.8 |
| | | | + | 17 | 47.2 |

Table 5.5 compiles lipping data broken down by time period, flake type, and chert type. Muldraugh thinning flakes demonstrate some of the greatest change over time in the dataset. In the Lower Late Archaic only 38.9% of these flakes show evidence of

platform lipping. In the Riverton component, 40.2% of flakes have platform lipping. By the Early Woodland component, 57.8% of flakes have lipping.  That is close to a 44% increase in lipping presence in the Early Woodland component, likely demonstrating a change in lithic reduction process.

Table 5.5: Lipping Data by Time Period, Flake Type, and Chert Type.

| Period | N | Flake Type | Chert Type | Lipping | Frequency | Percent |
|---|---|---|---|---|---|---|
| Lower L. Archaic | 547 | Initial | Muldraugh | - | 35 | 97.2 |
| | | | | + | 1 | 2.8 |
| | | | Wyandotte | - | 4 | 100 |
| | | | | + | 0 | 0 |
| | | | Allens Creek | - | 14 | 87.5 |
| | | | | + | 2 | 12.5 |
| | | | Other | - | 10 | 90.9 |
| | | | | + | 1 | 9.1 |
| | | | | | | |
| | | Biface Reduction | Muldraugh | - | 91 | 81.3 |
| | | | | + | 21 | 18.8 |
| | | | Wyandotte | - | 140 | 70.7 |
| | | | | + | 58 | 29.3 |
| | | | Allens Creek | - | 32 | 74.4 |
| | | | | + | 11 | 25.6 |
| | | | Other | - | 6 | 100 |
| | | | | + | 0 | 0 |
| | | | | | | |
| | | Thinning | Muldraugh | - | 91 | 81.3 |
| | | | | + | 58 | 38.9 |
| | | | Wyandotte | - | 12 | 75 |
| | | | | + | 4 | 25 |
| | | | Allens Creek | - | 12 | 60 |
| | | | | + | 8 | 40 |

Table 5.5 (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Other | - | 20 | 64.5 |
| | | | | + | 11 | 35.5 |
| | | | | | | |
| | | Finishing | Muldraugh | - | 25 | 69.4 |
| | | | | + | 11 | 30.6 |
| | | | Wyandotte | - | 5 | 50 |
| | | | | + | 5 | 50 |
| | | | Allens Creek | - | 6 | 85.7 |
| | | | | + | 1 | 14.3 |
| | | | Other | - | 6 | 60 |
| | | | | + | 4 | 40 |
| | | | | | | |
| Riverton | 755 | Initial | Muldraugh | - | 31 | 88.6 |
| | | | | + | 4 | 11.4 |
| | | | Wyandotte | - | 0 | 0 |
| | | | | + | 0 | 0 |
| | | | Allens Creek | - | 12 | 92.3 |
| | | | | + | 1 | 7.7 |
| | | | Other | - | 0 | 0 |
| | | | | + | 0 | 0 |
| | | | | | | |
| | | Biface Reduction | Muldraugh | - | 152 | 73.4 |
| | | | | + | 55 | 26.6 |
| | | | Wyandotte | - | 16 | 88.9 |
| | | | | + | 2 | 11.1 |
| | | | Allens Creek | - | 18 | 75 |
| | | | | + | 6 | 25 |
| | | | Other | - | 12 | 85.7 |
| | | | | + | 2 | 14.3 |

Table 5.5 (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Thinning | Muldraugh | - | 149 | 59.8 |
| | | | | + | 100 | 40.2 |
| | | | Wyandotte | - | 9 | 50 |
| | | | | + | 9 | 50 |
| | | | Allens Creek | - | 15 | 65.2 |
| | | | | + | 8 | 34.8 |
| | | | Other | - | 6 | 42.9 |
| | | | | + | 8 | 57.1 |
| | | | | | | |
| | | Finishing | Muldraugh | - | 61 | 53 |
| | | | | + | 54 | 47 |
| | | | Wyandotte | - | 5 | 50 |
| | | | | + | 5 | 50 |
| | | | Allens Creek | - | 5 | 83.3 |
| | | | | + | 1 | 16.7 |
| | | | Other | - | 2 | 66.7 |
| | | | | + | 1 | 33.3 |
| | | | | | | |
| E. Woodland | 1318 | Initial | Muldraugh | - | 31 | 88.6 |
| | | | | + | 4 | 11.4 |
| | | | Wyandotte | - | 31 | 93.9 |
| | | | | + | 2 | 6.1 |
| | | | Allens Creek | - | 30 | 85.7 |
| | | | | + | 5 | 14.3 |
| | | | Other | - | 5 | 83.3 |
| | | | | + | 1 | 16.7 |
| | | | | | | |
| | | Biface Reduction | Muldraugh | - | 120 | 73.2 |
| | | | | + | 44 | 26.8 |
| | | | Wyandotte | - | 140 | 70.7 |
| | | | | + | 58 | 29.3 |

Table 5.5 (continued)

| | | | | | |
|---|---|---|---|---|---|
| | | Allens Creek | - | 50 | 72.5 |
| | | | + | 19 | 27.5 |
| | | Other | - | 6 | 100 |
| | | | + | 0 | 0 |
| | | | | | |
| | Thinning | Muldraugh | - | 98 | 42.2 |
| | | | + | 134 | 57.8 |
| | | Wyandotte | - | 132 | 45.4 |
| | | | + | 159 | 54.6 |
| | | Allens Creek | - | 22 | 56.4 |
| | | | + | 17 | 43.6 |
| | | Other | - | 6 | 30 |
| | | | + | 14 | 70 |
| | | | | | |
| | Finishing | Muldraugh | - | 33 | 51.6 |
| | | | + | 31 | 48.4 |
| | | Wyandotte | - | 44 | 41.1 |
| | | | + | 63 | 58.9 |
| | | Allens Creek | - | 9 | 60 |
| | | | + | 6 | 40 |
| | | Other | - | 2 | 50 |
| | | | + | 2 | 50 |

Bulb of Percussion

All flakes were evaluated for prominence of bulb of percussion. By analyzing trends in bulb of percussion prominence through time, chert type, and flake type, this data complements lipping data in providing evidence for technological change through time. Table 5.6 presents data for bulb of percussion by time period. Looking exclusively at bulbs with a value of 1 (least prominent bulbs), there is a slight increase in percentage through time. Table 5.7 examines bulb of percussion by chert type. Muldraugh chert is found in the greatest quantities at the site and shows a slight increase in the percentage of bulb=1 (no bulb of percussion present) values through time. Table 5.8 presents bulb of percussion data by flake type. Thinning flakes demonstrate an increase in bulb=1 values through time. Thinning flakes with a bulb=1 value occur at a rate of 48.6% in the Lower Late Archaic. By the Riverton component, bulb=1 values increase slightly to make up 52.3% of the assemblage. The Early Woodland component has 59.5% of its thinning flakes with a bulb of percussion value of 1.

Table 5.9 examines prominence of bulb of percussion broken down by time period and context. Through time, there is an overall increase in the percentage of flakes with prominence values of 1. This increase occurs in both feature and unit contexts. Feature contexts have a higher percentage of bulb=1 values than unit contexts in each time period. It is unclear as to why feature contexts were more likely to have smaller bulbs of percussion. Additionally, it is interesting that the Riverton component shows the least difference between site contexts in terms of bulb=1 values (features=47.4%, units=45.7%).

Table 5.6. Bulb of Percussion Data by Time Period.

| Period | N | Bulb of Percussion | Frequency | Percent |
|---|---|---|---|---|
| Lower L. Archaic | 547 | 1 | 232 | 42.4 |
| | | 2 | 177 | 32.4 |
| | | 3 | 101 | 18.5 |
| | | 4 | 30 | 5.5 |
| | | 5 | 7 | 1.3 |
| | | | | |
| Riverton | 755 | 1 | 351 | 46.5 |
| | | 2 | 250 | 33.1 |
| | | 3 | 115 | 15.2 |
| | | 4 | 32 | 4.2 |
| | | 5 | 7 | 0.9 |
| | | | | |
| E. Woodland | 1318 | 1 | 674 | 51.1 |
| | | 2 | 396 | 30 |
| | | 3 | 174 | 13.2 |
| | | 4 | 60 | 4.6 |
| | | 5 | 14 | 1.1 |

Table 5.7. Bulb of Percussion by Chert Type.

| Period | N | Chert Type | Bulb of Percussion | Frequency | Percent |
|---|---|---|---|---|---|
| Lower L. Archaic | 547 | Muldraugh | 1 | 131 | 39.3 |
| | | | 2 | 115 | 34.5 |
| | | | 3 | 60 | 18 |
| | | | 4 | 22 | 6.6 |
| | | | 5 | 5 | 1.5 |
| | | | | | |
| | | Wyandotte | 1 | 19 | 38 |
| | | | 2 | 13 | 26 |
| | | | 3 | 14 | 28 |
| | | | 4 | 4 | 8 |
| | | | 5 | 0 | 0 |
| | | | | | |
| | | Allens Creek | 1 | 41 | 47.7 |
| | | | 2 | 27 | 31.4 |
| | | | 3 | 15 | 17.4 |
| | | | 4 | 2 | 2.3 |
| | | | 5 | 1 | 1.2 |
| | | | | | |
| | | Other | 1 | 41 | 52.6 |
| | | | 2 | 22 | 28.2 |
| | | | 3 | 12 | 15.4 |
| | | | 4 | 2 | 2.6 |
| | | | 5 | 1 | 1.3 |
| | | | | | |
| Riverton | 755 | Muldraugh | 1 | 291 | 47.5 |
| | | | 2 | 199 | 32.5 |
| | | | 3 | 88 | 14.4 |
| | | | 4 | 29 | 4.7 |
| | | | 5 | 5 | 0.8 |
| | | | | | |
| | | Wyandotte | 1 | 17 | 37 |
| | | | 2 | 18 | 39.1 |
| | | | 3 | 8 | 17.4 |
| | | | 4 | 3 | 6.5 |
| | | | 5 | 0 | 0 |

Table 5.7 (continued)

| | | | | | |
|---|---|---|---|---|---|
| | | Allens Creek | 1 | 31 | 47 |
| | | | 2 | 21 | 31.8 |
| | | | 3 | 12 | 18.2 |
| | | | 4 | 0 | 0 |
| | | | 5 | 2 | 3 |
| | | | | | |
| | | Other | 1 | 12 | 38.7 |
| | | | 2 | 12 | 38.7 |
| | | | 3 | 7 | 22.6 |
| | | | 4 | 0 | 0 |
| | | | 5 | 0 | 0 |
| | | | | | |
| E. Woodland | 1318 | Muldraugh | 1 | 253 | 51.1 |
| | | | 2 | 146 | 29.5 |
| | | | 3 | 72 | 14.5 |
| | | | 4 | 19 | 3.8 |
| | | | 5 | 5 | 1 |
| | | | | | |
| | | Wyandotte | 1 | 311 | 49.4 |
| | | | 2 | 194 | 30.8 |
| | | | 3 | 80 | 12.7 |
| | | | 4 | 37 | 5.9 |
| | | | 5 | 7 | 1.1 |
| | | | | | |
| | | Allens Creek | 1 | 92 | 58.2 |
| | | | 2 | 45 | 28.5 |
| | | | 3 | 18 | 11.4 |
| | | | 4 | 2 | 1.3 |
| | | | 5 | 1 | 0.6 |
| | | | | | |
| | | Other | 1 | 18 | 50 |
| | | | 2 | 11 | 30.6 |
| | | | 3 | 4 | 11.1 |
| | | | 4 | 2 | 5.6 |
| | | | 5 | 1 | 2.8 |

Table 5.8. Bulb of Percussion by Flake Type.

| Period | N | Flake Type | Bulb of Percussion | Frequency | Percent |
|---|---|---|---|---|---|
| Lower L. Archaic | 547 | Initial | 1 | 31 | 46.3 |
| | | | 2 | 14 | 20.9 |
| | | | 3 | 12 | 17.9 |
| | | | 4 | 8 | 11.9 |
| | | | 5 | 2 | 3 |
| | | | | | |
| | | Biface Reduction | 1 | 64 | 31.8 |
| | | | 2 | 76 | 37.8 |
| | | | 3 | 45 | 22.4 |
| | | | 4 | 13 | 6.5 |
| | | | 5 | 3 | 1.5 |
| | | | | | |
| | | Thinning | 1 | 105 | 48.6 |
| | | | 2 | 67 | 31 |
| | | | 3 | 35 | 16.2 |
| | | | 4 | 8 | 3.7 |
| | | | 5 | 1 | 0.5 |
| | | | | | |
| | | Finishing | 1 | 32 | 50.8 |
| | | | 2 | 20 | 31.7 |
| | | | 3 | 9 | 14.3 |
| | | | 4 | 1 | 1.6 |
| | | | 5 | 1 | 1.6 |
| | | | | | |
| Riverton | 755 | Initial | 1 | 18 | 33.3 |
| | | | 2 | 17 | 31.5 |
| | | | 3 | 13 | 24.1 |
| | | | 4 | 3 | 5.6 |
| | | | 5 | 3 | 5.6 |
| | | | | | |
| | | Biface Reduction | 1 | 98 | 37.3 |
| | | | 2 | 88 | 33.5 |
| | | | 3 | 54 | 20.5 |

Table 5.8 (continued)

| | | | | | |
|---|---|---|---|---|---|
| | | | 4 | 20 | 7.6 |
| | | | 5 | 3 | 1.1 |
| | | | | | |
| | | Thinning | 1 | 159 | 52.3 |
| | | | 2 | 104 | 34.2 |
| | | | 3 | 34 | 11.2 |
| | | | 4 | 6 | 2 |
| | | | 5 | 1 | 0.3 |
| | | | | | |
| | | Finishing | 1 | 76 | 56.7 |
| | | | 2 | 41 | 30.6 |
| | | | 3 | 14 | 10.4 |
| | | | 4 | 3 | 2.2 |
| | | | 5 | 0 | 0 |
| | | | | | |
| E. Woodland | 1318 | Initial | 1 | 41 | 37.6 |
| | | | 2 | 30 | 27.5 |
| | | | 3 | 20 | 18.3 |
| | | | 4 | 16 | 14.7 |
| | | | 5 | 2 | 1.8 |
| | | | | | |
| | | Biface Reduction | 1 | 175 | 40 |
| | | | 2 | 135 | 30.9 |
| | | | 3 | 87 | 19.9 |
| | | | 4 | 32 | 7.3 |
| | | | 5 | 8 | 1.8 |
| | | | | | |
| | | Thinning | 1 | 345 | 59.3 |
| | | | 2 | 172 | 29.6 |
| | | | 3 | 50 | 8.6 |
| | | | 4 | 11 | 1.9 |
| | | | 5 | 4 | 0.7 |
| | | | | | |
| | | Finishing | 1 | 113 | 59.5 |
| | | | 2 | 59 | 31.1 |
| | | | 3 | 17 | 8.9 |
| | | | 4 | 1 | 0.5 |
| | | | 5 | 0 | 0 |

Table 5.9. Bulb of Percussion by Context.

| Period | Context | N | Bulb of Percussion | Frequency | Percent |
|---|---|---|---|---|---|
| Lower L. Archaic | Features | 289 | 1 | 134 | 46.4 |
| | | | 2 | 85 | 29.4 |
| | | | 3 | 49 | 17 |
| | | | 4 | 17 | 5.9 |
| | | | 5 | 4 | 1.4 |
| | | | | | |
| | Units | 258 | 1 | 98 | 38 |
| | | | 2 | 92 | 35.7 |
| | | | 3 | 52 | 20.2 |
| | | | 4 | 13 | 5 |
| | | | 5 | 3 | 1.2 |
| | | | | | |
| Riverton | Features | 363 | 1 | 172 | 47.4 |
| | | | 2 | 114 | 31.4 |
| | | | 3 | 59 | 16.3 |
| | | | 4 | 16 | 4.4 |
| | | | 5 | 2 | 0.6 |
| | | | | | |
| | Units | 392 | 1 | 179 | 45.7 |
| | | | 2 | 136 | 34.7 |
| | | | 3 | 56 | 14.3 |
| | | | 4 | 16 | 4.1 |
| | | | 5 | 5 | 1.3 |
| | | | | | |
| E. Woodland | Features | 649 | 1 | 363 | 55.9 |
| | | | 2 | 175 | 27 |
| | | | 3 | 68 | 10.5 |
| | | | 4 | 34 | 5.2 |
| | | | 5 | 9 | 1.4 |
| | | | | | |
| | Units | 669 | 1 | 311 | 46.5 |
| | | | 2 | 221 | 33 |
| | | | 3 | 106 | 15.8 |
| | | | 4 | 26 | 3.9 |
| | | | 5 | 5 | 0.7 |

When lipping and bulb of percussion data are considered together, an interesting correlation can be seen. A general increase in the presence of lipping (Table 5.1) occurs alongside the slight overall decrease in the prominence of bulb of percussion (Table 5.6). Lipping data found in Table 5.3 shows that the greatest increase in lipping through time occurs in the later stages of the lithic reduction process. When bulbs of percussion are examined for thinning and finishing flakes, we find that there is an increase in the presence of bulb=1 values moving from the Lower Late Archaic through the Early Woodland. The non-metric data presented here suggest that there is an increase in the use of soft-hammer percussion in the late stages of production through time.

## Principle Component Analysis

In order to complement the descriptive statistics described above a Principle Components Analysis was performed using IBM SPSS Statistics 19. A principle component analysis for the purposes of this study is useful because it creates a set of composite variables that measure the underlying dimensions in the dataset (VanPool and Leonard 2011:289). By identifying the underlying dimensions in a dataset, it is possible to reduce the number of variables in a study down to a fewer number of principle components. In the case of this study, six variables were used in order to obtain the general size of each flake. It is difficult to critically compare debitage size between categories because 'flake size' is spread across six variables. By reducing these six variables down to two principle components it is possible to plot these components against each other and provide an easier to digest measure of general size through time and between raw materials.

The new dimensions created by the principle components allow for a researcher to see how much of the variation in each variable is shared with other variables (VanPool and Leonard 2011:290). This analysis allows for the dataset to be structured around the components that explain the most variation (VanPool and Leonard 2011:290). Therefore, the first principle component will be defined as the underlying dimension that summarizes the greatest amount of variation in the dataset. For the purposes of this study, the first principle component can be viewed as representative of general flake size. It is important to emphasize that in a PCA, the underlying dimensions in the data do not correspond to any single variable. Dimensions represent underlying variables that can be very general, like flake size or platform size. The second principle component summarizes the second most variation in the dataset and so on.

Eigenvalues observed in Table 5.10 reflect the proportion of the total amount of variation of all variables described by an individual principle component (VanPool and Leonard 2011:294). Principle Component 1 has an eigenvalue of 4.139. Principle Component 1 is responsible for approximately 69% of the total variation among all of the variables. Principle Component 2 describes only 15% of the total variation while PC 3 describes 6%. PC 1 has by far the greatest eigenvalue and can be seen as the single best line summarizing variation in the dataset. PC 2 summarizes most of the remaining variation. Meaningful relationships found in the dataset are mostly accounted for in the first two principle components as they combine to account for 84% of the overall variance in the dataset (Table 5.10). The remaining principle components describe very weak or possibly even accidental relationships in the data. It is important to keep in mind that there are no hard rules for determining at what point meaningful relationships stop in the principle components.  VanPool and Leonard (2011:296) provide a rule of thumb in which eigenvalues less than 1.0 should usually not be considered as meaningful relationships.  While a good roadmap, this cutoff is admittedly arbitrary.  The Scree Plot in Figure 5.1 visually demonstrates the fall-off of meaningful relationships associated with the principle components.  The Scree Plot demonstrates that after PC 2 the graph straightens out.  VanPool and Leonard (2011:297) state that where the Scree Plot straightens out is the spot where most of the common variation has already been summarized.  Using the eigenvalue cutoff of 1.0 and the visual evidence of the Scree Plot (Figure 5.1), most of the variation is contained in PC 1 and PC 2.

Table 5.11 displays the Factor Loadings for the dataset.  Factor Loadings reflect the correlation of each variable and the principle component.  Essentially these are weights associated with each of the original six variables and that variable's contribution to the underlying dimension.  Loadings are on a scale between -1 to 1.  The closer the loading to 0, the greater the independence between the variable and principle component.  Conversely, the closer to -1 or 1, the greater the amount of variation in the variable is summarized by the principle component (VanPool and Leonard 2011:298).  Positive numbers reflect positive correlations while negative numbers indicate negative correlations.  Looking at PC 1 in Table 5.11 it is easy to see that all six variables have a positive relationship with the principle component.  This is not surprising.  PC 1 can be essentially viewed as general flake size.  Considering that the six variables measured in this study were selected in order to understand overall flake size, it is easy to see why loadings for PC 1 are generally high indicating strong positive relationships with the variables.  PC 2 demonstrates negative relationships with variables for Flake Length, Width, Thickness, and Weight (Table 5.11). Positive relationships are demonstrated for both Platform Width and Platform Thickness. Due the fact that platform measurements are positively related to PC 2, it can be assumed that PC 2 is essentially a measure of general platform size. Graph 2 visually demonstrates the distinction between PC 1 and PC 2 and their respective contributions from the variables. Variables Flake Length, Width, and Weight cluster closely together when PC 1 and PC 2 are plotted against each other. Thickness is only very slightly negative and has essentially no correlation with PC 2 (Figure 5.2). Thickness is highly correlated with Weight and PC 1. Variables Platform Width and Platform Thickness cluster closely together as well. The correlation matrix (Table 5.12) shows the relationship between variables with one another. It is now possible to discuss PC 1 and PC 2 as flake size and platform size respectively rather than seeking to examine the interrelationships of the six original variables.

Results

After it is determined that PC 1 and PC 2 represent the most meaningful relationships amongst six principle components it is possible to plot these components against each other to see if meaningful clustering occurs. To demonstrate that this type of plot is a fruitful exercise in understanding debitage size I first examine how the principle components plot regarding Flake Type (Figure 5.3). Looking at Figure 5.3 it is easy to see the clustering of flake types. Biface finishing flakes, represented as purple on the plot, demonstrate tight clustering when compared to all other flake types. This is not surprising as I expect biface finishing flakes to demonstrate less overall flake size variation. Earlier stages in reduction sequence demonstrate increasingly less clustering. Figure 5.4 illustrates a similar pattern regarding Platform Type. As expected, abraded platforms, associated with later stages in the reduction sequence, demonstrate the greatest clustering. Variation in size of flake increases (less clustering) as platform types move closer towards those generally associated with earlier stages in reduction sequence (cortex, flat). The point of highlighting Figures 5.3 and 5.4 is to demonstrate that plotting PC 1 and PC 2 together creates accurate visual evidence for how flakes cluster based on stage in the reduction sequence.

It is possible to examine these plots and see changes in the frequency of debitage size during lithic reduction at the Knob Creek site. Figure 5.5 plots the assemblage flake size based on time period. Figure 5.5 demonstrates that there are differences in the variation of overall flake size by time period. The Riverton component demonstrates the most clustering while the Late Archaic and Early Woodland components appear to have little noticeable clustering. Riverton clustering is most likely due to the microtool technological complex observed by Winters (1969). The microtool complex at Knob Creek appears to be limited to biface preforms of points and projectile points. Nevertheless, it is likely that these smaller bifaces contributed to the general small size of Riverton debitage.

Figures 5.6, 5.7, and 5.8 examine the clustering of overall flake size when broken down by time period and chert type. Flakes from the Late Archaic component are plotted in Figure 5.6. Overall, there appears to be no patterning or clustering. The most noticeable aspect of Figure 5.6 is the abundance of Muldraugh and Allens Creek cherts compared to Wyandotte. Figure 5.7 examines the Riverton component. It is in this plot that we clearly see changes in the frequency of debitage size based on raw material type.

Muldraugh chert continues to dominate the assemblage and appears to generally cluster together. Wyandotte chert, with much lower quantities, appears to cluster together around smaller flake sizes than Muldraugh. Smaller overall flake size is representative of later stages in the lithic reduction sequence. Figure 5.8 shows a substantial increase in the use of Wyandotte chert during the Early Woodland. Additionally, as the quantity of Wyandotte chert increases in the Early Woodland, there is also an expansion in the stages of the lithic reduction sequence. While the Riverton component (Figure 5.7) appears to indicate only later stages, the Early Woodland appears to represent an increase in the number of stages.

