

A COMPARISON OF CLOVIS CACHES

A Thesis

by

ROBERT DETLEF LASSEN

Submitted to the Office of Graduate Studies of  
Texas A&M University  
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

December 2005

Major Subject: Anthropology

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Approved by

Chair of Committee: David Carlson

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## ABSTRACT

A Comparison of Clovis Caches. (December 2005)

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The Clovis caches in this study consist of assemblages of tools left behind in an area either for future use or as ritual offerings. Clovis caches are the earliest of such assemblages known in North America. This research specifically examines a sample of four caches: East Wenatchee from Douglas County, Washington; Anzick from Park County, Montana; Simon from Camas County, Idaho; and Fenn, inferred to be from Sweetwater County, Wyoming. The artifact types in this study include fluted points, bifaces, blades, flakes, bone rods, and miscellaneous. The variables used in this study include maximum length, mid-length and maximum width, thickness,  $(\text{length} \times \text{width} \times \text{thickness}) / 1000$ , length/width, and width/thickness; using millimeters as the basic measurement unit. This study utilizes five methods in the study of the caches: descriptive statistics, factor analysis, cluster analysis, correspondence analysis, and geoarchaeology. The descriptive statistics reveal the most prominent trends that become more apparent in the subsequent statistical analyses. Such trends include East Wenatchee containing the largest points but the smallest bifaces, Anzick and Simon having significant biface variation, Fenn tending to be average in most respects, and bone rods being larger in East Wenatchee than they are in Anzick. The factor analysis explores the relationships between the variables and assigns them to larger components. Length,

width, thickness, and length\*width\*thickness comprise the size component, and length/width and width/thickness make up the shape component. The cluster analysis examines the artifacts within each site and between all sites to identify the most appropriate grouping arrangements based on similarities in artifact measurements. The general results show that fluted points form three clusters according to size more than shape, bifaces are highly variable but have no obvious clusters, and bone rods form three clusters with the first two being strictly divided by site. The correspondence analysis shows that the differences in count data between caches appear to relate to the geographic distances between them. Finally, geoarchaeological analysis posits that East Wenatchee has no discernable pit feature, Anzick contains only one human burial, Simon was not deposited in a pluvial lake, and Fenn would have been shallowly buried but was probably disturbed by erosion.

## ACKNOWLEDGEMENTS

First of all, this thesis is dedicated to the memory of Dr. Robson Bonnichsen. Dr. Bonnichsen was my committee chair through most of my career as a masters student, and it was his notes, resources, and wisdom that set this thesis in motion. He was a brilliant archaeologist and a genuinely fun-loving human being. My three final committee members, Dr. David Carlson, Dr. Michael Waters, and Dr. Vatche Tchakerian, have helped immensely with various aspects of my thesis. Dr. Carlson has been extremely helpful with his knowledge of statistical techniques and computer programs. Dr. Waters has provided invaluable help in suggesting geological literature that is relevant to this research. Finally, Dr. Tchakerian has been willing to join my committee and offer his help, despite the fact that he has an already busy schedule as the new associate dean of the College of Geosciences.

Other archaeologists and scientists have been extremely helpful in more specific aspects of my research. Dr. Alston Thoms has always been willing to listen to and discuss my hypotheses on the ecology of Clovis cache sites. Dr. Bruce Dickson was kind enough to let me rehearse my presentation to the Society for American Archaeology with him. Dr. Sheela Athreya and Dr. Darryl DeRuiter familiarized me with the software used in the correspondence analyses. Pat Clabaugh taught me how to use 7.5 topographic maps, and the employees at the Map Room in the Evans Library were gracious enough to give me access to their collection. I also would like to thank Kevin Miller for providing me a free copy of his own thesis on Texas biface caches. Lynette Miller of the Washington State Historical Society was very helpful in matching the catalog numbers of

the East Wenatchee artifacts to their drawings on the site map. I would also like to thank the Park County, Montana and Sweetwater County, Wyoming Natural Resources Conservation Service for their help in analyzing soil chemistry. Jeff Louis of the Wyoming NRCS and Montana state archaeologist Stan Wilmoth were especially helpful.