This chapter synthesizes the results of both descriptive statistics and principle component plots. These two forms of complementary data suggest that changes to overall flake size did occur from the Late Archaic through the Early Woodland. Additionally, there also appears to be changes through time associated with the use of specific raw material types.

Table 5.10: Total Variance Explained.

| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| Component | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 4.139 | 68.979 | 68.979 | 4.139 | 68.979 | 68.979 |
| 2 | .879 | 14.646 | 83.625 | .879 | 14.646 | 83.625 |
| 3 | .373 | 6.217 | 89.842 | | | |
| 4 | .304 | 5.069 | 94.911 | | | |
| 5 | .190 | 3.175 | 98.085 | | | |
| 6 | .115 | 1.915 | 100.000 | | | |

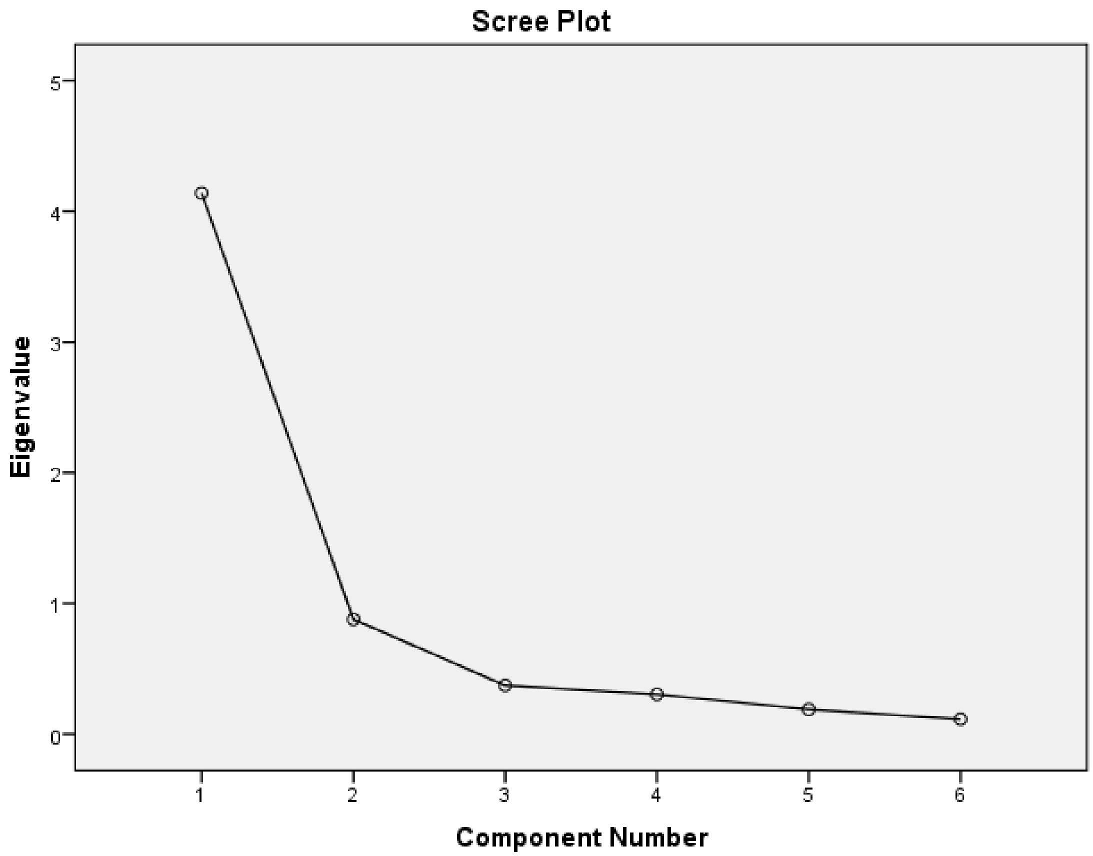


Figure 5.1: Scree Plot.

Table 5.11: Factor Loadings.

| | Component | |
|---|---|---|
| | 1 | 2 |
| Length | .771 | -.464 |
| Width | .833 | -.309 |
| Thickness | .884 | -.025 |
| Platform Width | .810 | .474 |
| Platform Thickness | .786 | .550 |
| Weight | .891 | -.201 |

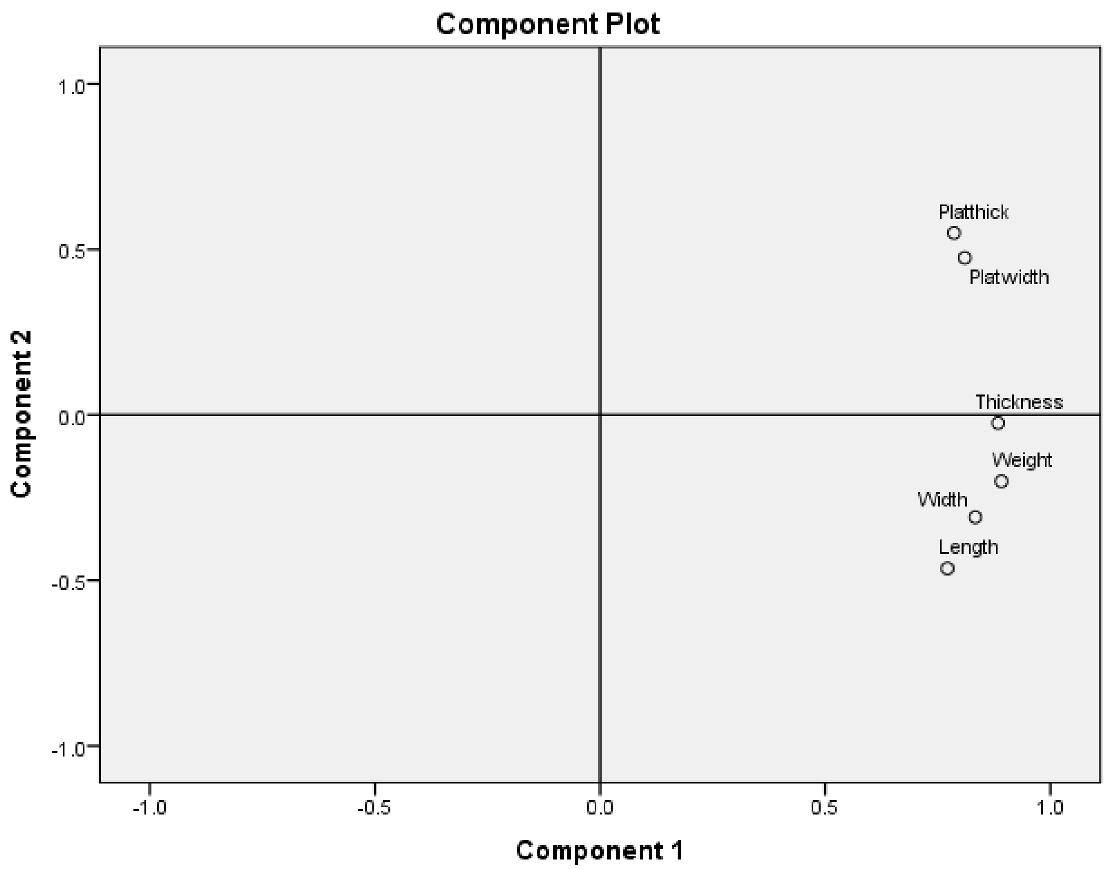


Figure 5.2: Component Plot of Metric Variables.

Table 5.12: Correlation Matrix.

| | | Length | Width | Thickness | Platform Width | Platform Thickness | Weight |
|---|---|---|---|---|---|---|---|
| Correlation | Length | 1.000 | .702 | .610 | .433 | .407 | .703 |
| | Width | .702 | 1.000 | .674 | .576 | .460 | .730 |
| | Thickness | .610 | .674 | 1.000 | .609 | .670 | .811 |
| | Platform Width | .433 | .576 | .609 | 1.000 | .832 | .600 |
| | Platform Thickness | .407 | .460 | .670 | .832 | 1.000 | .567 |
| | Weight | .703 | .730 | .811 | .600 | .567 | 1.000 |
| Sig. (1-tailed) | Length | | .000 | .000 | .000 | .000 | .000 |
| | Width | .000 | | .000 | .000 | .000 | .000 |
| | Thickness | .000 | .000 | | .000 | .000 | .000 |
| | Platform Width | .000 | .000 | .000 | | .000 | .000 |
| | Platform Thickness | .000 | .000 | .000 | .000 | | .000 |
| | Weight | .000 | .000 | .000 | .000 | .000 | |

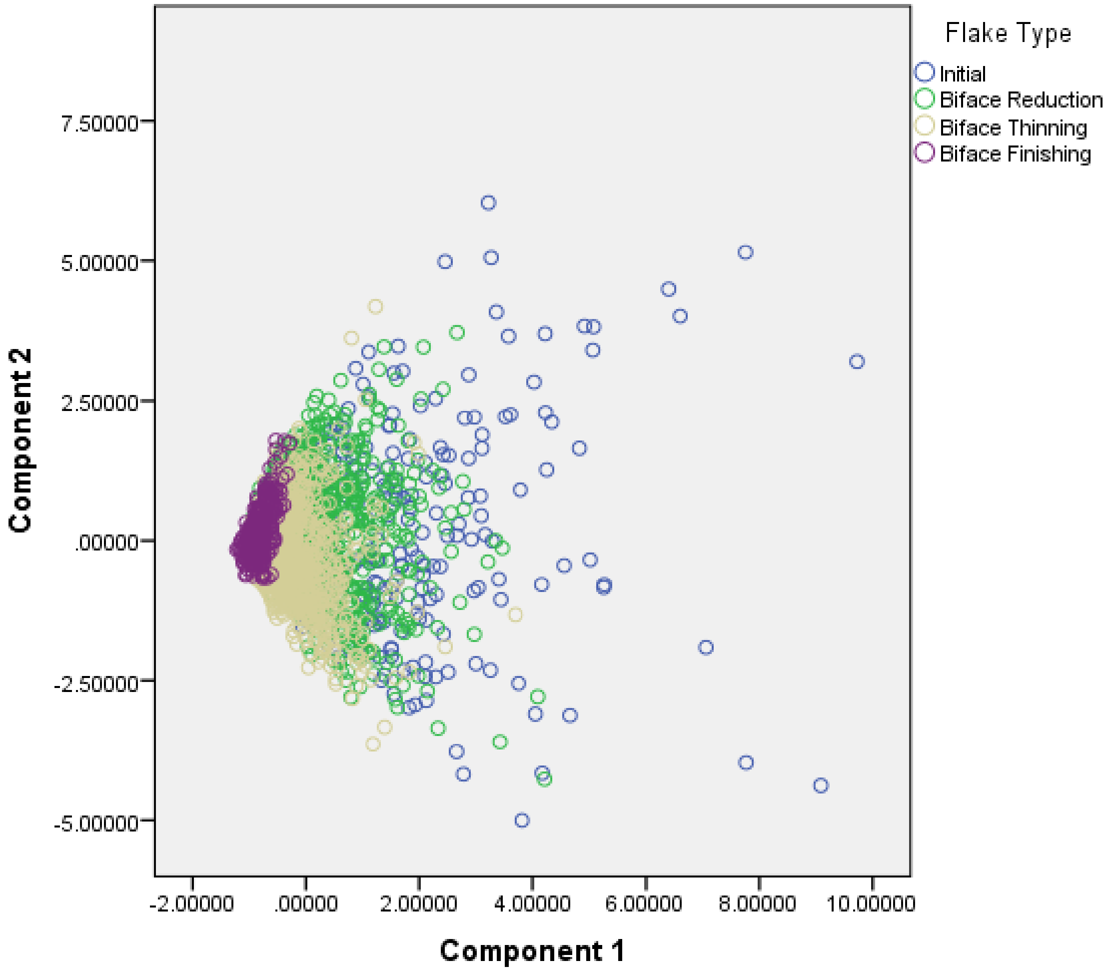


Figure 5.3: Principle Component Plot by Flake Type.

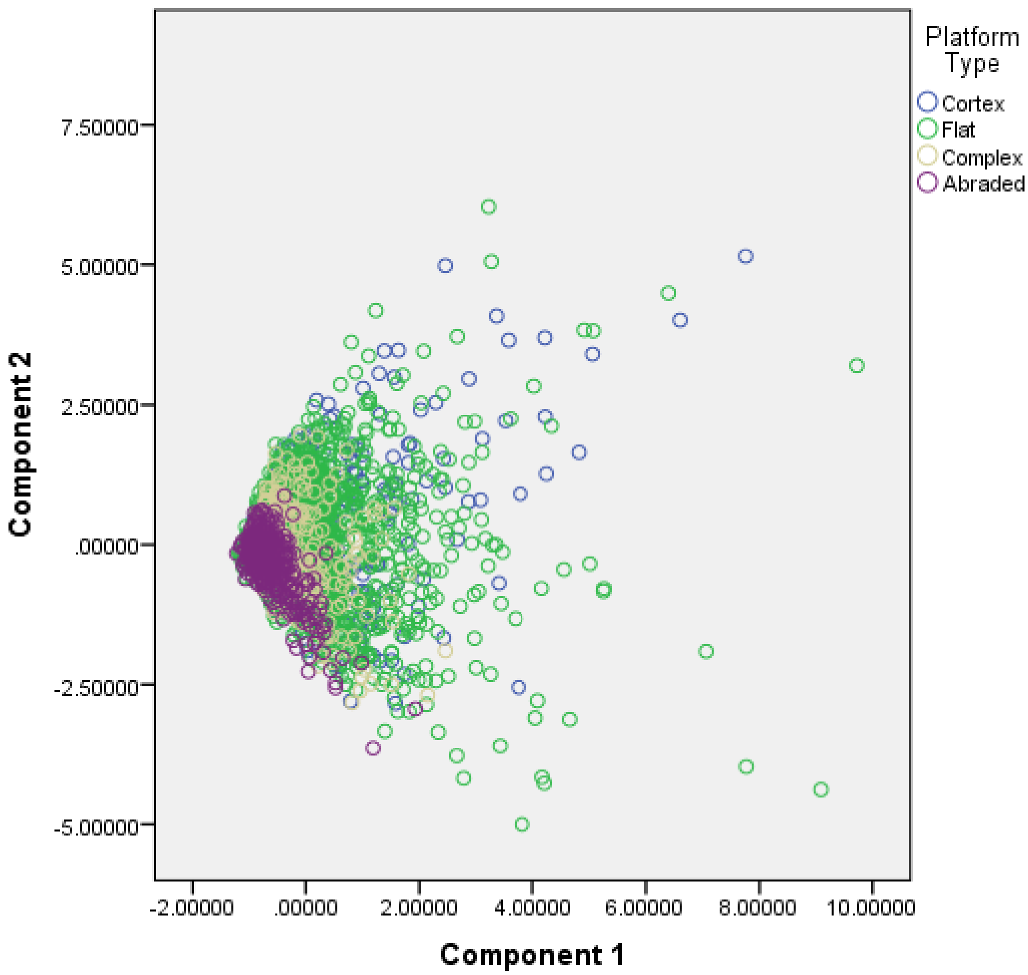


Figure 5.4: Principle Component Plot by Platform Type.

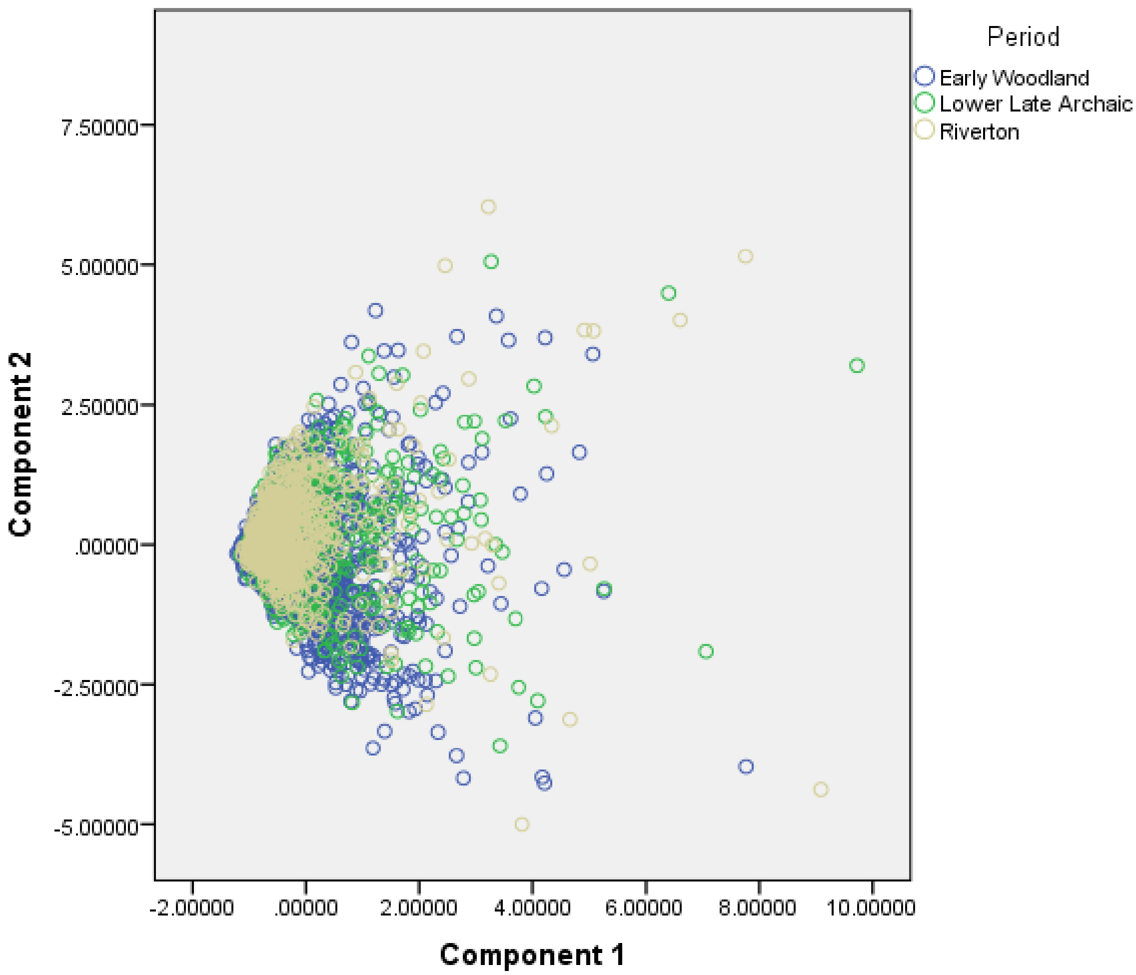


Figure 5.5: Principle Component Plot by Time Period.

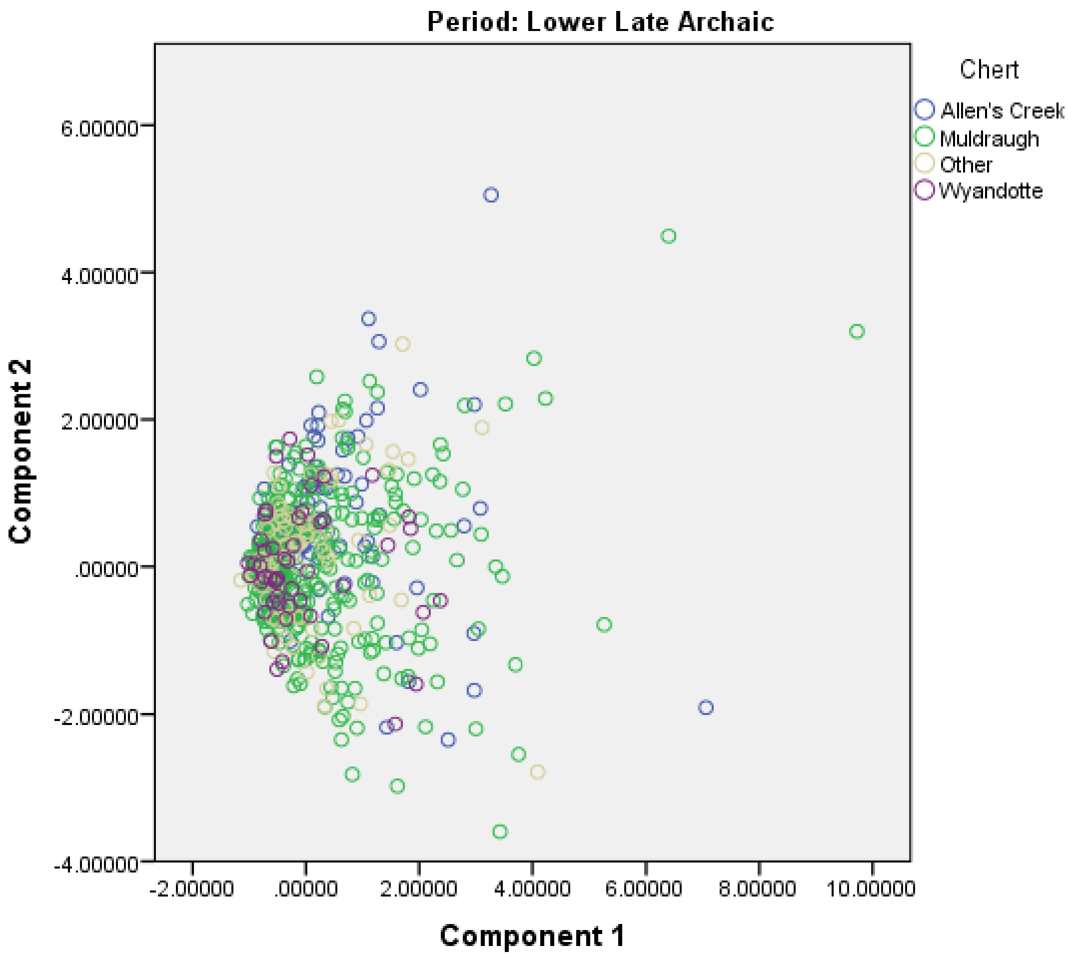


Figure 5.6: Lower Late Archaic Principle Component Plot by Chert Type.

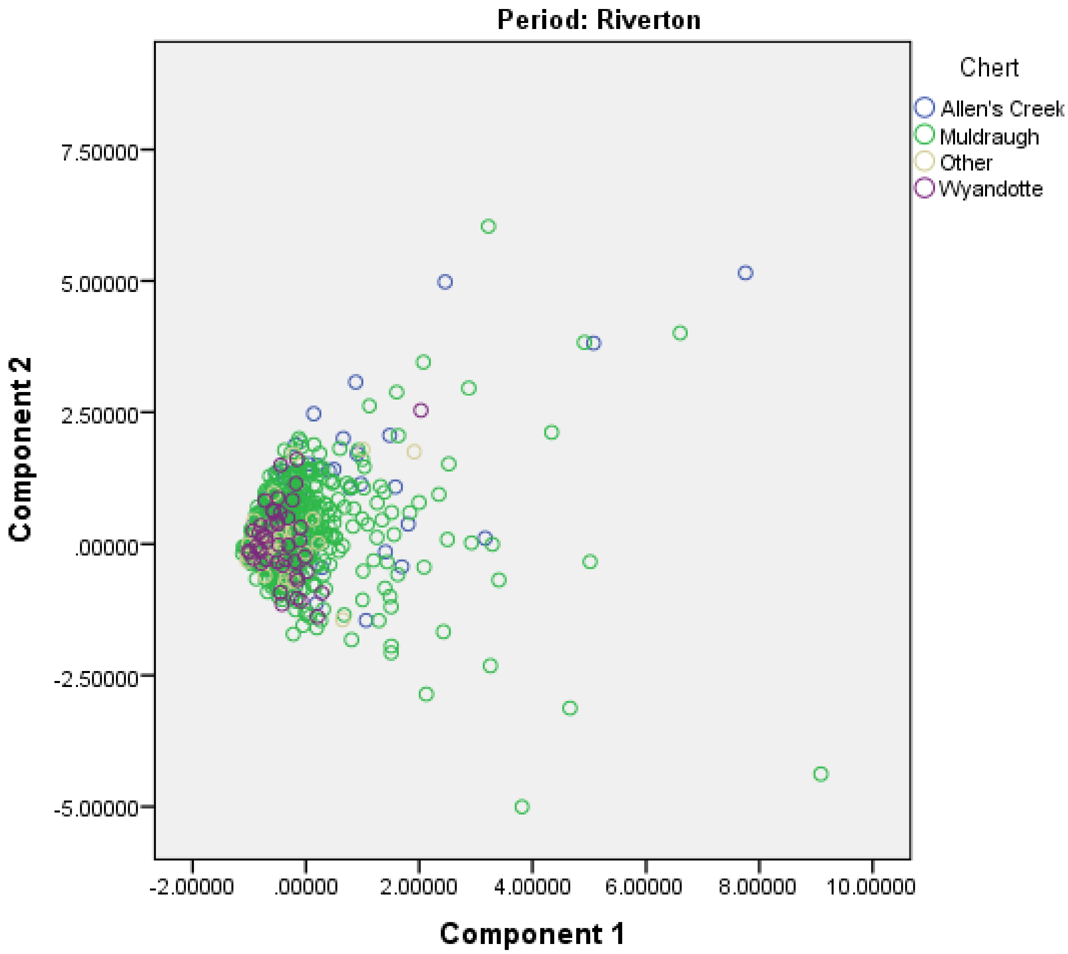


Figure 5.7: Riverton Principle Component Plot by Chert Type.