Next, all my friends at the Texas A&M Anthropology Department deserve a hearty thanks for providing a close-knit support group of stressed out grad students. Victoria Springer, Eleanor Dahlin, Juan Urista, David Foxe, Shanna Richardson, Michael Aiuvalasit, Tim Riley, Phil Johnson, Chris Cook, Charlotte Penvy, Jason Barrett, Victor Galan, Jesse Halligan, Katherine Turner-Pearson, Retno Sulistijo, Eric Bartelink, Jason Wiersema, Cassady Yoder, Maria Parks, Bill Dickens, Jim Wiederhold, Scott Minchak, and Katie Custer have all made my life and my work more enjoyable.

Also, I would like to thank my family for enduring and encouraging my fanatical interest in archaeology. My parents, Peter and Carol Lassen, always support me in any way possible and constantly send archaeologically related newspaper clippings my way. My brother, James, has always been willing to join me in exploring the Texas countryside whenever we get together.

Finally, I owe a huge debt of gratitude to my good friend, Ashley Smallwood. Ever since Dr. Bonnicksen first assigned us to work together, Ashley has been my harshest critic and my biggest fan. I want to thank her for making me a better person.

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## INTRODUCTION

### Overview

#### *The Problem*

Clovis caches present a unique problem to those who study early Paleoindians. Most prehistoric archaeological sites in North America have a purpose that can be understood through careful archaeological research. Camp sites, kill sites, and quarries have identifiable features, tools, and locations to indicate their function. On the other hand, Clovis caches of finished and unfinished tools often pose more questions than answers. Are they for trade or for ceremony? Are they left behind for the living to retrieve, or are they offerings to the dead? Not all caches contain the same types of artifacts, and it is almost certain that not all caches serve the same purpose. This research examines Clovis caches – the earliest tool caches known in North America – and attempts to quantify their similarities and differences as objectively as possible. The study of Clovis caches has been marred with conjecture and opinionated statements with little attention to quantitative comparative methods. This analysis provides the some of the first steps to the systematic comparison of these enigmatic tool kits.

### *The Clovis Technological Complex*

Clovis technology cannot be considered a “culture” in the way that historic Native American groups are referred. Clovis may represent multiple early North American cultures that shared the same technology. However, since the technology (particularly the stone tools) is the only surviving remnant of these groups, they are bound under the umbrella term of the Clovis complex.

Clovis technology became known to modern Americans in 1937, when Clovis points were found in association with extinct Pleistocene mammal remains at Blackwater Draw Locality No. 1 near the town of Clovis, New Mexico (Hester 1972:26). However, Clovis tools (previously believed to be Folsom) had been found before 1937, particularly at the Dent site in 1932 (Haynes et al. 1998). In the subsequent decades, Clovis sites have been found throughout much of North America, and from coast to coast in the continental United States. Clovis sites typically fall into categories of kill sites like Blackwater Draw and Colby (Hester 1972, Frison 1991), camp sites such as Aubrey (Ferring 1989), quarry sites such as Gault (Collins and Hester 2001), and cache sites such as East Wenatchee (Gramly 1993), although sites can have multiple purposes and their functions can overlap.

The Clovis “tool kit” tends to vary across archaeological sites and regions of North America, so any general summary of Clovis technology presents an idealized perspective. The most distinctive product of Clovis technology is the Clovis fluted point. Clovis points are typically lanceolate with concave bases and straight sides that gradually bend to a point at the distal end. The most distinctive characteristic is the flute: the flake scar that the knapper leaves on the point after long, narrow flakes are struck from the

center of the proximal end. Flutes usually extend to about one third of the length of a typical Clovis point and give the point a grooved appearance. In most cases (Collins 1999:46), pristine Clovis points are at least 10 cm long, and the points found in Clovis caches are considerably longer (Figure 1).