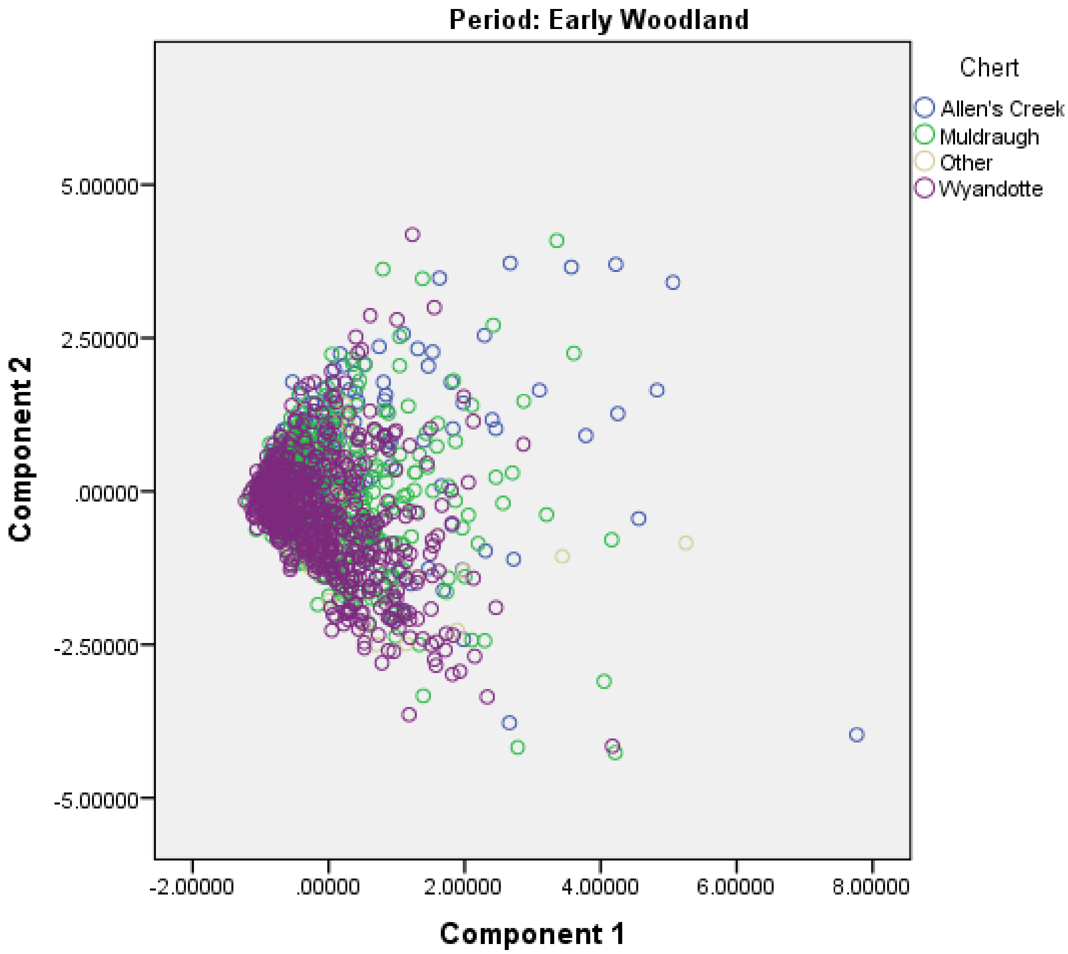


Figure 5.8: Early Woodland Principle Component Plot by Chert Type.

Descriptive Statistics for Metric Variables

One objective of this analysis is to determine how debitage size changes from the Late Archaic through the Early Woodland periods at the Knob Creek site. Basic descriptive statistics were initially performed in order to understand the general patterns in the data and to compare them with previous mass analysis performed by Stafford (2007b).

Change in debitage variable means and standard deviations through time can be seen in the descriptive statistics of Table 5.13, visually represented in Figures 5.9-5.14. Examining the Late Archaic debitage assemblage as a whole reveals that the time period displays the largest average flake size when compared to the Terminal Archaic Riverton and Early Woodland components. Standard deviation data, however, suggests that this difference is not statistically significant. Late Archaic (N=547) debitage displays a mean flake length of 22.27 mm., width of 17.68 mm., thickness of 4.49 mm., and a weight of 2.92 grams. The Terminal Archaic Riverton component (N=755) shows an overall decrease in size as mean flake length is 18.21 mm., 14.42 mm. width, 3.56 mm. thickness, and an average weight of 1.65 grams. Lastly, the Early Woodland component (N=1,318) demonstrates an increase in size from the preceding Riverton component, however average flake size is still slightly smaller than the Late Archaic component. Early Woodland debitage had an average flake length of 21.77 mm., flake width of 16.71 mm., flake thickness of 3.85 mm., and an average flake weight of 2.30 grams. Interestingly, there is a continual decrease in platform width and platform thickness dimensions from the Late Archaic through the Early Woodland (Figures 5.12 and 5.13).

This likely suggests a greater reliance on soft-hammer percussion technology through time.

Table 5.13: Descriptive Statistics by Time Period.

| Period | Number | | Flake Length (mm.) | Flake Width (mm.) | Flake Thickness (mm.) | Platform Width (mm.) | Platform Thickness (mm.) | Weight (g.) |
|---|---|---|---|---|---|---|---|---|
| Lower Late Archaic | 547 | Mean | 22.27 | 17.68 | 4.49 | 9.12 | 3.62 | 2.92 |
| | | Median | 19.58 | 15.33 | 3.58 | 7.66 | 2.92 | 1 |
| | | Std. Deviation | 11.21 | 8.41 | 3.06 | 5.48 | 2.72 | 5.59 |
| | | | | | | | | |
| Riverton | 755 | Mean | 18.21 | 14.42 | 3.56 | 7.38 | 3.05 | 1.65 |
| | | Median | 16.44 | 12.52 | 2.84 | 6.26 | 2.49 | 0.6 |
| | | Std. Deviation | 8.09 | 6.51 | 2.85 | 4.7 | 2.18 | 4.62 |
| | | | | | | | | |
| Early Woodland | 1318 | Mean | 21.77 | 16.71 | 3.85 | 7.37 | 2.8 | 2.3 |
| | | Median | 19.22 | 14.9 | 3.01 | 6.4 | 2.26 | 0.9 |
| | | Std. Deviation | 10.27 | 7.46 | 2.69 | 4.04 | 2.01 | 4.23 |

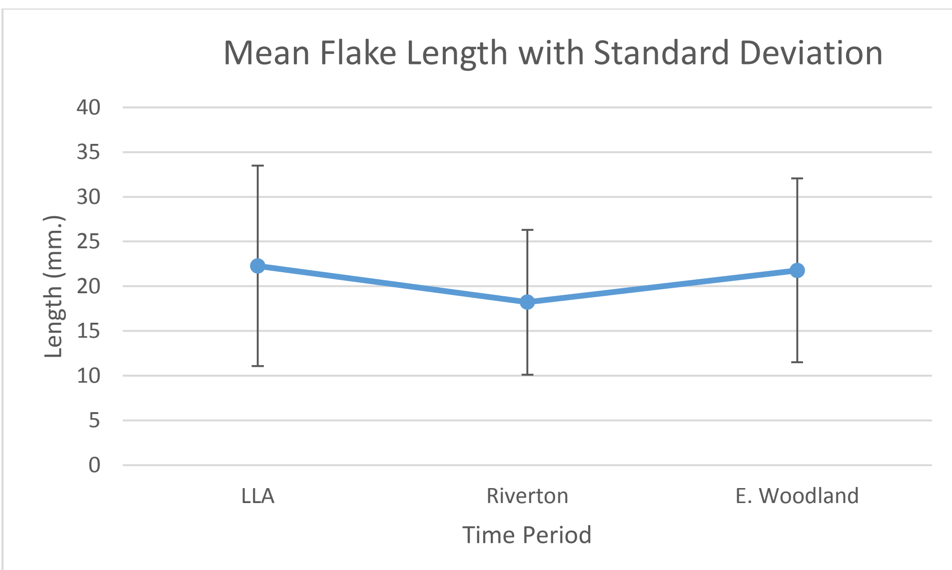


Figure 5.9: Mean Flake Length by Time with Standard Deviation Brackets.

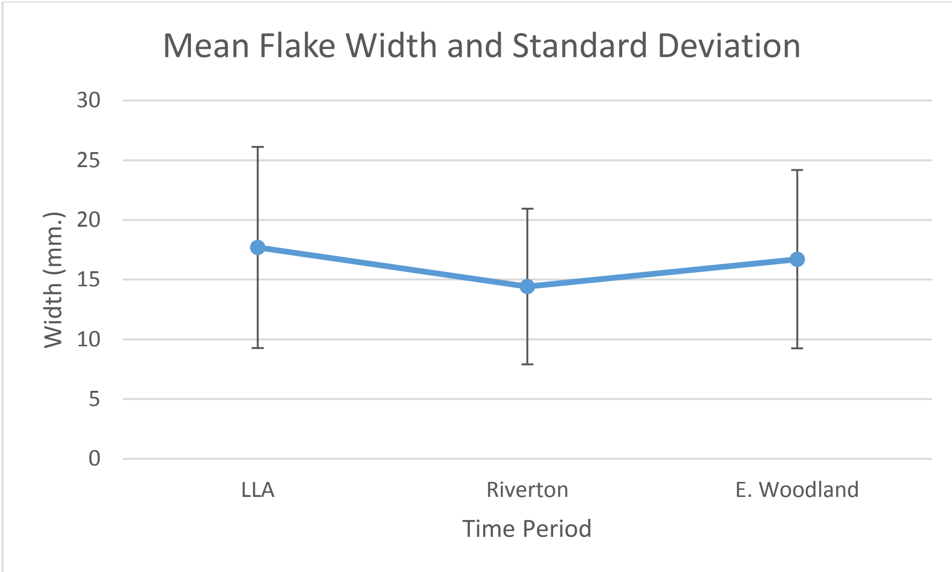


Figure 5.10: Mean Flake Width by Time with Standard Deviation Brackets.

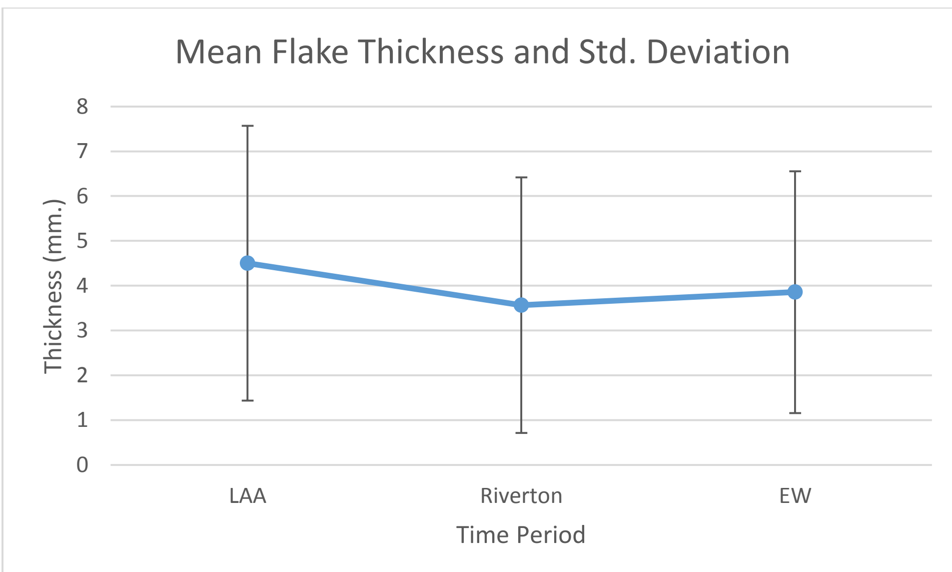


Figure 5.11: Mean Flake Thickness by Time with Standard Deviation Brackets.

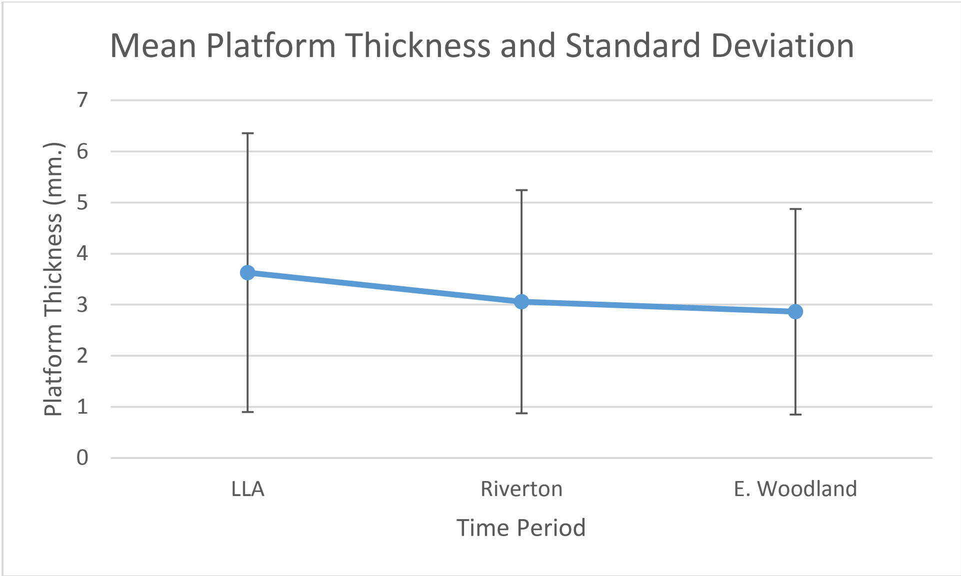


Figure 5.12: Mean Platform Thickness by Time with Standard Deviation Brackets.

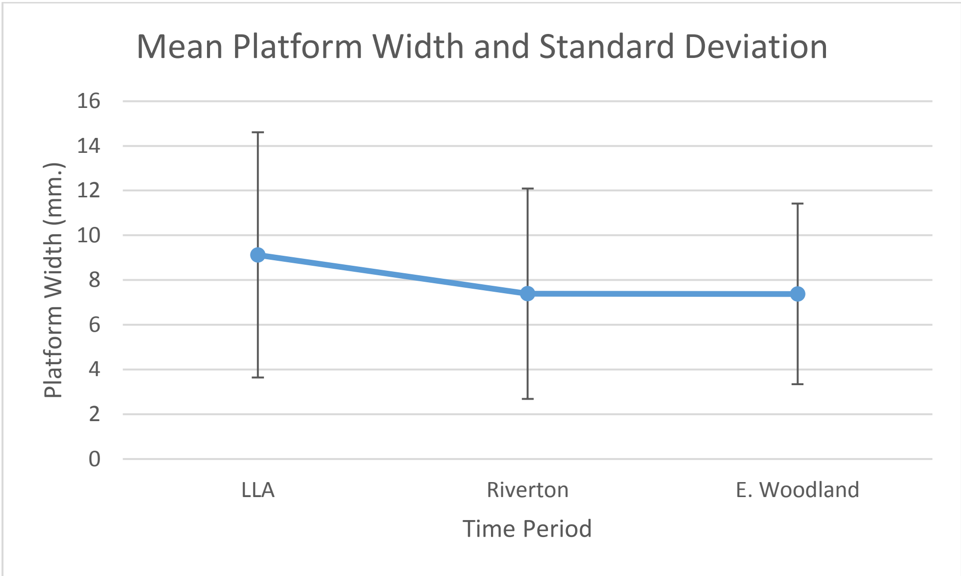


Figure 5.13: Mean Platform Width by Time with Standard Deviation Brackets.

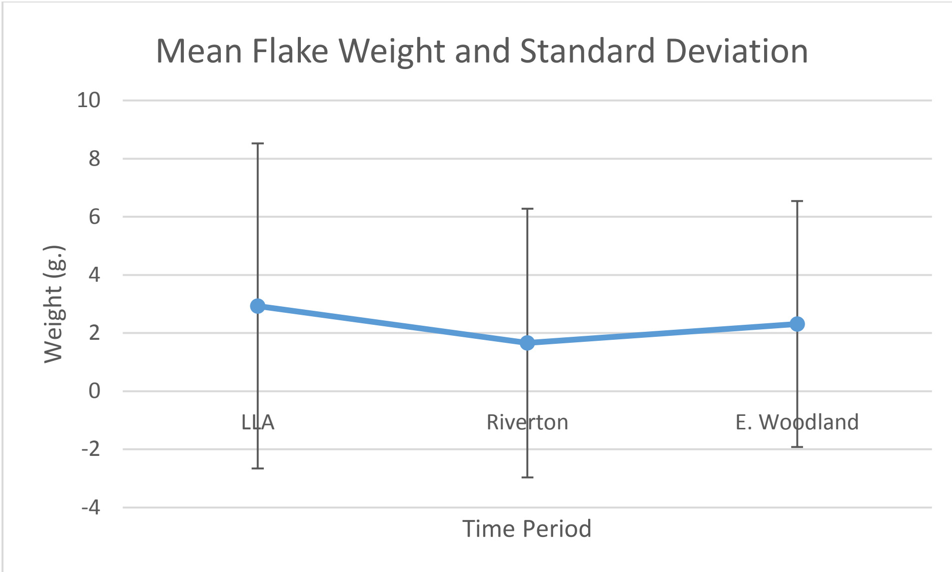


Figure 5.14: Mean Flake Weight by Time with Standard Deviation Brackets.

Standard deviation data presented in Table 5.13 suggests an interesting trend. Flake thickness, platform width, platform thickness and flake weight all demonstrate a decline in standard deviation through time. This may suggest that the Knob Creek site occupants obtained better technological control from the Late Archaic through the Early Woodland. Additionally, mean platform thickness and width size and standard deviation decrease continuously from the Late Archaic through the Early Woodland (Figures 5.12 and 5.13).

Descriptive statistics for flake dimensions by site context are presented in Table 5.14. Feature contexts in the Lower Late Archaic component have smaller sizes across all variables when compared with units. During the Riverton, there is little difference in flake dimensions based on context. Some variables show slightly greater vales for features, others for units. It is interesting to note that the standard deviation values of

Riverton unit contexts are significantly less than feature contexts. Additionally, Riverton unit standard deviations show smaller values than unit contexts during the Lower Late Archaic. During the Early Woodland, flake length, width, and thickness dimensions are greater in features than units. Interestingly, platform width and thickness values are greater in unit contexts. Standard deviations during this time follow a similar pattern as values are greater for feature contexts for flake length, width, thickness and weight but lower for platform width and thickness.

Table 5.14. Descriptive Statistics by Time Period and Context.

| Period | Context | N | | Flake Length (mm.) | Width (mm.) | Thickness (mm.) | Platform Width (mm.) | Platform Thickness (mm.) | Weight (g.) |
|---|---|---|---|---|---|---|---|---|---|
| Lower L. Archaic | Features | 289 | Mean | 21.59 | 17.32 | 4.34 | 8.72 | 3.39 | 2.68 |
| | | | Median | 18.9 | 15.01 | 3.54 | 7.51 | 2.88 | 1 |
| | | | Std. Deviation | 10.5 | 8.23 | 2.66 | 4.98 | 2.22 | 4.51 |
| | | | | | | | | | |
| | Units | 258 | Mean | 23.05 | 18.1 | 4.68 | 9.57 | 3.9 | 3.21 |
| | | | Median | 20.99 | 15.74 | 3.62 | 8.03 | 2.94 | 1.1 |
| | | | Std. Deviation | 11.93 | 8.61 | 3.46 | 5.98 | 3.18 | 6.59 |
| | | | | | | | | | |
| Riverton | Features | 363 | Mean | 18.17 | 14.75 | 3.58 | 7.16 | 3.06 | 1.95 |
| | | | Median | 15.75 | 12.44 | 2.67 | 6.04 | 2.48 | 0.5 |
| | | | Std. Deviation | 9.15 | 7.52 | 3.3 | 4.31 | 2.24 | 5.78 |
| | | | | | | | | | |
| | Units | 392 | Mean | 18.26 | 14.13 | 3.56 | 7.6 | 3.06 | 1.38 |
| | | | Median | 16.84 | 12.66 | 2.96 | 6.42 | 2.54 | 0.7 |
| | | | Std. Deviation | 6.98 | 5.42 | 2.37 | 5.03 | 2.13 | 3.18 |
| | | | | | | | | | |
| E. Woodland | Features | 649 | Mean | 22.96 | 17.55 | 4.04 | 7.26 | 2.85 | 2.72 |
| | | | Median | 20.08 | 15.8 | 3.14 | 6.34 | 2.3 | 1 |
| | | | Std. Deviation | 10.91 | 7.9 | 2.88 | 3.86 | 1.95 | 5.04 |
| | | | | | | | | | |
| | Units | 669 | Mean | 20.63 | 15.9 | 3.67 | 7.49 | 2.88 | 1.91 |
| | | | Median | 18.21 | 14.14 | 2.94 | 6.46 | 2.23 | 0.8 |
| | | | Std. Deviation | 9.48 | 6.92 | 2.5 | 4.21 | 2.07 | 3.21 |

Debitage from each of the three time periods is broken down further by raw material type (Table 5.15). Muldraugh chert exhibits the largest average sized flakes in both the Late Archaic and Riverton components. It is important to note that during both these time periods Muldraugh chert is the dominant raw material type in use. It is not until the Early Woodland that Wyandotte chert (N=629) becomes the most abundant raw material type at the Knob Creek site. When average flake size of Wyandotte chert is compared with Muldraugh chert, for the first time there is a raw material other than Muldraugh that represents the largest average size flake for a given time period. For the first time, the occupants of the Knob Creek site are using a raw material from 35 km away in greater abundance than the locally found Muldraugh and Allens Creek cherts (Figure 1.3).

Table 5.16 breaks down the data by time period and flake type. Recall that the four flake types (initial biface reduction, biface reduction, biface thinning, and biface finishing) that were attributed to flakes in this study are categories imposed upon the data that serve to lump flakes together. Consequently this serves to mask variation within the dataset. Nevertheless, by examining a certain flake type through the three time periods it is possible to further demonstrate changes in the debitage patterns. Take biface thinning flakes for example (Table 5.16). Biface thinning flakes follow similar size patterns as seen in Table 5.13. There is a general decrease in biface thinning flake size from the Late Archaic to the Riverton component. Biface thinning flake size increases from the Riverton to the Early Woodland component (Table 5.16).

Table 5.15: Descriptive Statistics for Time Period and Chert Type.

| Period | Chert Type | Number | | Flake Length (mm.) | Flake Width (mm.) | Flake Thickness (mm.) | Platform Width (mm.) | Platform Thickness (mm.) | Weight (g.) |
|---|---|---|---|---|---|---|---|---|---|
| LLA | Muldraugh | 333 | Mean | 23.07 | 18.44 | 4.35 | 9.12 | 3.56 | 3 |
| | | | Median | 20.38 | 15.76 | 3.35 | 7.66 | 2.74 | 1 |
| | | | Std. Deviation | 11.26 | 9.04 | 3.16 | 5.76 | 2.79 | 5.56 |
| | | | | | | | | | |
| | Wyandotte | 50 | Mean | 21.13 | 15.71 | 3.83 | 8.18 | 2.8 | 2.09 |
| | | | Median | 18.12 | 14.56 | 3.32 | 6.52 | 2.09 | 0.9 |
| | | | Std. Deviation | 11.93 | 7.19 | 2.22 | 4.98 | 1.59 | 2.98 |
| | | | | | | | | | |
| | Allens Creek | 86 | Mean | 21.41 | 17.49 | 5.59 | 10.28 | 4.6 | 3.71 |
| | | | Median | 17.85 | 15.95 | 4.94 | 9.78 | 4.03 | 1.2 |
| | | | Std. Deviation | 11.94 | 7.83 | 3.2 | 5.4 | 3.02 | 7.61 |
| | | | | | | | | | |
| | Other | 78 | Mean | 20.53 | 15.92 | 4.34 | 8.46 | 3.36 | 2.25 |
| | | | Median | 19.15 | 14.2 | 3.68 | 7.47 | 2.94 | 1 |
| | | | Std. Deviation | 9.42 | 6.34 | 2.69 | 4.36 | 2.37 | 4.1 |
| | | | | | | | | | |
| Riverton | Muldraugh | 612 | Mean | 18.24 | 14.6 | 3.48 | 7.29 | 2.98 | 1.62 |
| | | | Median | 16.5 | 12.64 | 2.8 | 6.24 | 2.49 | 0.6 |
| | | | Std. Deviation | 8.09 | 6.72 | 2.76 | 4.44 | 1.97 | 4.67 |
| | | | | | | | | | |
| | Wyandotte | 46 | Mean | 17.83 | 12.69 | 2.83 | 6.22 | 2.48 | 0.93 |
| | | | Median | 16.79 | 11.54 | 2.69 | 5.55 | 2.22 | 0.5 |
| | | | Std. Deviation | 6.49 | 4.03 | 1.12 | 3.16 | 1.54 | 1.21 |
| | | | | | | | | | |
| | Allens Creek | 66 | Mean | 18.54 | 14.6 | 5.16 | 9.47 | 4.35 | 2.74 |
| | | | Median | 15.41 | 12.18 | 3.77 | 6.85 | 3.24 | 0.8 |
| | | | Std. Deviation | 9.64 | 6.45 | 4.18 | 7.2 | 3.6 | 6.23 |
| | | | | | | | | | |
| | Other | 31 | Mean | 17.5 | 13.22 | 2.96 | 6.37 | 2.56 | 0.98 |
| | | | Median | 15.45 | 12.32 | 2.94 | 5.75 | 1.92 | 0.5 |
| | | | Std. Deviation | 6.73 | 4.97 | 1.42 | 3.46 | 2 | 1.39 |
| | | | | | | | | | |
| EW | Muldraugh | 495 | Mean | 21.26 | 16.48 | 3.71 | 7.44 | 2.87 | 1.98 |
| | | | Median | 18.84 | 14.6 | 2.96 | 6.5 | 2.3 | 0.8 |
| | | | Std. Deviation | 9.74 | 7.27 | 2.32 | 4.04 | 1.86 | 3.46 |
| | | | | | | | | | |
| | Wyandotte | 629 | Mean | 22.32 | 16.9 | 3.31 | 6.81 | 2.44 | 2.05 |
| | | | Median | 19.68 | 15.37 | 2.76 | 6.07 | 2 | 0.9 |
| | | | Std. Deviation | 10.41 | 7.31 | 1.97 | 3.37 | 1.41 | 2.92 |
| | | | | | | | | | |
| | Allens Creek | 158 | Mean | 20.02 | 15.96 | 6.31 | 9.3 | 4.45 | 3.86 |
| | | | Median | 17.52 | 13.04 | 5.14 | 7.77 | 3.37 | 1 |
| | | | Std. Deviation | 10.65 | 8.19 | 4.37 | 5.41 | 3.29 | 7.84 |
| | | | | | | | | | |
| | Other | 36 | Mean | 27.02 | 19.63 | 4.45 | 7.76 | 2.99 | 4.4 |
| | | | Median | 24.58 | 17.98 | 3.23 | 6.63 | 2.54 | 1.5 |
| | | | Std. Deviation | 11.12 | 8.7 | 3 | 5.02 | 1.93 | 7.5 |

Table 5.16: Descriptive Statistics by Time Period and Flake Type.

| Period | Flake Type | Number | | Flake Length (mm.) | Flake Width (mm.) | Flake Thickness (mm.) | Platform Width (mm.) | Platform Thickness (mm.) | Weight (g.) |
|---|---|---|---|---|---|---|---|---|---|
| LLA | Initial | 67 | Mean | 35.82 | 26.73 | 9.26 | 15.84 | 7.26 | 10.47 |
| | | | Median | 34.66 | 25.04 | 8.82 | 14.35 | 6.2 | 8.3 |
| | | | Std. Deviation | 13.29 | 11.65 | 4.51 | 8.1 | 4.61 | 11.08 |
| | | | | | | | | | |
| | Reduction | 201 | Mean | 22.81 | 18.6 | 5.08 | 10.35 | 4.21 | 3.05 |
| | | | Median | 20.48 | 16.12 | 4.79 | 9.54 | 3.83 | 1.5 |
| | | | Std. Deviation | 10.69 | 8.28 | 2.32 | 4.54 | 2.08 | 4.22 |
| | | | | | | | | | |
| | Thinning | 216 | Mean | 20.6 | 16.09 | 3.17 | 7.11 | 2.5 | 1.25 |
| | | | Median | 19.02 | 15.2 | 2.83 | 6.54 | 2.18 | 0.8 |
| | | | Std. Deviation | 8.04 | 5.46 | 1.3 | 3.33 | 1.19 | 1.54 |
| | | | | | | | | | |
| | Finishing | 63 | Mean | 11.86 | 10.6 | 2.09 | 4.95 | 1.74 | 0.25 |
| | | | Median | 11.39 | 10.56 | 2.01 | 4.52 | 1.56 | 0.2 |
| | | | Std. Deviation | 2.53 | 1.76 | 0.56 | 1.96 | 0.73 | 0.12 |
| | | | | | | | | | |
| Riverton | Initial | 54 | Mean | 31.58 | 26.14 | 10.03 | 15.57 | 7.15 | 11.07 |
| | | | Median | 29.52 | 21.7 | 8.79 | 12.37 | 6.49 | 6.7 |
| | | | Std. Deviation | 14.67 | 12.83 | 6.45 | 10.47 | 4.5 | 13.66 |
| | | | | | | | | | |
| | Reduction | 263 | Mean | 18.91 | 15.49 | 4.07 | 8.37 | 3.61 | 1.47 |
| | | | Median | 17.78 | 14.19 | 3.75 | 7.35 | 3.27 | 0.9 |
| | | | Std. Deviation | 7.14 | 5.69 | 1.65 | 3.81 | 1.74 | 1.63 |
| | | | | | | | | | |
| | Thinning | 304 | Mean | 18.07 | 13.32 | 2.74 | 6.13 | 2.39 | 0.77 |
| | | | Median | 17.6 | 12.64 | 2.61 | 5.73 | 2.17 | 0.6 |
| | | | Std. Deviation | 5.34 | 3.59 | 0.89 | 2.22 | 1.01 | 0.82 |
| | | | | | | | | | |
| | Finishing | 134 | Mean | 11.79 | 10.09 | 1.83 | 4.97 | 1.81 | 0.21 |
| | | | Median | 11.32 | 9.98 | 1.77 | 4.78 | 1.57 | 0.2 |
| | | | Std. Deviation | 2.16 | 1.5 | 0.49 | 1.73 | 0.74 | 0.08 |
| | | | | | | | | | |
| EW | Initial | 109 | Mean | 32.5 | 25.31 | 9.02 | 12.88 | 5.96 | 9.13 |
| | | | Median | 30.8 | 25.04 | 8.48 | 11.12 | 4.87 | 6.6 |
| | | | Std. Deviation | 12.78 | 10.13 | 4.24 | 6.37 | 3.64 | 10.1 |
| | | | | | | | | | |
| | Reduction | 437 | Mean | 22.9 | 18.26 | 4.72 | 8.48 | 3.52 | 2.69 |
| | | | Median | 20.93 | 16.89 | 4.31 | 7.8 | 3.19 | 1.4 |
| | | | Std. Deviation | 10.26 | 7.63 | 2.2 | 3.8 | 1.69 | 3.21 |
| | | | | | | | | | |
| | Thinning | 582 | Mean | 22.07 | 16.13 | 2.93 | 6.46 | 2.22 | 1.42 |
| | | | Median | 20.24 | 15.15 | 2.69 | 5.95 | 1.95 | 0.8 |
| | | | Std. Deviation | 8.63 | 5.61 | 1.21 | 2.75 | 1.13 | 1.65 |
| | | | | | | | | | |
| | Finishing | 190 | Mean | 12.11 | 9.96 | 1.7 | 4.46 | 1.49 | 0.2 |
| | | | Median | 11.8 | 9.66 | 1.62 | 4.17 | 1.41 | 0.2 |
| | | | Std. Deviation | 2.43 | 1.71 | 0.54 | 1.57 | 0.58 | 0.1 |

Tests of Significance for Metric Data

In order to better understand the statistical significance associated with metric variables in the dataset, a series of *F*- and *t*- tests were performed. This was done in order to better evaluate and compare differences found among variable variance and means. The PCA plots described above are suggestive of a general skewed distribution for most variables. This is seen when the data points cluster near the point of origin and then spray out in all directions from there. This section will evaluate the differences in the amount of variation of the six metric flake dimensions through histograms, *F*-tests, and *t*-tests.

Flake Length

Flake length dimensions are presented for each time period as histograms in order to visually evaluate the distribution of the dataset (Figures 5.15-5.17). These histograms demonstrate that the flake length datasets are not normally distributed in any of the three time periods. A series of *F*-tests were performed in order to compare the variances associated with flake length through time. The comparison between the Lower Late Archaic and Riverton components is summarized in Table 5.17. A preliminary test for the equality of variance indicates that the two groups were significantly different at $F=1.91$, $p=8.8\times10^{-17}$. Therefore, a two-sample *t*-test was performed that did *not* assume equal variances using the Microsoft Excel Data Analysis package. The *t*-test brought back a *p*-value of $1.69\times10^{-12}$ (Table 5.18). With the *p*-value being less than .05, it is possible to reject the null hypothesis of equal means. Table 5.19 compares flake length means for the Riverton and Early Woodland components. An *F*-test for the equality of variance indicates significant differences with values $F=0.622$, $p=4.16\times10^{-13}$. Once again, a two-sample *t*-test was performed that did not assume equal variances. The results are shown in Table 5.20. It is possible to reject the null hypothesis of equal means as $p=8.43\times10^{-18}$. Lastly, the Early Woodland component was compared against the Lower Late Archaic. *F*-test results are summarized in Table 5.21. This preliminary test for the equality of variance shows that the two groups are significantly different with values of $F=0.84$ and $p=.007$. A two-sample *t*-test was performed that did not assumed equal variance. In this case, however, the *p*-value of 0.39 is greater than .05 and it is not possible to reject the null hypothesis of equal means (Table 5.22).

The range of variation in flake length decreases at a statistically significant level in the Riverton component when compared to both the Lower Late Archaic and Early Woodland time periods.

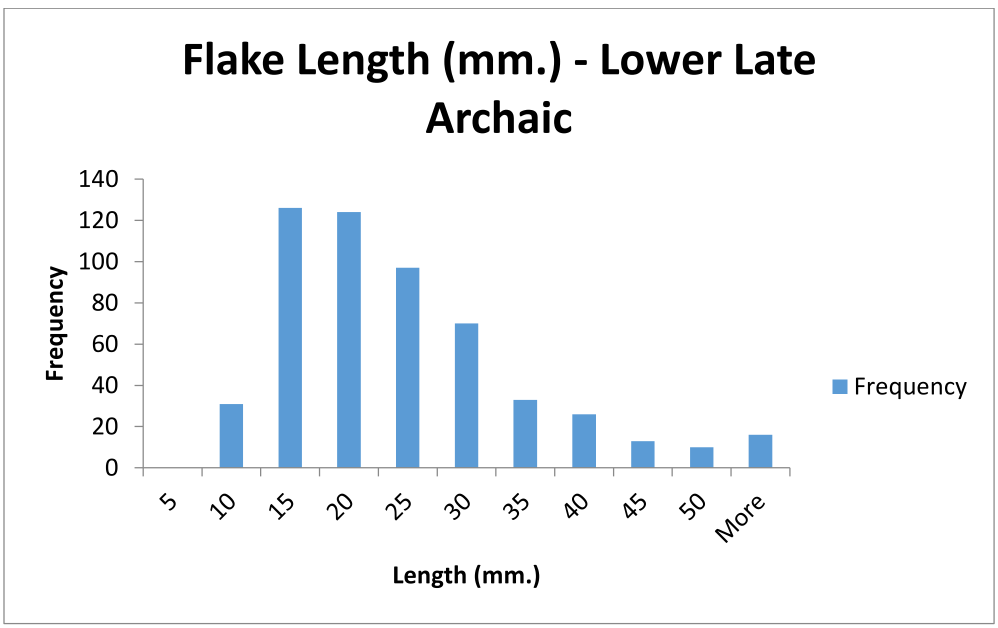


Figure 5.15: Histogram of Flake Length Values for the Lower Late Archaic.

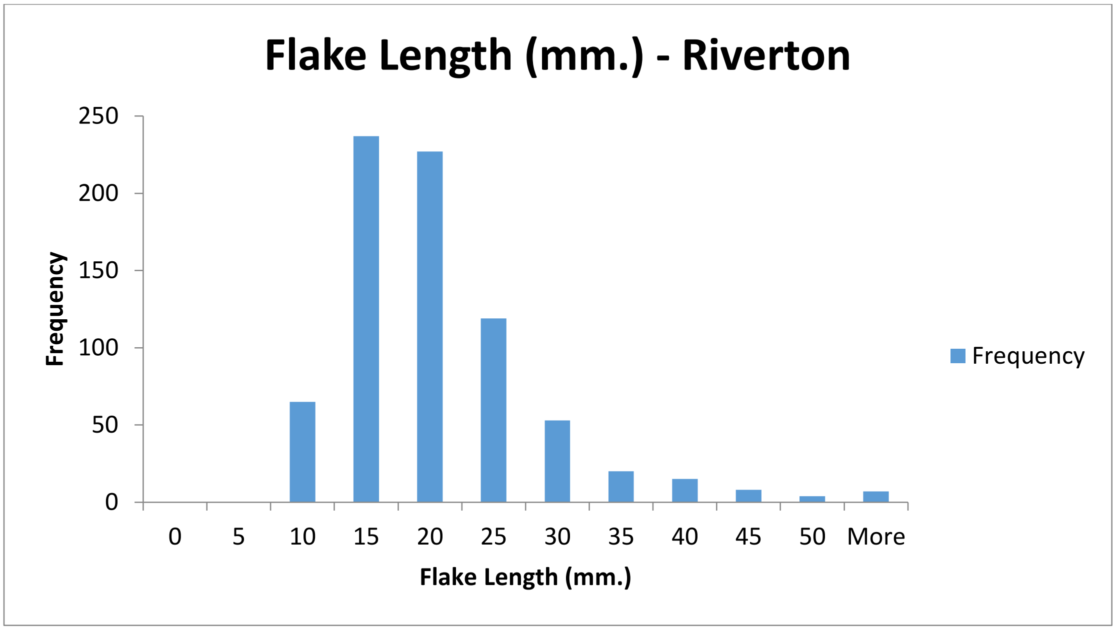


Figure 5.16: Histogram of Flake Length Values for the Riverton.

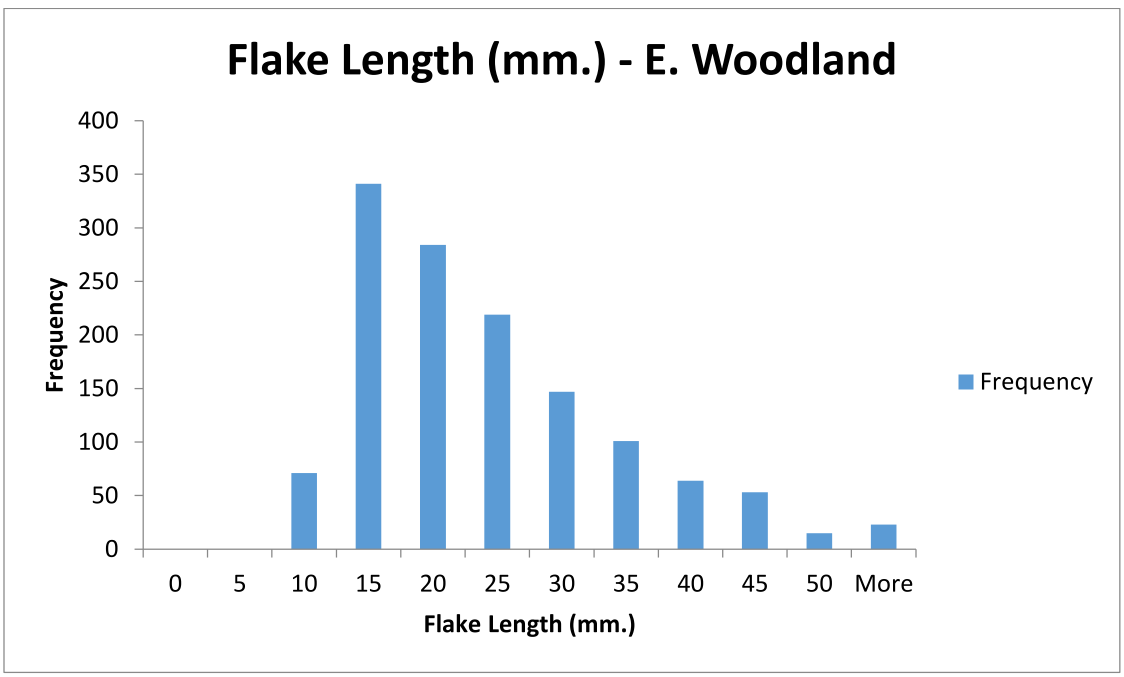


Figure 5.17: Histogram of Flake Length Values for the Early Woodland.

Table 5.17: *F*-Test for Flake Length (LLA and Riverton). Two sample for variances.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 22.2468681 | 18.2200928 |
| Variance | 125.48722 | 65.5486668 |
| Observations | 546 | 754 |
| df | 545 | 753 |
| F | 1.914413 | |
| P(F<=f) one-tail | 8.8035E-17 | |
| F Critical one-tail | 1.13897339 | |

Table 5.18: *T*-Test for Flake Length (LLA and Riverton). Two samples assuming unequal variance.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 22.24687 | 18.2200928 |
| Variance | 125.4872 | 65.5486668 |
| Observations | 546 | 754 |
| Hypothesized Mean Difference | 0 | |
| df | 938 | |
| t Stat | 7.154661 | |
| P(T<=t) one-tail | 8.45E-13 | |
| t Critical one-tail | 1.64648 | |
| P(T<=t) two-tail | 1.69E-12 | |
| t Critical two-tail | 1.962496 | |

Table 5.19: *F*-Test for Flake Length (Riverton and EW). Two sample for variances.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 18.2200928 | 21.76681093 |
| Variance | 65.5486668 | 105.3811354 |
| Observations | 754 | 1317 |
| df | 753 | 1316 |
| F | 0.62201519 | |
| P(F<=f) one-tail | 4.1611E-13 | |
| F Critical one-tail | 0.89831098 | |

Table 5.20: *T*-Test for Flake Length (Riverton and EW). Two samples assuming unequal variance.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 18.2200928 | 21.76681093 |
| Variance | 65.5486668 | 105.3811354 |
| Observations | 754 | 1317 |
| Hypothesized Mean Difference | 0 | |
| df | 1870 | |
| t Stat | -8.6802584 | |
| P(T<=t) one-tail | 4.2167E-18 | |
| t Critical one-tail | 1.64566888 | |
| P(T<=t) two-tail | 8.4334E-18 | |
| t Critical two-tail | 1.96123339 | |

Table 5.21: *F*-Test for Flake Length (EW and LLA). Two sample for variance.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 21.76681093 | 22.24687 |
| Variance | 105.3811354 | 125.4872 |
| Observations | 1317 | 546 |
| df | 1316 | 545 |
| F | 0.839775838 | |
| P(F<=f) one-tail | 0.006918303 | |
| F Critical one-tail | 0.889685475 | |

Table 5.22: *T*-Test for Flake Length (EW and LLA). Two samples assuming unequal variance.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 21.76681093 | 22.24687 |
| Variance | 105.3811354 | 125.4872 |
| Observations | 1317 | 546 |
| Hypothesized Mean Difference | 0 | |
| df | 943 | |
| t Stat | -0.862422252 | |
| P(T<=t) one-tail | 0.194337232 | |
| t Critical one-tail | 1.646471099 | |
| P(T<=t) two-tail | 0.388674464 | |
| t Critical two-tail | 1.962482826 | |

Flake Width

Figure 5.10 provides a visual representation of flake width means through time. Figure 5.10 demonstrates a decrease in flake width mean during the Riverton component along with what appears to be a decrease in the range of variation. Histograms (Figures 5.18-5.20) provide visual evidence that supports the PCA plots in which the datasets is not normally distributed. To further test these assertions, the same methods described above for flake length were used to compare variances amongst pairs for flake width.

Data from the *F*-test conducted for flake width means in the Lower Late Archaic and Riverton components is presented in Table 5.23. *F*-tests performed to evaluate the equality of variance between the Lower Late Archaic and Riverton widths show that variance between the groups is significantly different ($F$=1.66, $p$=4.65×10$^{-11}$). The following *t*-test therefore was conducted assuming unequal variance between groups (Table 5.24). Notice that the *p*-value ($p$=8.6×10$^{-14}$) is less than our significance level of .05. Therefore, it is possible to reject the null hypothesis of equal means between widths of the Lower Late Archaic and Riverton components. Next, an *F*-test evaluated the variances between the Riverton and Early Woodland components (Table 5.25). This preliminary test demonstrates that variances of the groups are significantly different ($F$=0.76, $p$=1.77×10$^{-05}$). Table 5.26 shows the results of the ensuing *t*-test that was conducted that did not assume equal variances. The result is a *p*-value (5.13×10$^{-13}$) that allows for the rejection of the null hypothesis of equal means. Table 5.27 provides the results of the *F*-test conducted between the E. Woodland and the Lower Late Archaic. This preliminary test of variances demonstrates that the two groups are significantly different ($F$=0.787, $p$=0.0003). *T*-test results can be found on Table 5.28. With a *p*-value of 0.018 (less than the .05 significance level) it is possible to reject the null hypothesis of equal means.

Comparing the variances of the three time periods against one another it becomes evident that the Lower Late Archaic has the greatest range of variation for flake width. As with flake length, there is a statistically significant decrease in range of variation during the Riverton component. The range of variation increases again in the Early Woodland component, yet it does not reach the level of variation found in the Lower Late Archaic.