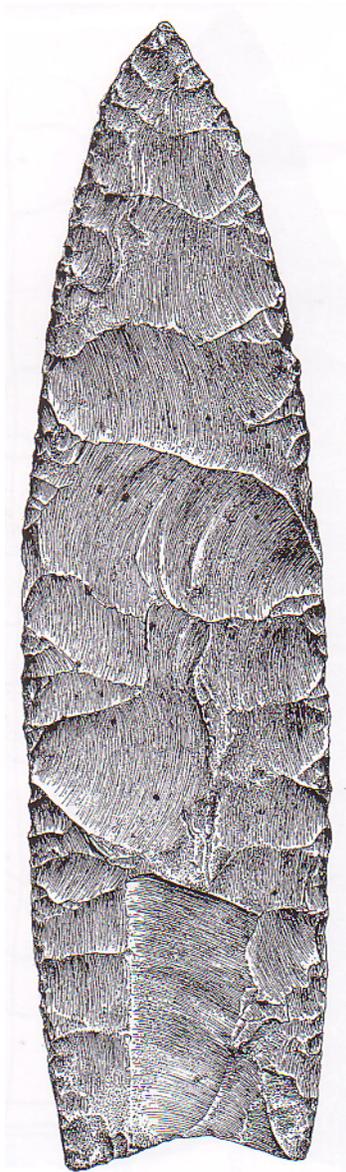


Figure 1: Illustration of a fluted point from the East Wenatchee cache by Valarie Waldorf (Gramly 1993:26).

Common tools in Clovis sites also include various other chipped stone artifacts. Bifaces, scrapers, and prismatic blades also appear frequently. In some areas, notably the Gault site in Texas, Clovis blades are made from polyhedral, conical cores. However, blades and blade cores are not universally present in Clovis sites, as they are absent in the northeastern United States and rare in the west (Collins and Hester 2004). Tools made from organic materials are rare, but they do exist. The most notable are bone rods, such as the ones that are present in the East Wenatchee and Anzick caches (Gramly 1993, Lahren and Bonnicksen 1974). Additionally, a shaft-straightener made of mammoth bone from the Murray Springs site in Arizona (Haynes and Hemmings 1968) and the flaked mammoth bone from South Dakota's Lange-Ferguson site (Hannus 1989) indicate further Clovis use of organic materials. For the most part, adzes and other woodworking tools are considered to be absent from Clovis sites (Thoms personal communication), but some archaeologists interpret some Clovis bifacial artifacts to be adzes (Collins and Hester 2004, Gramly 1993). Additionally, logic would indicate that Clovis technology did involve some form of woodworking, if only for building shelters or creating shafts for spears and darts (Haynes 2002:116-117).

### *Caching Behavior*

The term "cache" has highly variable definitions depending on the author, so the same stone tool assemblage that one archaeologist considers a cache might not fit the definition of the term according to another archaeologist. Some archaeologists, such as Miller (1993:7-8) tend to lump all similar assemblages together under the heading of caches, regardless of their possible purposes or associations. On the other hand, Collins

(1999:173-177) splits such assemblages based on their purposes. Technically, a cache is something that is retrieved at a later date. An assemblage that is left at a location for an undetermined period of time is considered storage, and an assemblage that is deposited for religious reasons is called votive. In this research, I lump all of these assemblage types under the general heading of cache behavior. The purposes of each collection in this study may have been different or the same, but since theories surrounding the purposes of most caches are so speculative, it makes more logical sense to group them together based solely on composition. All the caches in this study are made up of Clovis stone and sometimes bone tools, nearly all of them contain finished fluted points and indicate some presence of red ochre, and they are in relatively useful condition (i.e. not merely discarded).

Archaeologists have put forth numerous theories on the purpose of tool caching, but a general synthesis can place them into three categories: trade, security, and ritual. Trade theories involve economic interactions between people or groups. Miller (1993) states that trade caches could be used for the exchange of exotic raw materials between groups. Additionally, Kornfeld et al. (1990:302) states that caches can indicate signs of a power struggle among more and less dominant groups. If a dominant group caches tools, it may be in order to increase the scarcity of the resources and to ensure their value. If a less dominant group utilizes tool caches, they could be asserting their independence from other groups who have greater control over raw materials. Lafferty (1994:199) argues that caches could represent a form of ceremonial exchange between groups in order to improve their prestige and interpersonal relations. These exchanges ensure that one group would help the other in times of need.

Security is the second general purpose for caches. Overall, security caches are intended for the storage of tools that may be needed at a later date. In some cases, a group may knap more tools at a quarry site than they are able to carry, and so they must secure the tools in a cache until they can return with enough people to remove the tools. Similarly, a group may use the tools to extract resources (such as food), then cache the tools at the site in order to carry more of the resources. These assemblages are known as load-exchange caches (Miller 1993:10-11). Another commonly held theory is that caches may have served as “banks” of tools to be exchanged for other resources or services. Also, these caches may have been located along trade or travel routes to supply people with tools as needed (Rathje and Schiffer 1982). Wiseman et al. (1994:69) claim that some caches aid in the exploration and exploitation of a new area.