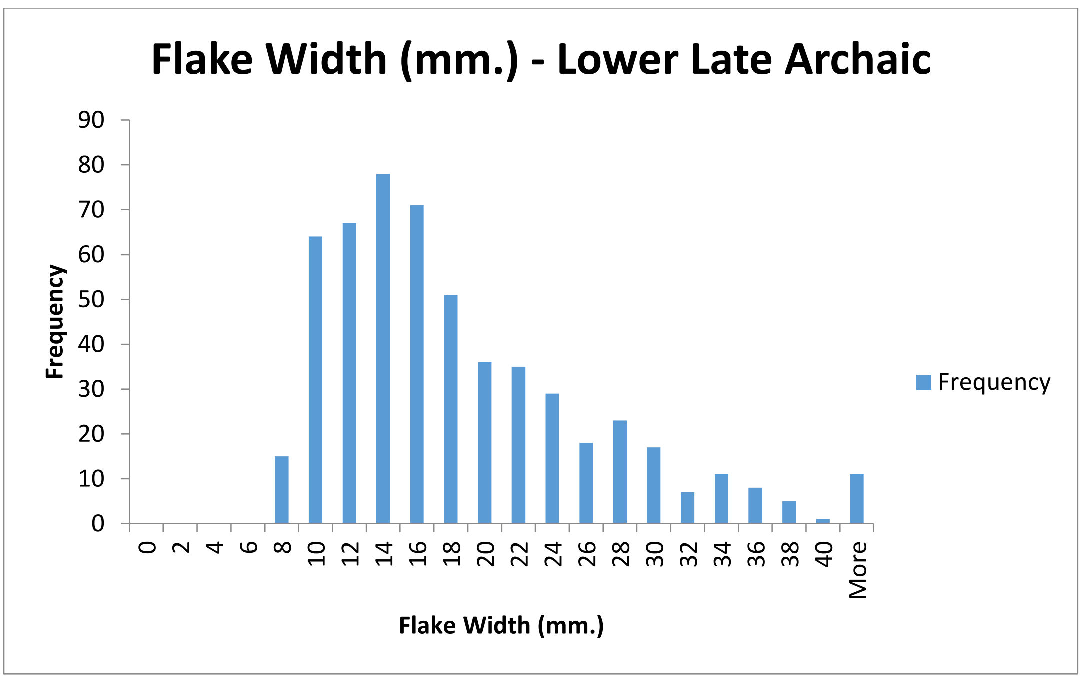


Figure 5.18: Histogram of flake width in the Lower Late Archaic.

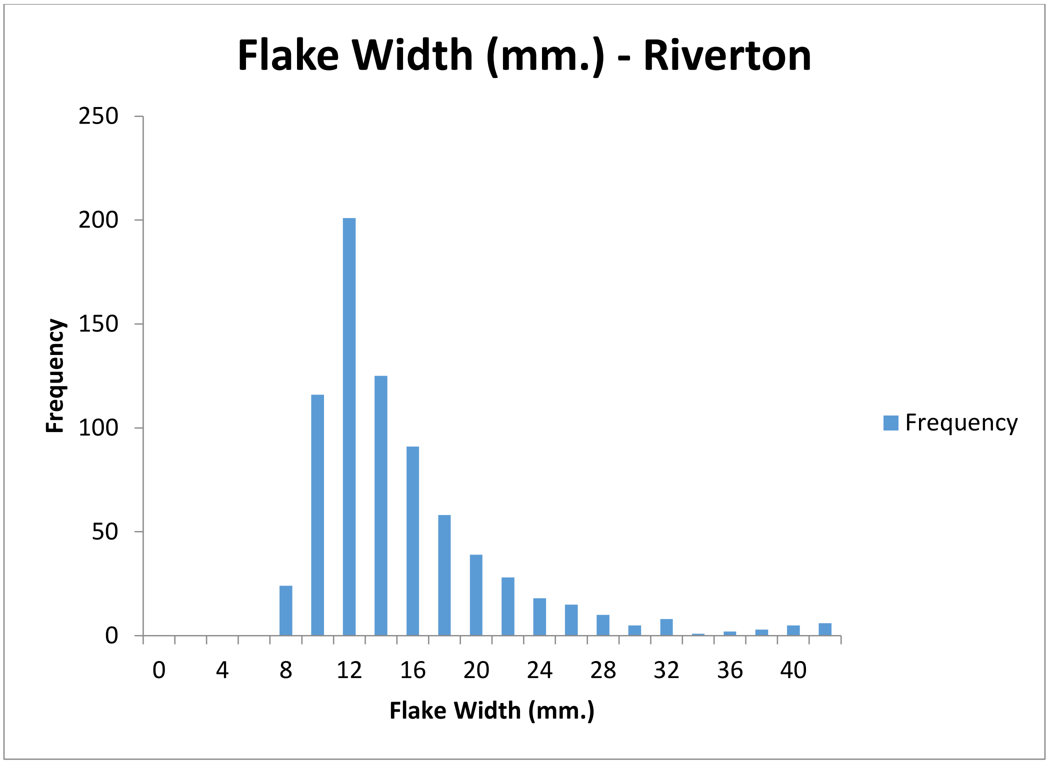


Figure 5.19: Histogram of Flake Width Values for the Riverton.

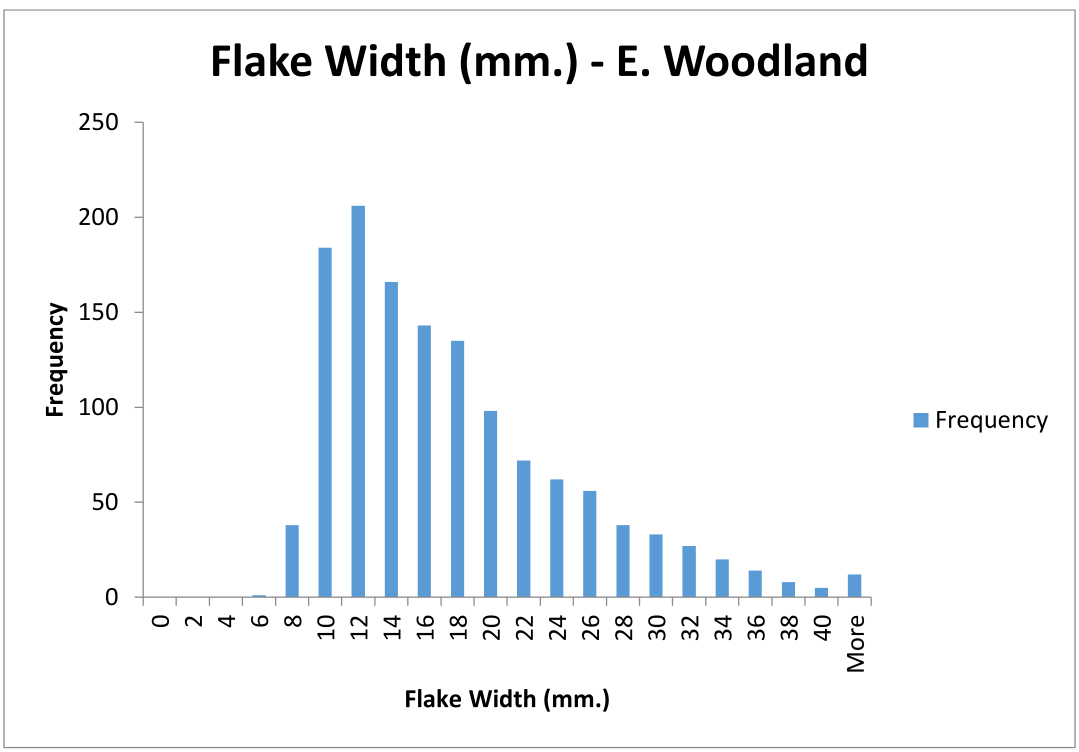


Figure 5.20: Histogram of Flake Width Values for the Early Woodland.

Table 5.23: *F*-Test for Flake Width (LLA and Riverton). Two sample for variances.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 17.6894 | 14.4280662 |
| Variance | 70.77558 | 42.4826944 |
| Observations | 547 | 755 |
| df | 546 | 754 |
| F | 1.665986 | |
| P(F<=f) one-tail | 4.65E-11 | |
| F Critical one-tail | 1.138855 | |

Table 5.24: *T*-test for Flake Width (LLA and Riverton). Two sample assuming unequal variances.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 17.6894 | 14.4280662 |
| Variance | 70.77558 | 42.4826944 |
| Observations | 547 | 755 |
| Hypothesized Mean Difference | 0 | |
| df | 989 | |
| t Stat | 7.569009 | |
| P(T<=t) one-tail | 4.3E-14 | |
| t Critical one-tail | 1.646396 | |
| P(T<=t) two-tail | 8.6E-14 | |
| t Critical two-tail | 1.962366 | |

Table 5.25: *F*-Test Flake Width (Riverton and EW). Two sample for variances.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 14.4280662 | 16.71093323 |
| Variance | 42.4826944 | 55.71639207 |
| Observations | 755 | 1318 |
| df | 754 | 1317 |
| F | 0.76248107 | |
| P(F<=f) one-tail | 1.7724E-05 | |
| F Critical one-tail | 0.89836622 | |

Table 5.26: *T*-Test for Flake Width (Riverton and EW). Two sample assuming unequal variances.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 14.4280662 | 16.71093323 |
| Variance | 42.4826944 | 55.71639207 |
| Observations | 755 | 1318 |
| Hypothesized Mean Difference | 0 | |
| df | 1748 | |
| t Stat | -7.2722722 | |
| P(T<=t) one-tail | 2.655E-13 | |
| t Critical one-tail | 1.64572581 | |
| P(T<=t) two-tail | 5.31E-13 | |
| t Critical two-tail | 1.96132204 | |

Table 5.27: *F*-Test for Flake Width (EW and LLA). Two sample for variances.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 16.71093323 | 17.6894 |
| Variance | 55.71639207 | 70.77558 |
| Observations | 1318 | 547 |
| df | 1317 | 546 |
| F | 0.787226196 | |
| P(F<=f) one-tail | 0.000356215 | |
| F Critical one-tail | 0.889761794 | |

Table 5.28: *T*-Test for Flake Width (EW and LLA). Two sample assuming unequal variance.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 16.71093323 | 17.6894 |
| Variance | 55.71639207 | 70.77558 |
| Observations | 1318 | 547 |
| Hypothesized Mean Difference | 0 | |
| df | 920 | |
| t Stat | -2.361606012 | |
| P(T<=t) one-tail | 0.009201749 | |
| t Critical one-tail | 1.646511577 | |
| P(T<=t) two-tail | 0.018403498 | |
| t Critical two-tail | 1.962545878 | |

Flake Thickness

Figure 5.11 visually presents flake thickness data for each time period. Histograms for each time period (Figures 5.21-5.23) demonstrate that mean flake thickness (mm.) is not normally distributed during any time period. To test the range of variation associated with flake thickness through time, *F*-tests were conducted for each pair in order to evaluate the equality of variances. *T*-tests were then conducted in order to evaluate the significance associated between means for each time period. The results are presented below.

Flake thickness data from an *F*-test conducted between the Lower Late Archaic and Riverton is presented in Table 5.29. This preliminary test for the equality of variances between components shows that variance between groups is significantly different ($F$=1.16, $p$=0.03). A *t*-test that assumes unequal variances was performed and the data is summarized in Table 5.30. Notice that the *p*-value ($3.12 \times 10^{-08}$) is far below the .05 alpha level. It is possible to reject the null hypothesis of equal means between the Lower Late Archaic and the Riverton components. Next, an *F*-test evaluated the variances between Riverton and Early Woodland components (Table 5.31). This preliminary test demonstrates that flake thickness between these components is significantly different ($F$=1.12, $p$=0.04). Therefore, a *t*-test assuming unequal variances was performed and the results are summarized in Table 5.32. The *t*-test provides a *p*-value (0.02) that is less than the alpha level of .05, making it possible to reject the null hypothesis of equal means. Lastly, an *F*-test was performed between the Early Woodland and Lower Late Archaic components (Table 5.33). The *F*-test confirms that variances between groups are significantly different ($F$=0.77, $p$=<0.00). A two sample *t*-test was performed that did not assume equal variances between the groups. *T*-test results (Table 5.34) provide a *p*-value ($2.10\times10^{-05}$) that is less than the alpha level of .05, making it possible to reject the null hypothesis of equal means.

The results presented above demonstrate that all time periods have statistically significant variation between flake thickness means.

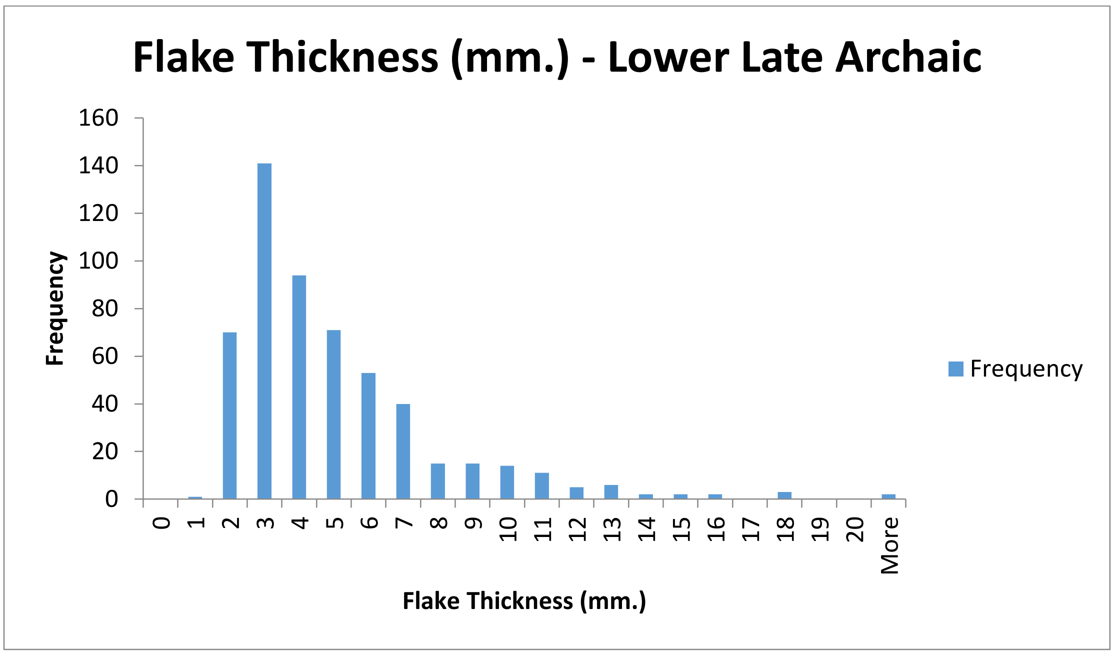


Figure 5.21: Histogram of Flake Thickness Values for the Lower Late Archaic.

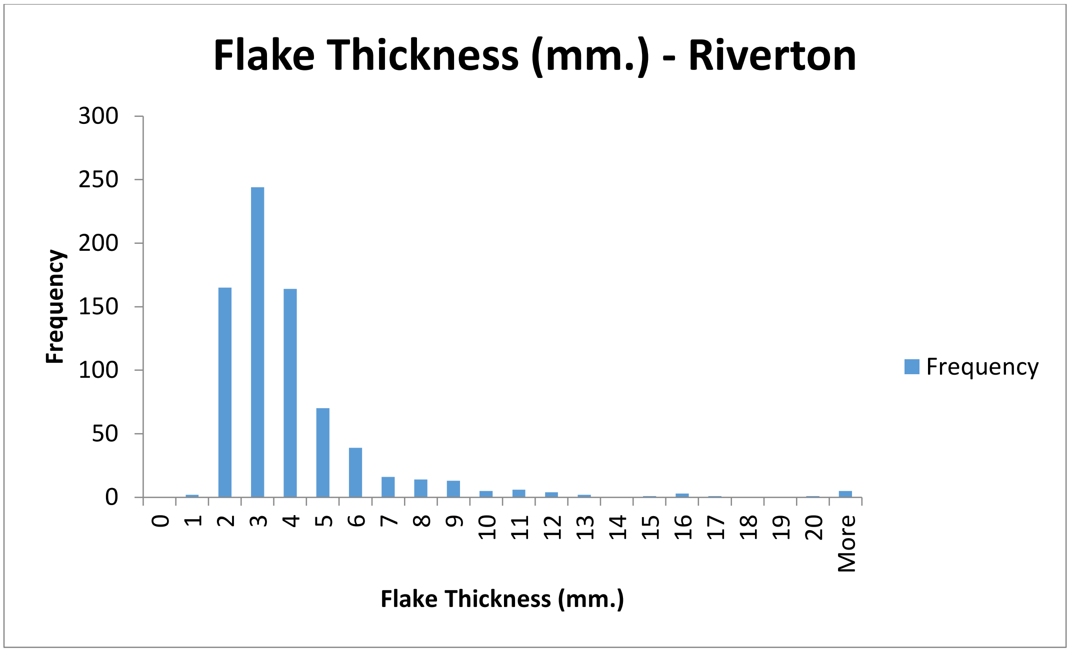


Figure 5.22: Histogram of Flake Thickness Values for the Riverton.

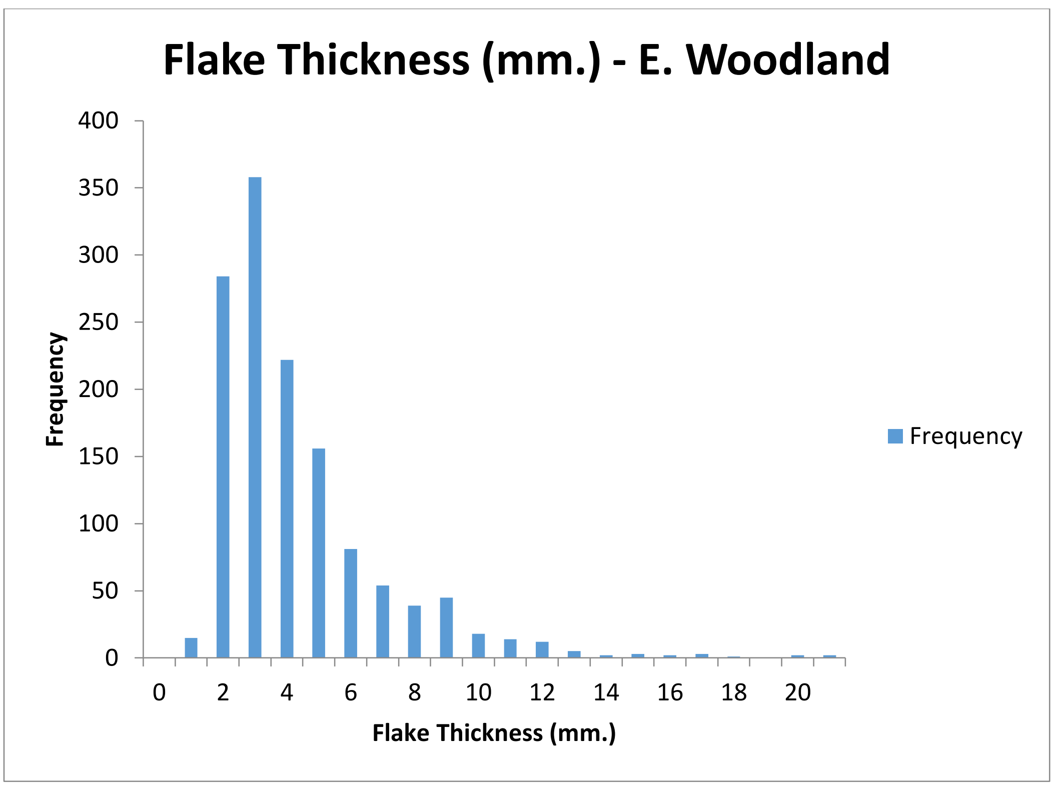


Figure 5.23: Histogram of Flake Thickness Values for the Early Woodland.

Table 5.29: *F*-Test for Flake Thickness (LLA and Riverton). Two sample for variances.

| | LLA | Riverton |
|---|---|---|
| Mean | 4.49533 | 3.56628647 |
| Variance | 9.420688 | 8.14534662 |
| Observations | 546 | 754 |
| df | 545 | 753 |
| F | 1.156573 | |
| P(F<=f) one-tail | 0.032974 | |
| F Critical one-tail | 1.138973 | |

Table 5.30: *T*-Test for Flake Thickness (LLA and Riverton). Two sample assuming unequal variances.

| | LLA | Riverton |
|---|---|---|
| Mean | 4.4998172 | 3.567417219 |
| Variance | 9.4144491 | 8.135509103 |
| Observations | 547 | 755 |
| Hypothesized Mean Difference | 0 | |
| df | 1125 | |
| t Stat | 5.5734926 | |
| P(T<=t) one-tail | 1.562E-08 | |
| t Critical one-tail | 1.6462092 | |
| P(T<=t) two-tail | 3.124E-08 | |
| t Critical two-tail | 1.9620749 | |

Table 5.31: *F*-Test for Flake Thickness (Riverton and EW). Two sample for variances.

| | Riverton | E. Woodland |
|---|---|---|
| Mean | 3.56628647 | 3.851275626 |
| Variance | 8.14534662 | 7.27080901 |
| Observations | 754 | 1317 |
| df | 753 | 1316 |
| F | 1.12028065 | |
| P(F<=f) one-tail | 0.03822128 | |
| F Critical one-tail | 1.11121624 | |

Table 5.32: *T*-Test for Flake Thickness (Riverton and EW). Two sample assuming unequal variances.

| | Riverton | E. Woodland |
|---|---|---|
| Mean | 3.56741722 | 3.855045524 |
| Variance | 8.1355091 | 7.284019854 |
| Observations | 755 | 1318 |
| Hypothesized Mean Difference | 0 | |
| df | 1500 | |
| t Stat | -2.2527351 | |
| P(T<=t) one-tail | 0.01220994 | |
| t Critical one-tail | 1.6458701 | |
| P(T<=t) two-tail | 0.02441987 | |
| t Critical two-tail | 1.96154675 | |

Table 5.33: *F*-Test for Flake Thickness (EW and LLA). Two sample for variances.

| | E. Woodland | LLA |
|---|---|---|
| Mean | 3.851275626 | 4.49533 |
| Variance | 7.27080901 | 9.420688 |
| Observations | 1317 | 546 |
| df | 1316 | 545 |
| F | 0.771791747 | |
| P(F<=f) one-tail | 0.000123285 | |
| F Critical one-tail | 0.889685475 | |

Table 5.34: *T*-Test for Flake Thickness (EW and LLA). Two sample assuming unequal variances.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 3.855045524 | 4.499817 |
| Variance | 7.284019854 | 9.414449 |
| Observations | 1318 | 547 |
| Hypothesized Mean Difference | 0 | |
| df | 914 | |
| t Stat | -4.275957232 | |
| P(T<=t) one-tail | 1.05162E-05 | |
| t Critical one-tail | 1.646522472 | |
| P(T<=t) two-tail | 2.10323E-05 | |
| t Critical two-tail | 1.962562849 | |

Platform Thickness

An examination of Figure 5.12 demonstrates that there is a general decrease in platform thickness means through time. Standard deviation error bars suggest that the range of variation for platform thickness is greatest among Lower Late Archaic flakes. Figures 5.24-5.26 show that none of the three time periods demonstrate a normal distribution of frequencies. Table 5.35 provides the results of an *F*-test conducted between means of the Lower Late Archaic and Riverton components. A preliminary test for the equality of variances indicates that the variances of the two groups were significantly different at $F$=1.56, $p$=7.8×$10^{-09}$. A two sample *t*-test was performed that did not assume equal variance. *T*-test results are summarized in Table 5.36. With a *p*-value coming in at 5.48×$10^{-05}$, well under the alpha level of .05, it is possible to safely reject the null hypothesis of equal means. Next, an *F*-test was performed to evaluate the equality of variances for the Riverton and Early Woodland components. Table 5.37 presents the results. This preliminary test reveals that there is statistically significant differences between variances as $F$=1.18, $p$=.005. As before, a *t*-test was performed that did not assume equal variance between the two components. *T*-test results show a *p*-value of 0.04 (Table 5.38). Being slightly less than the alpha level set at .05, it is possible to reject the null hypothesis of equal means. Lastly, an *F*-test was performed for the Lower Late Archaic and the Early Woodland components (Table 5.39). This preliminary test for the equality of variances resulted in values of $F$=0.54 and $p$=0.0, meaning that variances were significantly different. *T*-test results found in Table 5.40 provide a *p*-value of 4.13×$10^{-09}$, well less than the .05 alpha level. This means that the null hypothesis of equal means can be rejected.

*F*- and *t*-tests to evaluate variance and the equality of means conclude that all platform thickness means are significantly different at the .05 level.

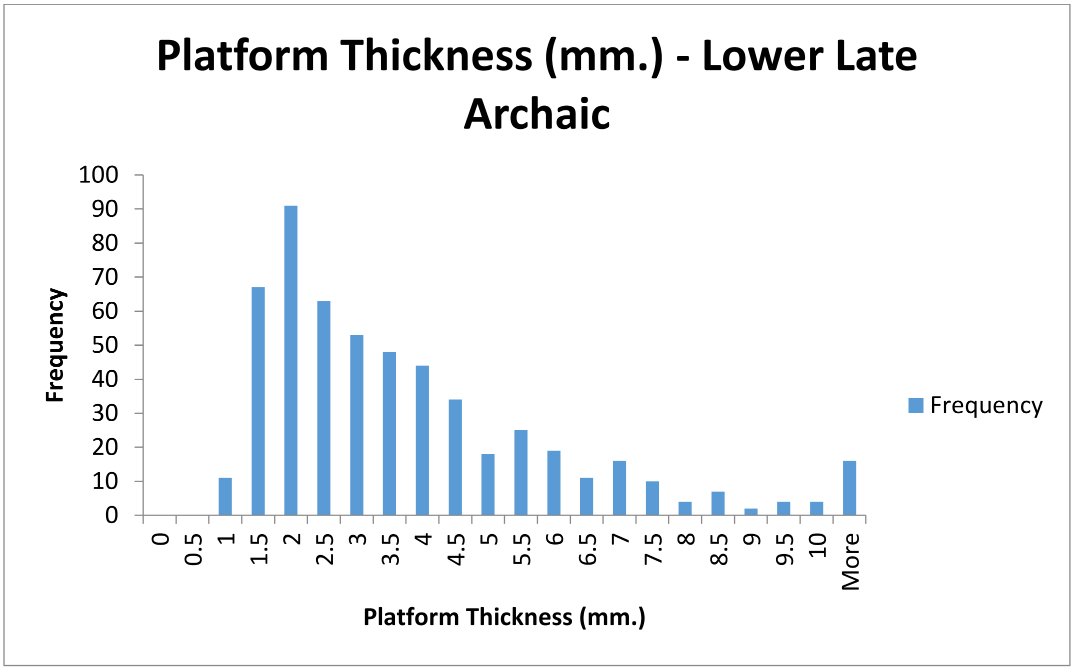


Figure 5.24: Histogram of Platform Thickness Values for the Lower Late Archaic.

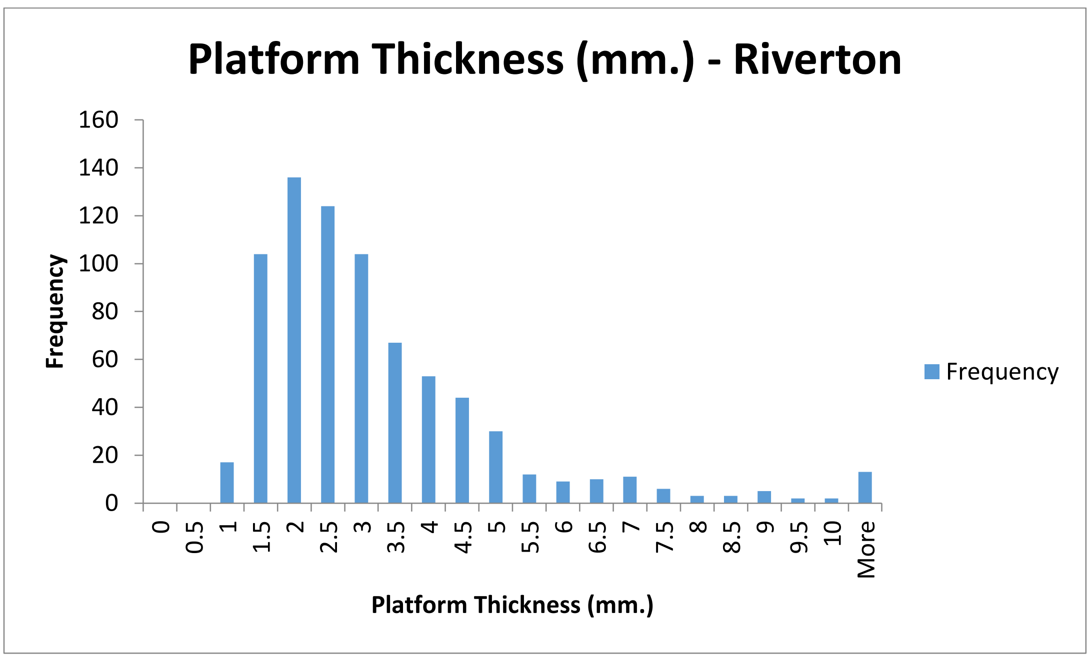


Figure 5.25: Histogram of Platform Thickness Values for the Riverton.

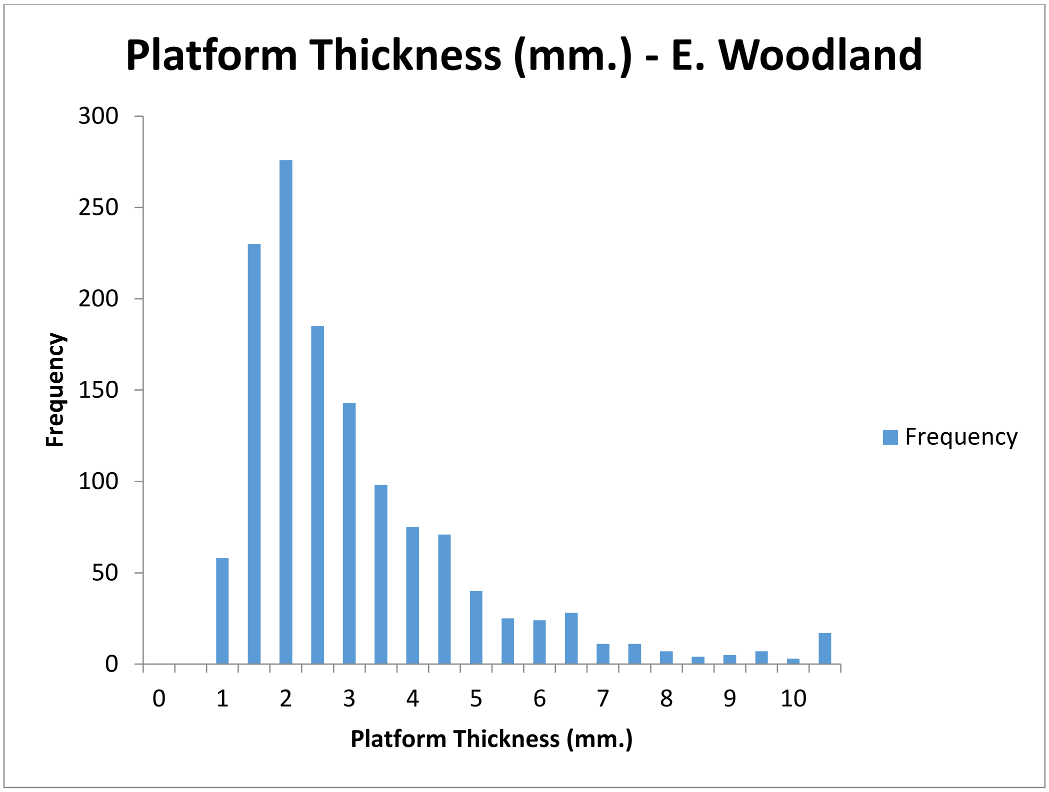


Figure 5.26: Histogram of Platform Thickness Values for the Early Woodland.

Table 5.35: *F*-Test for Platform Thickness (LLA and Riverton). Two sample for variances.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 3.629707 | 3.0581457 |
| Variance | 7.436804 | 4.76219841 |
| Observations | 547 | 755 |
| df | 546 | 754 |
| F | 1.561633 | |
| P(F<=f) one-tail | 7.8E-09 | |
| F Critical one-tail | 1.138855 | |

Table 5.36: *T*-Test for Platform Thickness (LLA and Riverton). Two sample assuming unequal variances.

| | LLA | Riverton |
|---|---|---|
| Mean | 3.629707 | 3.0581457 |
| Variance | 7.436804 | 4.76219841 |
| Observations | 547 | 755 |
| Hypothesized Mean Difference | 0 | |
| df | 1012 | |
| t Stat | 4.051372 | |
| P(T<=t) one-tail | 2.74E-05 | |
| t Critical one-tail | 1.646361 | |
| P(T<=t) two-tail | 5.48E-05 | |
| t Critical two-tail | 1.962311 | |

Table 5.37: *F*-Test for Platform Thickness (Riverton and EW). Two sample for variances.

| | Riverton | E. Woodland |
|---|---|---|
| Mean | 3.058145695 | 2.862412747 |
| Variance | 4.762198414 | 4.040443377 |
| Observations | 755 | 1318 |
| df | 754 | 1317 |
| F | 1.178632632 | |
| P(F<=f) one-tail | 0.005117944 | |
| F Critical one-tail | 1.11115204 | |

Table 5.38: *T*-Test for Platform Thickness (Riverton and EW). Two sample assuming unequal variances.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 3.0581457 | 2.862412747 |
| Variance | 4.76219841 | 4.040443377 |
| Observations | 755 | 1318 |
| Hypothesized Mean Difference | 0 | |
| df | 1467 | |
| t Stat | 2.02172238 | |
| P(T<=t) one-tail | 0.02169314 | |
| t Critical one-tail | 1.64589298 | |
| P(T<=t) two-tail | 0.04338628 | |
| t Critical two-tail | 1.96158239 | |

Table 5.39: *F*-Test for Platform Thickness (EW and LLA). Two sample for variances.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 2.862412747 | 3.629707 |
| Variance | 4.040443377 | 7.436804 |
| Observations | 1318 | 547 |
| df | 1317 | 546 |
| F | 0.543303711 | |
| P(F<=f) one-tail | 0 | |
| F Critical one-tail | 0.889761794 | |

Table 5.40: *T*-Test for Platform Thickness (EW and LLA). Two sample assuming unequal variances.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 2.862412747 | 3.629707 |
| Variance | 4.040443377 | 7.436804 |
| Observations | 1318 | 547 |
| Hypothesized Mean Difference | 0 | |
| df | 803 | |
| t Stat | -5.944413267 | |
| P(T<=t) one-tail | 2.06741E-09 | |
| t Critical one-tail | 1.646753427 | |
| P(T<=t) two-tail | 4.13483E-09 | |
| t Critical two-tail | 1.962922627 | |

Platform Width

Figure 5.13 presents the means for platform width through time. The chart shows that mean platform width decreases through time, with the Early Woodland period showing the lowest degree of variance. Figures 5.27-5.29 are histograms broken down by time period which demonstrate the non-normal distributions associated with platform width frequencies. In order to compare variances for platform widths through time, a series of *F*-tests were performed. Table 5.41 shows the results of the *F*-test comparing variances between the Lower Late Archaic and the Riverton time periods. This preliminary test indicates that the variances of the two groups are significantly different with $F=1.36$ and $p=5.01\times10^{-05}$. Next, a *t*-test was conducted that does not assume equal variances between groups. *T*-test results for this comparison can be found in Table 5.42. With a *p*-value of $2.81\times10^{-09}$, a value well below the .05 significance level, it is possible to reject the null hypothesis of equal means. Table 5.43 provides the results of an *F*-test performed between the Riverton and Early Woodland components. This preliminary test for the equality of variances indicates that variances of the groups are significantly different ($F=1.35$, $p=1.02\times10^{-06}$). Table 5.44 summarizes the results from a *t*-test that was then conducted that did not assume equal variances. With a *p*-value of 0.97, it is *not* possible to reject the null hypothesis of equal means between the Riverton and Early Woodland components. The last test conducted for platform widths is between the Early Woodland and the Lower Late Archaic. *F*-test results are shown in Table 5.45. This preliminary test for the equality of variances indicates that variances are significantly different ($F=0.54$, $p=0.0$). A *t*-test was then conducted that did not assume equal variances between the two groups. Table 5.46 provides a summary of the results from the *t*-test.  With a *p*-value of $3.18 \times 10^{-11}$, it is possible to reject the null hypothesis of equal means.

The data described above show some interesting trends.  Most notable is the fact that platform width means are essentially equal between the Riverton and Early Woodland components.  All other combinations demonstrate a statistically significant level of variance between means.

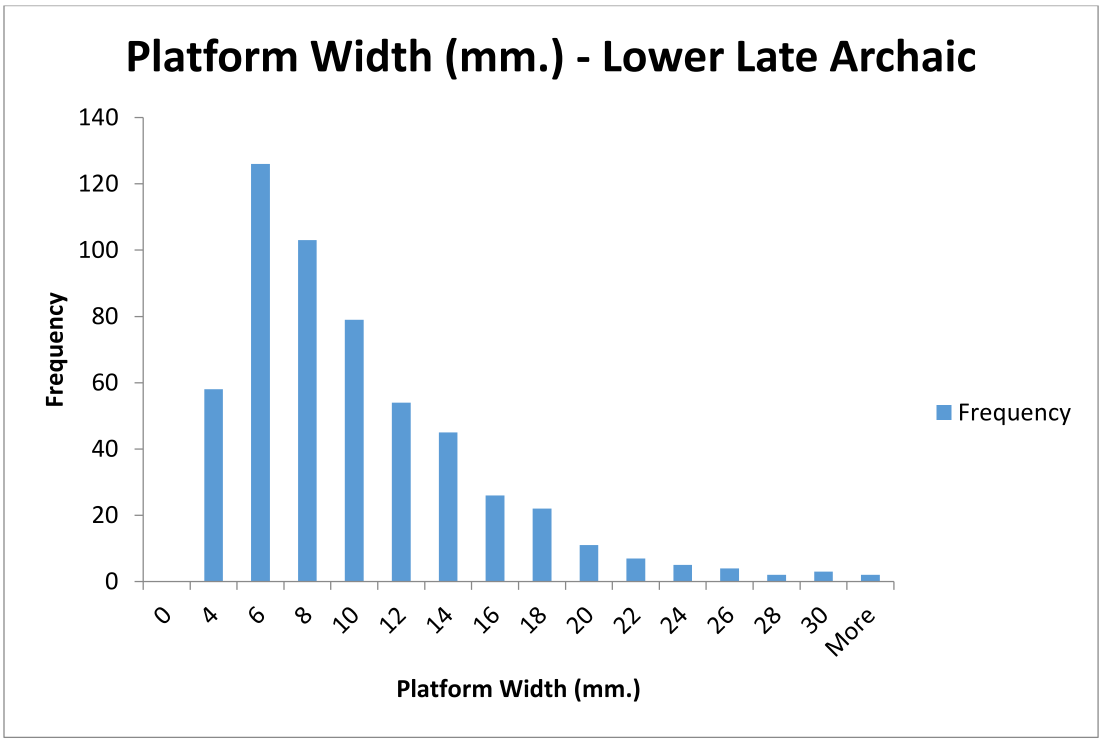


Figure 5.27: Histogram of Platform Width Values for the Lower Late Archaic.

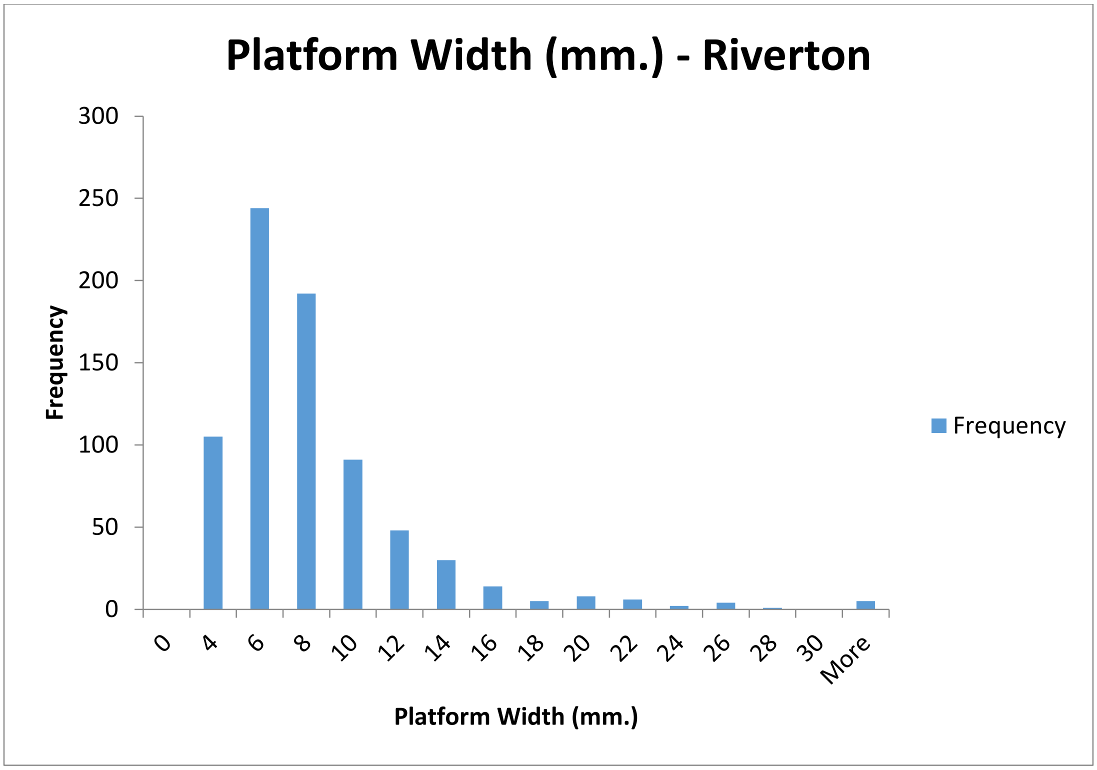


Figure 5.28: Histogram of Platform Width Values for the Riverton.

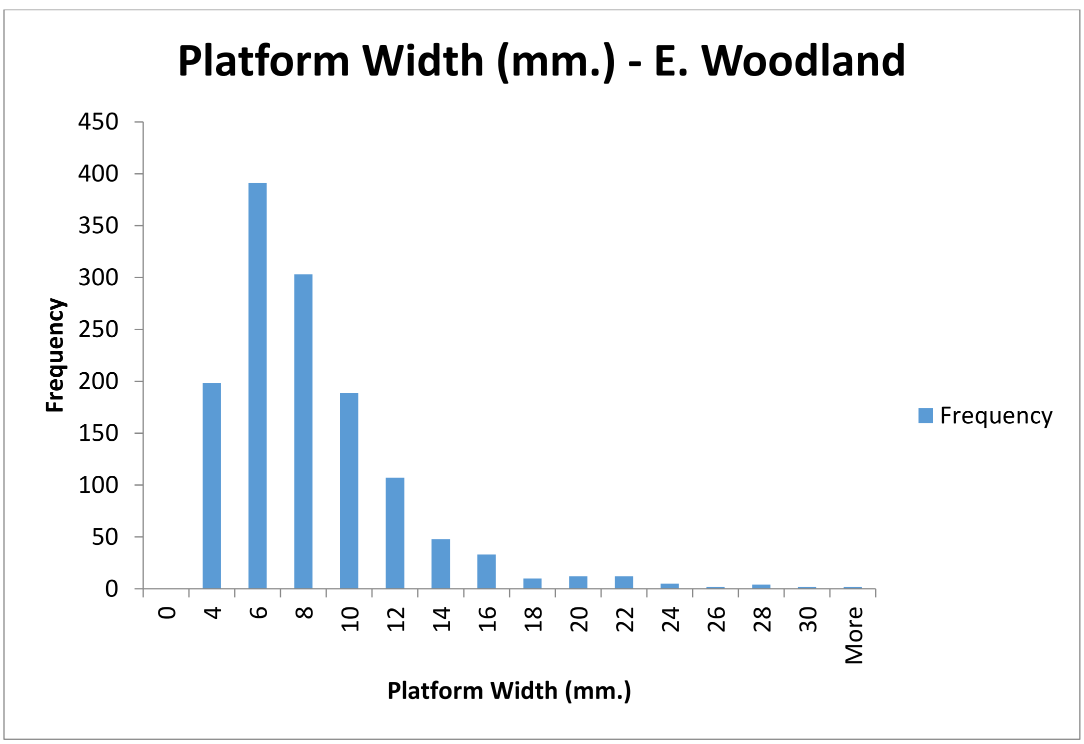


Figure 5.29: Histogram of Platform Width Values for the Early Woodland.

Table 5.41: *F*-Test for Platform Width (LLA and Riverton). Two sample for variances.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 9.124516 | 7.38486093 |
| Variance | 30.06189 | 22.1148383 |
| Observations | 547 | 755 |
| Df | 546 | 754 |
| F | 1.359354 | |
| P(F<=f) one-tail | 5.01E-05 | |
| F Critical one-tail | 1.138855 | |

Table 5.42: *T*-Test for Platform Width (LLA and Riverton). Two sample assuming unequal variances.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 9.124516 | 7.38486093 |
| Variance | 30.06189 | 22.1148383 |
| Observations | 547 | 755 |
| Hypothesized Mean Difference | 0 | |
| Df | 1064 | |
| t Stat | 5.993505 | |
| P(T<=t) one-tail | 1.4E-09 | |
| t Critical one-tail | 1.646287 | |
| P(T<=t) two-tail | 2.81E-09 | |
| t Critical two-tail | 1.962196 | |

Table 5.43: *F*-Test for Platform Width (Riverton and EW). Two sample for variances.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 7.38486093 | 7.377336874 |
| Variance | 22.1148383 | 16.33666693 |
| Observations | 755 | 1318 |
| Df | 754 | 1317 |
| F | 1.3536934 | |
| P(F<=f) one-tail | 1.016E-06 | |
| F Critical one-tail | 1.11115204 | |

Table 5.44: *T*-Test for Platform Width (Riverton and EW). Two sample assuming unequal variances.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 7.38486093 | 7.377336874 |
| Variance | 22.1148383 | 16.33666693 |
| Observations | 755 | 1318 |
| Hypothesized Mean Difference | 0 | |
| Df | 1385 | |
| t Stat | 0.03685154 | |
| P(T<=t) one-tail | 0.48530435 | |
| t Critical one-tail | 1.64595456 | |
| P(T<=t) two-tail | 0.97060869 | |
| t Critical two-tail | 1.96167829 | |

Table 5.45: *F*-Test for Platform Width (EW and LLA). Two sample for variances.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 7.377336874 | 9.124516 |
| Variance | 16.33666693 | 30.06189 |
| Observations | 1318 | 547 |
| Df | 1317 | 546 |
| F | 0.543434505 | |
| P(F<=f) one-tail | 0 | |
| F Critical one-tail | 0.889761794 | |

Table 5.46: *T*-Test for Platform Width (EW and LLA). Two sample assuming unequal variances.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 7.377336874 | 9.124516 |
| Variance | 16.33666693 | 30.06189 |
| Observations | 1318 | 547 |
| Hypothesized Mean Difference | 0 | |
| Df | 803 | |
| t Stat | -6.732238962 | |
| P(T<=t) one-tail | 1.59001E-11 | |
| t Critical one-tail | 1.646753427 | |
| P(T<=t) two-tail | 3.18002E-11 | |
| t Critical two-tail | 1.962922627 | |

Flake Weight

Figure 5.14 provides a visual representation of the mean flake weight through time. It is possible to visually comprehend a slight decrease in flake weight from the Lower Late Archaic to the Riverton, and then a slight increase from the Riverton to the Early Woodland. Figures 5.30-5.32 provide preliminary visual evidence that flake weights are not normally distributed across time periods. Performing an *F*-test for the equality of variances between the Lower Late Archaic and Riverton components demonstrates that variance between groups are significantly different ($F$=1.46, $p$=7.01×10$^{-07}$) (Table 5.47). Table 5.48 summarizes the results of a *t*-test conducted that did not assume equal variances between components. With a *p*-value of 1.53×10$^{-05}$, it is possible to reject the null hypothesis of equal means. The same tests were conducted between the Riverton and Early Woodland periods, as well as Early Woodland and Lower Late Archaic. The *F*-test for the Riverton and Early Woodland (Table 5.49) components shows that variances are significantly different ($F$=1.19, $p$=0.002). The accompanying *t*-test provided a *p*-value of 0.001, less than the .05 significance level (Table 5.50). It is possible to reject the null hypothesis of equal means. Lastly, Table 5.51 performs an *F*-test for the Early Woodland and Lower Late Archaic periods. Significant differences are found between the variances of the groups. Table 5.52 provides the results for the ensuing *t*-test and finds a *p*-value of .019, allowing for the rejection of the null hypothesis.

The results presented above demonstrate that all time periods have statistically significant variation between mean weights.