The final general purpose of caches is ritual. Some archaeologists do not consider these assemblages to be actual caches because there they are not intended to be retrieved. However, they often contain the same or similar types of artifacts as trade and security caches, so ritual assemblages can be studied as caches. The most obvious kind of ritual cache is the burial assemblage. One known burial cache, the Anzick site, is one of the four caches to be analyzed in this study. Burial caches consist of the artifacts that are associated with buried human remains. Other ritual caches are only indirectly associated with human remains. According to Kohntopp (2001:21), caches can serve as memorials to people who died but are buried elsewhere, much in the same way that modern people leave tributes along roadsides to friends or family members who have passed away. Other ritual caches, such as offertory or dedicatory, are not associated with human remains at all. Offertory caches may represent tributes paid to deities and may appear in

the archaeological record as isolated finds (Miller 1993:15). Dedicatory caches represent artifacts that individuals contribute towards the dedication of a new structure or site (Rathje and Schiffer 1982:114). Ritual caches such as these offer archaeologists a glimpse into the importance that earlier peoples placed on various artifacts.

Scott Jones (1997:12-13), states that archaeologists accept five Clovis caches as being “unique” among caches in general. These Clovis caches are East Wenatchee, Anzick, Simon, Fenn, and Drake. Archaeologists consider these five caches to be unique in particular because they are not associated with other activities such as habitation or the acquiring of raw materials, the caches contain finished artifacts that are large and well-made, and archaeologists have noted the presence of red ochre at most of these sites. Based on this evidence, many archaeologists have theorized that the “unique” Clovis caches are all representative of early Paleoindian ritual activities. Stanford and Jodry (1988) even suggest that all five caches indicate human burial sites, although preserved human remains have only been found in association with the Anzick cache.

The presence of red ochre is also a source of debate among archaeologists who seek to interpret these cache sites. Red ochre is a naturally occurring ferruginous red dye that Native Americans used extensively throughout prehistory. It is often sprinkled on human burials, used in rock art, applied as an insect repellent, used in the tawing of hides, and may aid in the preservation of wood (Roper 1991:291-292, 295-296). For the Clovis period, Roper (1996) states that red ochre is overwhelmingly more common at cache sites than at any other kind of Clovis site, and ochre is only present in Clovis sites in the northern half of the United States with the Busse cache in Kansas being the southernmost occurrence. Additionally, Roper (1991) asserts that during North America’s Paleoindian

and Eurasia's Upper Paleolithic periods, ochre is exclusively present in mortuary, ritual, and domestic contexts. Since none of the Clovis cache sites have evidence of habitation, one could reasonably infer that they are therefore mortuary or ritual sites. On the other hand, Titmus and Woods (1991) argue that red ochre may have additionally been used in the abrading and polishing of the basal edges of fluted points. Therefore, small traces of red ochre may not indicate ritual activity, but large quantities may.

Unfortunately, red ochre is not present in the same amounts in all Clovis cache sites. Ochre is extremely prevalent at the Anzick site, where the mineral is associated with the Clovis artifacts and one of the two human burials (Lahren 1999). Red ochre is probably also present at the Simon site, in that the artifacts were associated with a red-stained portion of the ground (Butler 1963:23). Red ochre is present at the East Wenatchee site, but only in an extremely small quantity. According to Gramly (1993:25-27), the red ochre appears only in the hafting area of three fluted points, indicated a possible utilitarian rather than ritual use of the mineral. Nearly all the artifacts from the Fenn cache exhibit traces of red ochre, but it lack of context complicates any further analyses (Frison and Bradley 1999:22). Finally, the Drake cache is unusual in that no red ochre is associated with it whatsoever (Stanford and Jodry 1988:21). Possibly, the differing quantities of red ochre at these cache sites represent different cache purposes, or they could reflect different cultures or trends within the Clovis technological complex.

## History of Discovery

The four Clovis caches that comprise the bulk of this study are East Wenatchee, Anzick, Simon, and Fenn (Figure 2). The selection of these four caches is based on the facts that they are definitely Clovis as indicated by their fluted point morphologies, they are considered “unique” based on Jones’ (1997) criteria, and they have reliable measurement data for use in statistical comparisons.