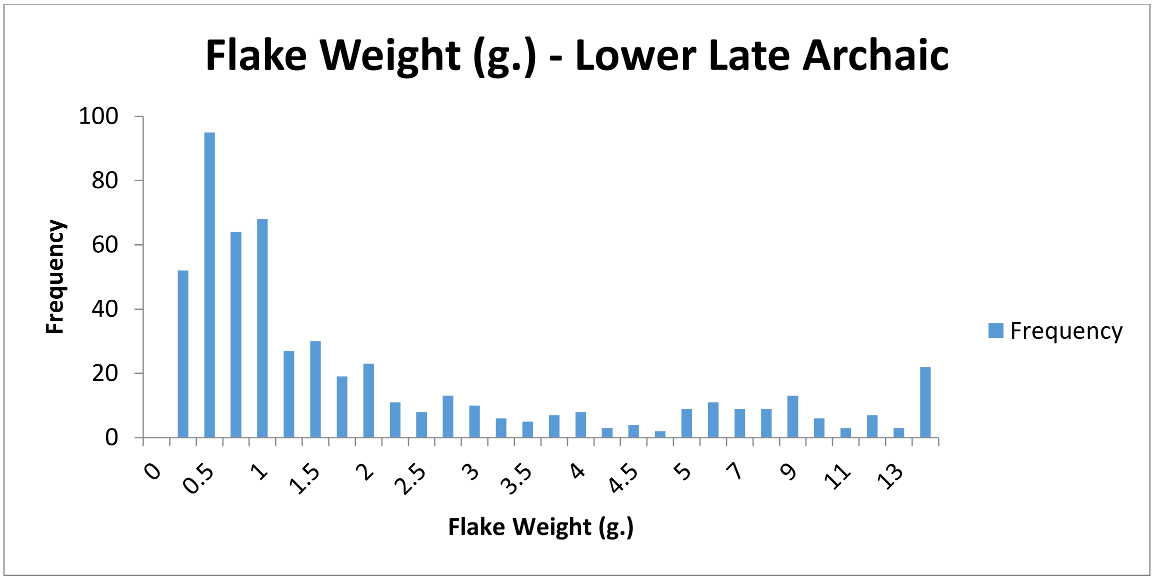


Figure 5.30: Histogram of Flake Weight Values for the Lower Late Archaic.

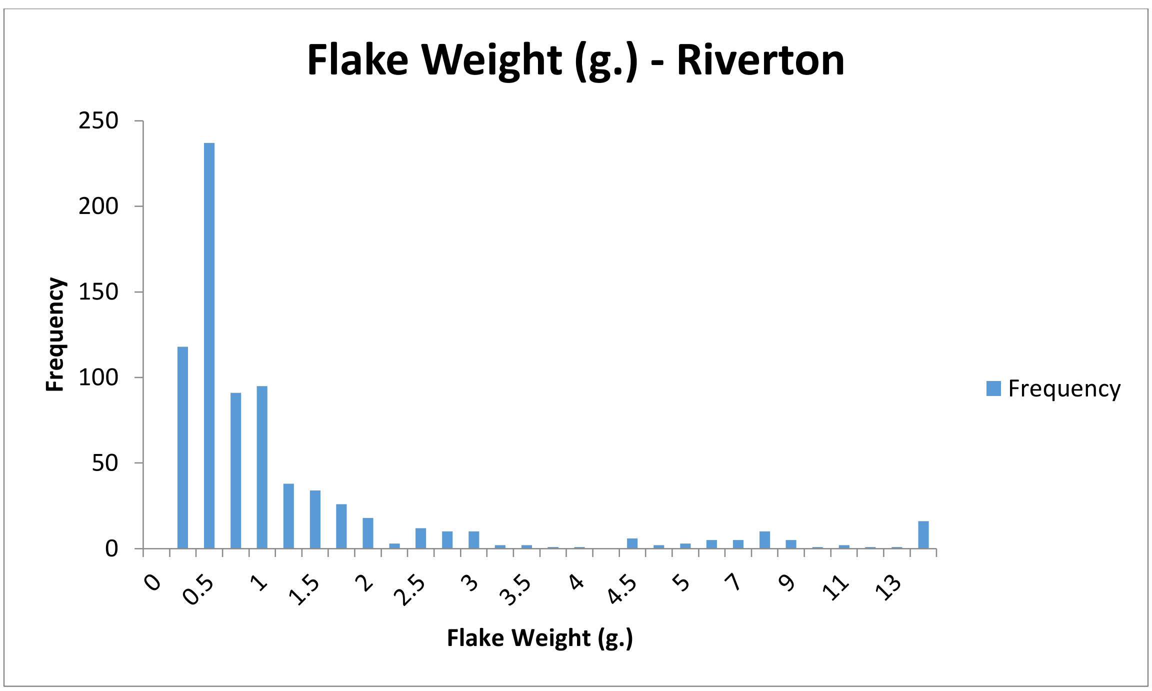


Figure 5.31: Histogram of Flake Weight Values for the Riverton.

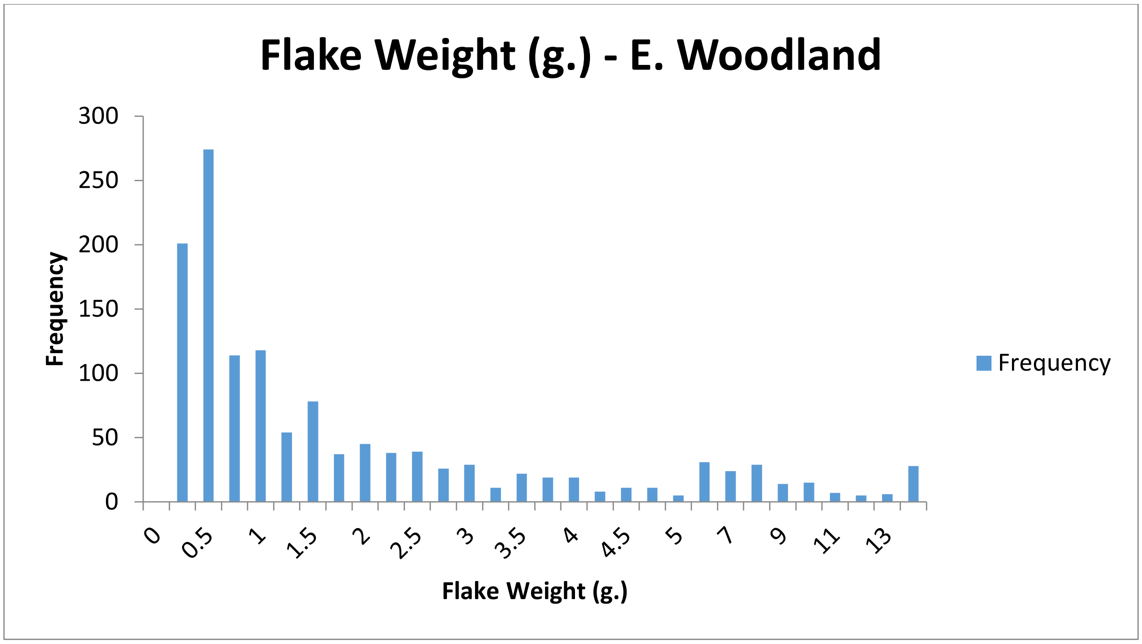


Figure 5.32: Histogram of Flake Weight Values for the Early Woodland.

Table 5.47: *F*-Test for Flake Weight (LLA and Riverton). Two sample for variances.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 2.927879 | 1.65768212 |
| Variance | 31.26993 | 21.3739608 |
| Observations | 547 | 755 |
| Df | 546 | 754 |
| F | 1.462992 | |
| P(F<=f) one-tail | 7.01E-07 | |
| F Critical one-tail | 1.138855 | |

Table 5.48: *T*-Test for Flake Weight (LLA and Riverton). Two sample assuming unequal variances.

| | *LLA* | *Riverton* |
|---|---|---|
| Mean | 2.927879 | 1.65768212 |
| Variance | 31.26993 | 21.3739608 |
| Observations | 547 | 755 |
| Hypothesized Mean Difference | 0 | |
| Df | 1037 | |
| t Stat | 4.34459 | |
| P(T<=t) one-tail | 7.66E-06 | |
| t Critical one-tail | 1.646324 | |
| P(T<=t) two-tail | 1.53E-05 | |
| t Critical two-tail | 1.962254 | |

Table 5.49: *F*-Test for Flake Weight (Riverton and EW). Two sample for variances.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 1.65768212 | 2.306752656 |
| Variance | 21.3739608 | 17.89775087 |
| Observations | 755 | 1318 |
| Df | 754 | 1317 |
| F | 1.19422608 | |
| P(F<=f) one-tail | 0.00276821 | |
| F Critical one-tail | 1.11115204 | |

Table 5.50: *T*-Test for Flake Weight (Riverton and EW). Two sample assuming unequal variances.

| | *Riverton* | *E. Woodland* |
|---|---|---|
| Mean | 1.65768212 | 2.306752656 |
| Variance | 21.3739608 | 17.89775087 |
| Observations | 755 | 1318 |
| Hypothesized Mean Difference | 0 | |
| Df | 1459 | |
| t Stat | -3.1713198 | |
| P(T<=t) one-tail | 0.00077453 | |
| t Critical one-tail | 1.64589869 | |
| P(T<=t) two-tail | 0.00154906 | |
| t Critical two-tail | 1.96159127 | |

Table 5.51: *F*-Test for Flake Weight (EW and LLA). Two sample for variances.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 2.306752656 | 2.927879 |
| Variance | 17.89775087 | 31.26993 |
| Observations | 1318 | 547 |
| Df | 1317 | 546 |
| F | 0.572362992 | |
| P(F<=f) one-tail | 4.44089E-16 | |
| F Critical one-tail | 0.889761794 | |

Table 5.52: *T*-Test for Flake Weight (EW and LLA). Two sample assuming unequal variances.

| | *E. Woodland* | *LLA* |
|---|---|---|
| Mean | 2.306752656 | 2.927879 |
| Variance | 17.89775087 | 31.26993 |
| Observations | 1318 | 547 |
| Hypothesized Mean Difference | 0 | |
| Df | 817 | |
| t Stat | -2.335232515 | |
| P(T<=t) one-tail | 0.009886258 | |
| t Critical one-tail | 1.646720835 | |
| P(T<=t) two-tail | 0.019772516 | |
| t Critical two-tail | 1.962871855 | |

ANOVA Tests

This last section provides the results of a one-way analysis of variance (ANOVA) conducted on flake length, width, and weight. ANOVA tests are used to determine if there are significant differences in means between multiple independent groups. Post-hoc Tukey tests were conducted in order to compare means amongst various groups where variance is assumed to be unequal. Some interesting trends are identified when metric variables (i.e., flake length, width, and weight) are examined based on chert type and time period. Flake length data are presented in Tables 5.53-5.54. For example, variance found for the length of Muldraugh flakes is significant between all time periods (Table 5.53). Additionally, Wyandotte flakes have statistically significant differences (.013) in variance between Riverton and Early Woodland components.

Table 5.54 summarizes the results of the ANOVA tests between time periods for flake length based on flake type. While initial reduction and finishing flake types display no significant differences, both biface reduction and thinning flakes show statistically significant variance between time periods. Biface reduction flake variance is significantly different between the Riverton component and both the Lower Late Archaic and Early Woodland components. Notice that biface reduction flakes for the Lower Late Archaic and Early Woodland periods produce a significance value (.993) far greater than the .05 alpha level. Thinning flakes show a similar yet slightly different trend. Variance between time periods is statistically significant for all comparisons.

Table 5.55 examines the relationship between flake widths based on time period and flake type. Similar to the results for flake length, width data shows that biface reduction and thinning flake variance is significant between the Riverton component and both the Lower Late Archaic and Early Woodland. When flake width variance is compared between the Lower Late Archaic and Early Woodland periods, there are no statistically significant differences. In a change from the flake length results, finishing flake variance is statistically significant only between the Lower Late Archaic and the Early Woodland components (Table 5.55).

Table 5.56 provides a summary of ANOVA tests conducted regarding flake widths and chert type. The results for Muldraugh chert are the same as for flake length where all time periods were found to have statistically significant variation between one another. Also, like flake length results, Wyandotte chert shows statistically significant variance only between the Riverton and Early Woodland components.

Flake weight was the final variable for which ANOVA testing was conducted. Table 5.57 summarizes the results that were based on the comparison of weights for flake types and time periods. Biface reduction and thinning flakes provide comparable results to those for flake length and width. That is, flake weight associated with the biface reduction stage shows statistically significant differences in variance between the Riverton component and both the Lower Late Archaic and Early Woodland components. This trend continues with thinning flakes in which flake weight variance is significantly different for the Riverton component. Finishing flakes show somewhat surprising results in that Lower Late Archaic flake weight variance is significantly different from both the Riverton and Early Woodland periods.

Table 5.58 shows the results for ANOVA tests for weight by chert type. Flake weights for Muldraugh chert show significant variance associated with the Lower Late

Archaic and both Riverton and Early Woodland periods. Unlike flake length and width ANOVA tests, there is not a significant difference for Muldraugh flake weight between Riverton and Early Woodland components. Wyandotte flake weight however does show a statistically significant difference between the Riverton and Early Woodland components. This same significant difference was found for flake length and width.

Table 5.53: ANOVA Results - Flake Length by Time Period and Chert Type.

| ANOVA - Flake Length by Chert Type and Time Period with Tukey Test (alpha =.05) | | | | | |
|---|---|---|---|---|---|
| Chert Type | Period | Period | Mean Difference | Std. Error | Significance Value |
| Muldraugh | LLA | Riverton | 4.83 | 0.645 | **<.000** |
| | | E. Woodland | 1.812 | 0.672 | **0.019** |
| | Riverton | LLA | -4.83 | 0.645 | **<.000** |
| | | E. Woodland | -3.017 | 0.573 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Wyandotte | LLA | Riverton | 3.3 | 2.109 | 0.262 |
| | | E. Woodland | -1.191 | 1.517 | 0.712 |
| | Riverton | LLA | -3.3 | 2.109 | 0.262 |
| | | E. Woodland | -4.491 | 1.577 | **0.013** |
| | | | | | |
| | | | | | |
| | | | | | |
| Allens Creek | LLA | Riverton | 2.878 | 1.772 | 0.237 |
| | | E. Woodland | 1.392 | 1.451 | 0.603 |
| | Riverton | LLA | -2.878 | 1.772 | 0.237 |
| | | E. Woodland | -1.486 | 1.587 | 0.617 |
| | | | | | |
| | | | | | |
| | | | | | |
| Other | LLA | Riverton | 3.028 | 1.994 | 0.285 |
| | | E. Woodland | -6.49 | 1.893 | **0.002** |
| | Riverton | LLA | -3.028 | 1.994 | 0.285 |
| | | E. Woodland | -9.518 | 2.301 | **<.000** |

Table 5.54: ANOVA Results - Flake Length by Time Period and Flake Type.

| ANOVA - Flake Length by Flake Type and Time Period with Tukey Test (alpha =.05) | | | | | |
|---|---|---|---|---|---|
| Flake Type | Period | Period | Mean Difference | Std. Error | Significance Value |
| Initial | LLA | Riverton | 4.235 | 2.45 | 0.197 |
| | | E. Woodland | 3.321 | 2.08 | 0.249 |
| | Riverton | LLA | -4.235 | 2.45 | 0.197 |
| | | E. Woodland | -0.914 | 2.23 | 0.912 |
| | | | | | |
| | | | | | |
| | | | | | |
| Biface Reduction | LLA | Riverton | 3.908 | 0.896 | **<.000** |
| | | E. Woodland | -0.089 | 0.815 | 0.993 |
| | Riverton | LLA | -3.908 | 0.896 | **<.000** |
| | | E. Woodland | -3.997 | 0.747 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Thinning | LLA | Riverton | 2.533 | 0.689 | **0.001** |
| | | E. Woodland | -1.475 | 0.617 | **0.045** |
| | Riverton | LLA | -2.533 | 0.689 | **0.001** |
| | | E. Woodland | -4.008 | 0.548 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Finishing | LLA | Riverton | 0.072 | 0.361 | 0.978 |
| | | E. Woodland | -0.244 | 0.344 | 0.757 |
| | Riverton | LLA | -0.072 | 0.361 | 0.978 |
| | | E. Woodland | -0.316 | 0.267 | 0.462 |

Table 5.55: ANOVA Results - Flake Width by Time Period and Flake Type.

| ANOVA - Flake Width by Flake Type and Time Period with Tukey Test (alpha =.05) | | | | | |
|---|---|---|---|---|---|
| Flake Type | Period | Period | Mean Difference | Std. Error | Significance Value |
| Initial | LLA | Riverton | 0.594 | 2.059 | 0.955 |
| | | E. Woodland | 1.424 | 1.748 | 0.694 |
| | Riverton | LLA | -0.594 | 2.059 | 0.955 |
| | | E. Woodland | 0.831 | 1.874 | 0.897 |
| | | | | | |
| | | | | | |
| | | | | | |
| Biface Reduction | LLA | Riverton | 3.105 | 0.682 | **<.000** |
| | | E. Woodland | 0.342 | 0.621 | 0.846 |
| | Riverton | LLA | -3.105 | 0.682 | **<.000** |
| | | E. Woodland | -2.764 | 0.568 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Thinning | LLA | Riverton | 2.77 | 0.455 | **<.000** |
| | | E. Woodland | -0.039 | 0.407 | 0.995 |
| | Riverton | LLA | -2.77 | 0.455 | **<.000** |
| | | E. Woodland | -2.809 | 0.362 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Finishing | LLA | Riverton | 0.504 | 0.253 | 0.114 |
| | | E. Woodland | 0.64 | 0.24 | **0.022** |
| | Riverton | LLA | -0.504 | 0.253 | 0.114 |
| | | E. Woodland | 0.135 | 0.187 | 0.749 |

Table 5.56: ANOVA Results - Flake Width by Time Period and Chert Type.

| ANOVA - Flake Width by Chert Type and Time Period with Tukey Test (alpha =.05) | | | | | |
|---|---|---|---|---|---|
| Chert Type | Period | Period | Mean Difference | Std. Error | Significance Value |
| Muldraugh | LLA | Riverton | 3.848 | 0.511 | **<.000** |
| | | E. Woodland | 1.96 | 0.532 | **0.001** |
| | Riverton | LLA | -3.848 | 0.511 | **<.000** |
| | | E. Woodland | -1.887 | 0.454 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Wyandotte | LLA | Riverton | 3.018 | 1.459 | 0.097 |
| | | E. Woodland | -1.19 | 1.049 | 0.494 |
| | Riverton | LLA | -3.018 | 1.459 | 0.097 |
| | | E. Woodland | -4.208 | 1.091 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Allens Creek | LLA | Riverton | 2.895 | 1.269 | 0.06 |
| | | E. Woodland | 1.526 | 1.04 | 0.308 |
| | Riverton | LLA | -2.895 | 1.269 | 0.06 |
| | | E. Woodland | -1.369 | 1.137 | 0.452 |
| | | | | | |
| | | | | | |
| | | | | | |
| Other | LLA | Riverton | 2.703 | 1.436 | 0.147 |
| | | E. Woodland | -3.701 | 1.363 | **0.02** |
| | Riverton | LLA | -2.703 | 1.436 | 0.147 |
| | | E. Woodland | -6.404 | 1.657 | **<.000** |

Table 5.57: ANOVA Results - Flake Weight by Time Period and Flake Type.

| ANOVA - Flake Weight (g.) by Flake Type and Time Period with Tukey Test (alpha =.05) | | | | | |
|---|---|---|---|---|---|
| Flake Type | Period | Period | Mean Difference | Std. Error | Significance Value |
| Initial | LLA | Riverton | -0.604 | 2.068 | 0.954 |
| | | E. Woodland | 1.338 | 1.755 | 0.727 |
| | Riverton | LLA | 0.604 | 2.068 | 0.954 |
| | | E. Woodland | 1.942 | 1.882 | 0.557 |
| | | | | | |
| | | | | | |
| | | | | | |
| Biface Reduction | LLA | Riverton | 1.572 | 0.293 | **<.000** |
| | | E. Woodland | 0.356 | 0.267 | 0.376 |
| | Riverton | LLA | -1.572 | 0.293 | **<.000** |
| | | E. Woodland | -1.216 | 0.244 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Thinning | LLA | Riverton | 0.476 | 0.129 | **0.001** |
| | | E. Woodland | -0.17 | 0.115 | 0.304 |
| | Riverton | LLA | -0.476 | 0.129 | **0.001** |
| | | E. Woodland | -0.646 | 0.103 | **<.000** |
| | | | | | |
| | | | | | |
| | | | | | |
| Finishing | LLA | Riverton | 0.046 | 0.016 | **0.014** |
| | | E. Woodland | 0.05 | 0.015 | **0.003** |
| | Riverton | LLA | -0.046 | 0.016 | **0.014** |
| | | E. Woodland | 0.005 | 0.012 | 0.922 |

Table 5.58: ANOVA Results - Flake Weight by Time Period and Chert Type.

| ANOVA - Flake Weight (g.) by Chert Type and Time Period with Tukey Test (alpha =.05) | | | | | |
|---|---|---|---|---|---|
| Chert Type | Period | Period | Mean Difference | Std. Error | Significance Value |
| Muldraugh | LLA | Riverton | 1.377 | 0.309 | **<.000** |
| | | E. Woodland | 1.025 | 0.322 | **0.004** |
| | Riverton | LLA | -1.377 | 0.309 | **<.000** |
| | | E. Woodland | -0.353 | 0.274 | 0.404 |
| | | | | | |
| | | | | | |
| | | | | | |
| Wyandotte | LLA | Riverton | 1.162 | 0.583 | 0.115 |
| | | E. Woodland | 0.04 | 0.419 | 0.995 |
| | Riverton | LLA | -1.162 | 0.583 | 0.115 |
| | | E. Woodland | -1.121 | 0.436 | **0.028** |
| | | | | | |
| | | | | | |
| | | | | | |
| Allens Creek | LLA | Riverton | 0.974 | 1.222 | 0.705 |
| | | E. Woodland | -0.146 | 1 | 0.988 |
| | Riverton | LLA | -0.974 | 1.222 | 0.705 |
| | | E. Woodland | -1.12 | 1.094 | 0.563 |
| | | | | | |
| | | | | | |
| | | | | | |
| Other | LLA | Riverton | 1.274 | 1.027 | 0.432 |
| | | E. Woodland | -2.149 | 0.975 | 0.074 |
| | Riverton | LLA | -1.274 | 1.027 | 0.432 |
| | | E. Woodland | -3.423 | 1.186 | **0.012** |

Dimensional Ratios

In order to further tease apart variation in the dataset, flake length to width and flake width to thickness ratios were examined. By comparing flake dimension ratios it is possible to understand, in general terms, how flake morphology changes through time. For example, do longer, skinnier flakes appear in greater frequencies during a certain time period? Or are shorter, thicker flakes the norm? Tables 5.59 and 5.60 summarize the ratio data by time period. An examination of the means for each time period reveals that length to width ratios are very similar through time (Table 5.59). Only a few hundredths of a millimeter separate the different means. When we examine the lower and upper bounds of the means, we see that there is much overlap. These lower and upper bounds represent the 95% confidence interval for each mean based on the assumption that ratios are normally distributed. Based on the overlap of confidence interval boundaries, it is difficult to draw any conclusions on these very slight differences.

Table 5.59: Flake Length to Width Ratio Data. The lower-upper bounds represent the 95% confidence interval for the mean.

| Period | Mean (mm.) | Lower Bound | Upper Bound | Std. Deviation |
|---|---|---|---|---|
| Lower Late Archaic | 1.323 | 1.281 | 1.366 | 0.501 |
| | | | | |
| Riverton | 1.331 | 1.297 | 1.366 | 0.481 |
| | | | | |
| E. Woodland | 1.352 | 1.328 | 1.376 | 0.445 |

Table 5.60: Flake Width to Thickness Ratio Data. The lower-upper bounds represent the 95% confidence interval for the mean.

| Period | Mean (mm.) | Lower Bound | Upper Bound | Std. Deviation |
|---|---|---|---|---|
| Lower Late Archaic | 4.678 | 4.51 | 4.847 | 2.007 |
| | | | | |
| Riverton | 4.772 | 4.648 | 4.896 | 1.739 |
| | | | | |
| E. Woodland | 5.182 | 5.075 | 5.29 | 1.993 |

When width to thickness ratios are examined, differences in ratio means through time are present (Table 5.60). The mean Lower Late Archaic ratio is 4.678 mm., with a 95% confidence interval between 4.51 and 4.847 mm. Width to thickness ratios for the Riverton component stand at 4.772 mm., with a confidence interval between 4.648 and 4.896 mm. While there is a slightly greater range in confidence interval for the Lower Late Archaic, both component means show a general overlap. The Early Woodland component has a ratio mean of 5.182 mm. with a 95% confidence interval between 5.075 and 5.29 mm. This confidence interval lies completely outside the upper bounds of both the Lower Late Archaic and Riverton means. Early Woodland flakes have a greater width to thickness mean ratio than other periods at a statistically significant level. Early Woodland flakes therefore tend to be wider and thinner than both Lower Late Archaic and Riverton flakes.

Table 5.61 presents data for length to width flake ratios based on context. Overall, the data show much overlap between feature and unit contexts. Length to width ratio means are slightly greater in unit contexts for the Lower Late Archaic and Riverton components.  Early Woodland feature contexts have slightly larger mean length to width ratios than unit contexts. Based on the significant overlap in bounds between contexts it is difficult to draw any conclusions from the data presented in Table 5.61.

Table 5.61. Flake Length to Width Ratio Data by Context.

| Period | Context | Mean (mm.) | Lower Bound | Upper Bound | Std. Deviation |
|---|---|---|---|---|---|
| Lower L. Archaic | Features | 1.317 | 1.259 | 1.375 | 0.5 |
| | Units | 1.331 | 1.269 | 1.392 | 0.503 |
| | | | | | |
| Riverton | Features | 1.307 | 1.256 | 1.358 | 0.495 |
| | Units | 1.354 | 1.307 | 1.4 | 0.467 |
| | | | | | |
| E. Woodland | Features | 1.365 | 1.329 | 1.4 | 0.466 |
| | Units | 1.34 | 1.308 | 1.372 | 0.423 |

Table 5.62 presents data for flake width to thickness ratios by context.  Ratio values for the Lower Late Archaic and Early Woodland components show that context made little difference.  The Riverton component is different.  Flakes in feature contexts have a greater mean width to thickness ratio value than unit contexts.  Looking at the lower and upper bounds, we see that there is no overlap between contexts.  Unit and feature 95% confidence intervals are completely outside one another.  Therefore, it is possible to confidently say that Riverton feature flakes tend to be wider and thinner than unit flakes.  While there is much confidence interval overlap between contexts in the Early Woodland component, both features and units have wider and thinner flakes than the Lower Late Archaic component and the Riverton unit component.

Table 5.62: Flake Width to Thickness Ratio Data by Context.

| Width/Thickness Ratios by Context | | | | | |
|---|---|---|---|---|---|
| Period | Context | Mean (mm.) | Lower Bound | Upper Bound | Std. Deviation |
| Lower L. Archaic | Features | 4.678 | 4.44 | 4.916 | 2.059 |
| | Units | 4.679 | 4.439 | 4.918 | 1.951 |
| | | | | | |
| Riverton | Features | 4.998 | 4.811 | 5.185 | 1.812 |
| | Units | 4.563 | 4.399 | 4.726 | 1.644 |
| | | | | | |
| E. Woodland | Features | 5.198 | 5.044 | 5.351 | 1.991 |
| | Units | 5.167 | 5.016 | 5.319 | 1.997 |

Table 5.63 presents data for width to thickness mean ratios by time period and flake type. Not surprisingly, in each time period, width to thickness mean ratios increase through the later stages in the lithic reduction process. I expect the early reduction stages to produce flakes that are substantially thicker than later stages. Table 5.63 highlights a few important trends. To start, Early Woodland thinning and finishing flakes appear to differ from the other two components. Lower Late Archaic thinning flakes have a mean width to thickness ratio of 5.23 mm. with a lower bound of 5.25 mm. and an upper bound of 5.795 mm. During the Riverton component, thinning flakes have a ratio mean of 5.169 mm. with a lower bound of 4.982 mm. and an upper bound of 5.356 mm. Between the Lower Late Archaic and Riverton components there is a slight overlap of mean ranges for thinning flakes, but the data suggest that Riverton thinning flakes become skinnier

and thicker than flakes from the Lower Late Archaic. Thinning flakes in the Early Woodland show a ratio mean of 5.864 mm., with a lower bound of 5.723 mm. and an upper bound of 6.006 mm. This increase in mean ratio in the Early Woodland suggests that thinning flakes become wider and less thick once again.

Table 5.63: Flake Width to Thickness Ratio Data by Flake Type.

| Ratio Width/Thickness By Flake Type | | | | | |
|---|---|---|---|---|---|
| Period | Flake Type | Mean (mm.) | Lower Bound | Upper Bound | Std. Deviation |
| Lower Late Archaic | Initial | 3.321 | 2.853 | 3.79 | 1.922 |
| | Biface Reduction | 3.999 | 3.775 | 4.222 | 1.609 |
| | Thinning | 5.523 | 5.25 | 5.795 | 2.032 |
| | Finishing | 5.395 | 5.006 | 5.783 | 1.542 |
| | | | | | |
| Riverton | Initial | 3.151 | 2.717 | 3.585 | 1.591 |
| | Biface Reduction | 4.093 | 3.922 | 4.263 | 1.404 |
| | Thinning | 5.169 | 4.982 | 5.356 | 1.655 |
| | Finishing | 5.857 | 5.588 | 6.127 | 1.578 |
| | | | | | |
| E. Woodland | Initial | 3.181 | 2.909 | 3.452 | 1.429 |
| | Biface Reduction | 4.282 | 4.121 | 4.443 | 1.716 |
| | Thinning | 5.864 | 5.723 | 6.006 | 1.736 |
| | Finishing | 6.313 | 6.043 | 6.583 | 1.886 |

Table 5.64 presents data for width to thickness ratios based on chert type. Muldraugh and Wyandotte show no significant differences in means during the Lower Late Archaic and Riverton components. By the Early Woodland period though, Muldraugh and Wyandotte width to thickness ratios are significantly different. Additionally, Early Woodland Wyandotte flakes are significantly different from both the Lower Late Archaic and Riverton components. Table 5.65 presents the mean length to

width ratios of flakes by chert type. It is interesting that the significant differences found with Wyandotte chert in the Early Woodland period for width to thickness ratios do not appear in length to width ratios. Wyandotte chert in the Early Woodland period shows a mean decrease from both previous periods, yet the confidence interval of these flakes lies well within the confidence intervals for both the Lower Late Archaic and Riverton components. It should be noted that Early Woodland Wyandotte flakes have a tighter confidence interval than in previous periods, making it less variable.

Table 5.64: Flake Width to Thickness Ratio Data by Chert Type.

| Ratio Width/Thickness By Chert Type | | | | | |
|---|---|---|---|---|---|
| Period | Chert Type | Mean (mm.) | Lower Bound | Upper Bound | Std. Deviation |
| Lower L. Archaic | Muldraugh | 5.013 | 4.794 | 5.232 | 2.028 |
| | Wyandotte | 4.771 | 4.207 | 5.334 | 1.984 |
| | Allens Creek | 3.637 | 3.292 | 3.982 | 1.61 |
| | Other | 4.338 | 3.907 | 4.769 | 1.911 |
| | | | | | |
| Riverton | Muldraugh | 4.89 | 4.754 | 5.026 | 1.712 |
| | Wyandotte | 4.903 | 4.41 | 5.397 | 1.661 |
| | Allens Creek | 3.455 | 3.082 | 3.828 | 1.518 |
| | Other | 5.044 | 4.409 | 5.679 | 1.73 |
| | | | | | |
| E. Woodland | Muldraugh | 5.108 | 4.948 | 5.267 | 1.806 |
| | Wyandotte | 5.773 | 5.624 | 5.922 | 1.899 |
| | Allens Creek | 3.062 | 2.845 | 3.278 | 1.377 |
| | Other | 5.199 | 4.557 | 5.842 | 1.899 |

Table 5.65: Flake Length to Width Ratio Data by Chert Type.

| Ratio Length/Width By Chert Type | | | | | |
|---|---|---|---|---|---|
| Period | Chert Type | Mean (mm.) | Lower Bound | Upper Bound | Std. Deviation |
| Lower L. Archaic | Muldraugh | 1.319 | 1.268 | 1.371 | 0.478 |
| | Wyandotte | 1.408 | 1.225 | 1.591 | 0.644 |
| | Allens Creek | 1.26 | 1.159 | 1.361 | 0.471 |
| | Other | 1.357 | 1.239 | 1.476 | 0.527 |
| | | | | | |
| Riverton | Muldraugh | 1.319 | 1.281 | 1.357 | 0.476 |
| | Wyandotte | 1.441 | 1.308 | 1.573 | 0.446 |
| | Allens Creek | 1.336 | 1.211 | 1.462 | 0.511 |
| | Other | 1.393 | 1.189 | 1.598 | 0.559 |
| | | | | | |
| E. Woodland | Muldraugh | 1.346 | 1.306 | 1.386 | 0.453 |
| | Wyandotte | 1.359 | 1.326 | 1.393 | 0.43 |
| | Allens Creek | 1.323 | 1.246 | 1.401 | 0.493 |
| | Other | 1.429 | 1.308 | 1.549 | 0.356 |

Mean length to width and width to thickness ratios were evaluated in order to determine changes in flake morphology in the assemblage. Length to width mean ratios show differences in variance amongst groups, however little can be concluded. Overall, the Early Woodland component has a larger mean width to thickness ratio. This is indicative of wider and thinner flakes during this time when compared to both the Lower Late Archaic and Riverton components. This is demonstrated when thinning and finishing flakes are compared across time periods (Table 5.63). When the Early Woodland assemblage is examined with regard to chert type, Wyandotte flakes prove to be wider and thinner than Muldraugh flakes. Lastly, Table 5.60 shows that the Riverton component has the lowest standard deviation of the three time periods regarding width to thickness mean ratios.  The lesser degree of variation amongst flakes of the Riverton component will be discussed in greater detail in the next section.

# Chapter 6 - Discussion and Conclusions

The data obtained through the analysis of 2,620 flakes sheds light on a number of interesting processes that will be reviewed here. To start, the preceding descriptive statistics and principle component plots demonstrate that there are identifiable patterns in the debitage assemblage based on time period and raw material. The data in this study appear to confirm Winters' (1969) study of the Riverton culture of the Wabash River in Illinois. Riverton components at the CAP were defined by radiocarbon dating and the presence of diagnostic artifacts. Winters proposed that one of the defining characteristics of the Riverton culture is its micro-tool technology. Both principle component plots (Figure 5.5 and 5.7) and *F*-tests conducted to evaluate the equality of variance for numerous variables (i.e. flake length and width) (Figures 5.9 and 5.10) suggest that the Riverton people at Knob Creek practiced a similar style of micro-tool lithic manufacture. Figures 5.9 and 5.10 visually demonstrate a general decrease in the range of variation during the Riverton component. Flake length, for example, became more uniform during the Riverton component when compared to both the Lower Late Archaic and Early Woodland components. This study focused exclusively on bifacial technology so it is yet to be seen if bipolar percussion is as prevalent at Knob Creek as in the Wabash River valley.

The most interesting finding to come out of this study however is what this fine-grained analysis at the Falls of the Ohio can tell us about the Archaic/Woodland transitional period. Recall that by the Late Archaic (ca. 5500-3500 BP) mobility patterns in the Lower Ohio Valley had changed from previous times. By the late Middle Archaic, hunter-gatherers in the region had developed multi-season base camps as evidenced by deep middens (Jefferies 2008:146). Late Archaic sites in the region increased dramatically in number and size. Exotic stone, marine shell and copper found at sites throughout the Lower Ohio River Valley suggest that long-distance trade networks had developed (Jefferies 2008:191). While long-distance trade networks were established there appears to be a continuing trend toward a greater reliance on local raw materials for chipped stone tools. The combination of all these factors may suggest that there was an overall decrease in group mobility in the Late Archaic compared with previous periods. Binford (1979) argued that tools are differently designed, manufactured and used as a function of the intended role they will serve in a group's organization of technology. According to Binford, the organization of technology is determined by both the hunter-gatherer's settlement strategy and the spatial distribution and quality of raw materials in a region. If lithic raw material procurement was embedded in residential moves prior to this time, decreased group mobility may be a product of this circumscription. Entrenchment in a particular area would likely cause changes in a group's ability to procurement raw materials. This may result in the development of a new settlement system in which logistical forays are used to secure vital resources while residential base camps are used for increasingly longer periods of time. If entrenchment or circumscription was taking place extended use lives of stone tools through curated technologies would be expected.

Attribute Analysis

The two main non-metric attributes that were analyzed in this study were for the presence of platform lipping and bulb of percussion size. These two attributes have long been acknowledged as reflective of the kind of percussion used in the lithic production sequence. Flakes with small or no bulb of percussion coupled with a pronounced platform lip have been argued to represent soft-hammer percussion flakes (Crabtree 1972:74, Frison 1968:149). Hard-hammer percussion flakes tend to have pronounced bulbs of percussion and no lipping. The data in this study show that these attributes varied through time.

Recall that platform lipping steadily increases in presence through time. Table 5.1 shows that platform lipping is found in 27% of Lower Late Archaic flakes, 34% of Riverton flakes, and 42% of Early Woodland flakes. Looking at thinning flakes (Table 5.3), the presence of lipping increases from only 37.5% during the Lower Late Archaic, to 41% in the Riverton component, to over 55% in the Early Woodland component. Both Muldraugh and Wyandotte chert demonstrate an overall increase in lipping presence through time as well (Table 5.4). Muldraugh biface thinning flakes show the greatest increase in lipping over time. Over 57% of Early Woodland flakes display lipping.

Bulb of percussion data generally supports the trends seen in the lipping data. Table 5.6 shows that there is a slight increase in the percentage of flakes assigned to a bulb=1 value. The Lower Late Archaic has 42% of its flakes with a bulb value of 1, the Riverton has 46%, and the Early Woodland has over 51% of its flakes with a bulb value of 1. Looking at thinning flakes, there is a general increase in bulb=1 values through time. Over 59% of Early Woodland biface thinning flakes have a bulb value of 1 (Table 5.8).

Combined the data for both attributes suggests that technological changes may have occurred during the Early Woodland period. The combination of an increase in platform lipping presence and decrease in bulb of percussion suggest that there is a greater emphasis placed on soft hammer percussion during the later stages in the lithic production process through time.

Ratio Statistics

Descriptive statistics were put to use in order to compare flake length to width ratios along with flake width to thickness ratios. Width to thickness ratios presented in Chapter 5 (Table 5.60) demonstrate that Early Woodland flakes tend to be wider and less thick than both Lower Late Archaic and Riverton flakes. Table 5.63 shows that this same pattern is found when ratios are compared by flake type. Both thinning and finishing flakes in the Early Woodland differ from previous time periods. Early Woodland thinning flakes are both wider and less thick from previous periods. Table 5.64 shows data broke down by chert type. Interestingly, Wyandotte and Muldraugh flake width to thickness ratios differ significantly during the Early Woodland period. It seems that Wyandotte flakes at this time were wider and thinner than flakes coming from the adjacent Muldraugh outcrops. This may be due to the fact that Wyandotte chert was entering the site already in a reduced form. Only 18 cores were attributed to the Early Woodland component (Mocas 2006:200). Wyandotte flakes are wider and thinner because Wyandotte chert entered the site further along in the biface reduction system. Muldraugh chert, found adjacent to the site, has wider and thicker flakes due to the initial reduction of the raw material that took place at Knob Creek. Lastly, Riverton width to thickness ratios (Table 5.60) have the least standard deviation of the three time periods. This supports the data acquired in *F*-tests that found a general decrease in variation during the Riverton component for numerous variables.

ANOVA

ANOVA tests conducted between time periods for flake length and width show that there is a statistically significant difference in the amount of variation between the Riverton component and the Late Archaic and Early Woodland. Biface reduction and thinning flakes adhere to these general trends. Wyandotte flake lengths and widths show a statistically significant difference in variation between the Riverton and Early Woodland components.

Hypothesis Results

This study attempted to compare the degree of bifacial reduction by time period and chert type. This section reviews the original two hypotheses to determine if they are supported, or fail to be supported. Hypothesis 1 is supported. The debitage assemblage at the Knob Creek site demonstrates clear changes in lithic technology through time. Attribute data show that platform lipping increases significantly during the Early Woodland period alongside slightly smaller bulbs of percussion. These patterns are especially noticeable when biface thinning flakes are considered. The data found in Figures 5.12 and 5.13 support the idea that technological change occurs during the Early Woodland. These charts examine platform width and platform thickness through time. They visually demonstrate that there is an overall decrease in variance associated with metric platform dimensions during this period. Flake morphology data demonstrates that there is a statistically significant difference between Early Woodland flakes and other time periods based on width to thickness ratios. Early Woodland flakes appear to be both wider and less thick when compared to previous time periods. These various lines of evidence suggest that the biface technological process changed through time. Early

Woodland occupants may have made greater use than their predecessors of soft-hammer percussion in the production process.

Hypothesis 1a was developed in order to better understand if the Riverton component at the Knob Creek site showed a similar technological tradition as Winters' Riverton component in the Wabash Valley. Hypothesis 1a is also supported. Principal component plots originally suggested that there were differences in variation among flake variables through time. Figures 5.9 and 5.10 in the previous chapter visually present flake length and width means with standard deviation error bars. Flake length and width show less variance during the Riverton component at a statistically significant level. Ratio data that compares flake width to thickness demonstrates that the Riverton component is statistically different from the later Early Woodland component. The various lines of data suggest that Riverton flakes were more uniform than flakes in the Lower Late Archaic or Early Woodland. The Riverton people's emphasis on small biface preform and projectile point technology may help explain this standardization. If the Riverton culture developed in the Wabash Valley of Indiana, a technological tradition may have developed that made use of the small chert river nodules in the area. This bifacial technological tradition, developed elsewhere, may have been brought to the Knob Creek site where the occupants continued to make small bifaces and points despite ample raw materials in the region.

### Context

Flake data was analyzed in order to compare differences in the collection based on the context from which flakes were recovered. The two contexts considered in this thesis were from features and hand-excavated units. For all three time periods, approximately equal numbers of flakes were analyzed from each context in order to eliminate any potential biases. It was believed that an analysis conducted entirely with flakes from feature contexts, for example, may be biased towards larger flakes. It was reasoned that the site's occupants would have been able to identify and remove larger sized flakes from activity areas to deposit in garbage pit features. Therefore, a more representative sample of the Knob Creek site could be attained by analyzing half the flakes from pit features and half the flakes from hand-excavated units.

Differences can be found in the dataset based on context. In the Riverton component, for example, width to thickness ratios demonstrate that feature flakes are both wider and thinner than unit flakes. It is unclear at this point as to why this is the case. Other data analyzed between feature and unit contexts generally shows small differences, but seemingly little in the way of meaningful patterns that can be identified at this time. Looking at descriptive statistics for flake variables, Table 5.14 shows that Lower Late Archaic flakes are on average, smaller in feature contexts than in unit contexts. This is the opposite of what was originally believed. Descriptive statistics for the Riverton component demonstrates that some variables are larger in feature contexts, while others show larger sizes in unit contexts. The Early Woodland component shows that flake length, width, and thickness display greater sizes in feature contexts, while platform width and thickness are larger in unit contexts. The data as a whole suggests that 'clean-up' behavior had little impact on flake size differences between feature and unit contexts.

Biface Data

Stone tools analyzed after excavations at Knob Creek revealed some interesting changes in technology over time. Stafford (2008a) described how hard-hammer percussion technology was more prevalent during the Lower Late Archaic component, composing approximately 10% of the entire lithic assemblage. Lipping and bulb of percussion data support this idea as the Lower Late Archaic component shows the lowest percentages of lipping presence and the lowest totals for bulb=1 values (Tables 5.1 and 5.6 ). The general lack of stone tool diversity at the site led Stafford to argue that Knob Creek served as a short term camp, or a special-function site. Biface data supports this idea as 71% are Stage III forms (Stafford 2008a:424). Had the site served as a longer-term occupation, a longer biface reduction trajectory could be identified (Johnson 1989).

The Riverton component shows the least variance in flake dimensions of any time period. Additionally, Riverton debitage appears to be the smallest of the three components. These trends can be partially explained by the fact that 71.4% of bifaces recovered during this time were Stage III forms. Since late stage bifaces were the most common, it makes sense that debitage, as a whole, would be of a smaller size. Many of the Stage III bifaces were likely preforms for Riverton points. Winters (1969) noted the small nature of Riverton points and this tradition took place at Knob Creek as well.

The Early Woodland component shows a different pattern from the previous two periods. It is during this time that two structures were identified at the site and stone tool diversity was high. Wyandotte chert became the dominant raw material, appearing in greater frequencies than the more local Muldraugh chert. Mocas (2006) notes that the most distinctive biface at this time appears to be a preform for an Adena Stemmed point.

Additionally, Stage III bifaces once again form the highest percentage of bifaces, composing 60% of the group. Stage II bifaces compose 27% of the tools, the highest percentage from any time period. The small percentage of Stage I bifaces recovered (13%) makes it unlikely that the Early Woodland component was a lithic workshop site. A more diverse biface assemblage would be expected in a workshop scenario. The increase in Stage II bifaces does signal a longer period of occupation as more lithic manufacturing and maintenance tasks were carried out at the site.

Wyandotte chert was used for the majority of stone tools at this time (70.1% of Stage III bifaces; 53% of Stage II bifaces). The high-quality chert is ideal for the long biface production sequence. It is interesting that at a time when Wyandotte chert becomes the most utilized chert type, the percentage of Stage III bifaces decreases from the previous two periods. This suggests that functional responses in lithic technology cannot fully explain the newfound intensive use of Wyandotte chert. Instead, Mocas (2006) suggests that the increase in Wyandotte chert use at this time likely had to do with symbolic reasons associated with the blue-gray chert from 35 km away. The continued use of Wyandotte chert in the Middle Woodland and its presence in a regional interaction sphere in later times supports this argument.

Chert

Due to the importance of the spatial distribution of raw material sources to Binford's theory (1979) it is important to consider the percentages of raw material use through each time period in order to better understand mobility patterns. The Late Archaic (ca. 5500-3500 BP) occupants at the Knob Creek site got the vast majority of their raw materials in the bluffs immediately surrounding the site. Debitage mass analysis by Stafford (2007b) demonstrates that 61% of the total Late Archaic debitage assemblage was Muldraugh chert as defined by weight. Combined with Allens Creek chert, also locally available, Muldraugh and Allens Creek combine to make up 77% of the total Late Archaic lithic assemblage. Wyandotte chert, found 35 km away in western Harrison County, Indiana makes up only 9% of the lithic assemblage for this time. The data measured for this study shows that debitage from Wyandotte chert is smaller than the locally available Muldraugh and Allens Creek cherts (Table 5.15).

Raw material use during the Riverton component (ca. 3500-2700 BP) shows similar patterning. Locally available Muldraugh and Allens Creek cherts dominate the debitage assemblage, accounting for 90% of the debitage recovered during this time. Once again, Muldraugh and Allens Creek cherts are slightly larger in overall flake size than the non-local Wyandotte chert (Table 5.15). Wyandotte chert accounts for slightly less (6%) of the overall Riverton assemblage compared to the Late Archaic (9%).

The Early Woodland component at Knob Creek demonstrates an increase in intensity of occupation. Additionally, raw material use changes as a much greater emphasis is placed on Wyandotte chert from previous time periods. Wyandotte chert makes up 48% of the debitage assemblage during this time. Muldraugh and Allens Creek combine to make up only 50% of the total assemblage. Wyandotte flakes remain approximately the same overall size as the Late Archaic while Muldraugh shows a decrease in size. It is likely that the increased importance of Wyandotte chert is due to its symbolic value as much as its crypto-crystalline structure. Wyandotte is considered a higher quality raw material type than both Muldraugh and Allens Creek.

This thesis began with a call for a more nuanced analysis of the Archaic/Woodland transitional period at the Falls of the Ohio. A careful flake-by-flake examination of the debitage at the Knob Creek site in Harrison County, Indiana provides an important lens through which to view this time. By examining changes in the size of the debitage assemblage and raw material types, it was possible to observe some of the changes that were taking place during this dynamic time in history. The data presented in this study suggests that there was a significant change in the lithic technology at the start of the Early Woodland period.

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