Figure 2: Clovis caches discussed in this research. The four sample caches are (1) East Wenatchee, (2) Anzick, (3) Simon, and (4) Fenn. Additional caches include (5) Drake, (6) Crook County, (7) Keven Davis, (8) Busse, and (9) Green.

### *East Wenatchee (45DO482)*

In May 1987, workers at R&R Orchards just north of Pangborn Airport in East Wenatchee, Washington uncovered a Clovis cache while digging a ditch for an irrigation pipe. In August of that year, Robert Mierendorf and R. Congdon dug test pits at the site

and uncovered artifacts below and next to the irrigation ditch. Upon realizing that the site is an important Clovis feature, the landowner (Mack Richey) placed concrete slabs over the site for protection (Mehringer 1989:1).

Excavation of the site resumed in April 1988 under the direction of Peter Mehringer, with participants ranging from Washington State University members, the Colville Confederated Tribes, and renowned Paleoindian experts from all over the United States. The purpose of this week-long excavation was to define the extent of the site, to understand the stratigraphy of the surrounding area, to obtain an approximate age for the site based on stratigraphic relationships, and to prepare for future large-scale excavations (Mehringer 1989:1). At the end of the week, the landowner replaced the concrete slabs over the site in the expectation that a well-prepared team of archaeologists would more fully excavate the site in the future (Wheat 1990).

By October 1990, the Mack and Susan Richey had selected Michael Gramly to excavate the site more completely. The excavation lasted for one month and was fraught with controversy. Representatives from the Colville Confederated Tribes protested the excavation (Rea 1990), other archaeologists contested Gramly's methods and interpretations (Mierendorf 1997), and the ownership of the artifacts and of the property itself became an issue (Wheat 1991, 1992a, 1992b). The dispute eventually settled with Mack Richey donating the assemblage to the Washington State History Museum in Tacoma, and with the Washington State Historical Society purchasing the rights to excavate the site in the future. However, the 1992 agreement also included the imposition of a 15-year moratorium on further excavations. In the meantime, apple trees have been replanted over the site, and the orchard continues to operate as before (Wheat

1992b). Currently as of 2000, one third of the East Wenatchee cache assemblage is on display at the Burke Museum in Seattle, one third is on display at the Washington State History Museum, and the final portion is in storage (Brooker 2000).

*Anzick (24PA506)*

According to Larry Lahren (ca 1990) Bill Bray found a large biface eroding out of a rocky outcrop along Flathead Creek, just southeast of Wilsall, Montana in 1961. No one noticed the significance of the site, however, until two construction workers uncovered the rest of the cache, along with human remains, in 1968. Ben Hargis and Calvin Sarver were removing fill from the outcrop with a front-end loader to be used in the construction of a high school. After removing the fill, they decided to use some finer sediment from the outcrop to fill a pothole. They noticed that the finer sediment contained a stone artifact, so they returned that evening to investigate the area with hand shovels. After discovering nearly a hundred artifacts covered in red ochre, they encountered human remains and stopped digging (Lahren ca 1990). Shortly afterwards, Lahren identified the artifacts as Clovis, and the ownership of the collection was split with half of the artifacts going to the landowner, Melvyn Anzick, and the other half being split equally among the two workers (Lahren and Bonnicksen 1971).

Later that same year, D. C. Taylor (1969) investigated the Anzick site and determined its excavation to be “an exercise in frustration,” based on the lack of intact deposits and artifacts. However, Hargis and Sarver believed that Taylor’s dismissal downplayed the importance of the site, so they contacted Lahren and Bonnicksen to conduct additional investigations in 1970 and 1971. These investigations defined the

stratigraphy of the site and uncovered an ochre-encrusted human clavicle (Lahren and Bonnicksen 1971). Lahren and Bonnicksen's interest in the Anzick cache brought much-deserved attention to the discovery and resulted in a presentation to the Society for American Archaeology and several publications (Lahren and Bonnicksen ca 1970s, 1971, 1974; Canby 1979).

However, despite the attention that the cache received, studying the entire collection was nearly impossible because it was split among several individuals. For nearly twenty years, Larry Lahren worked to reunite the artifacts under a single roof. Eventually, his efforts succeeded and the entire cache was put on permanent loan and put on display at the Montana State Museum in 1988 (Jones 1997:29-31).

#### *Simon (10CM7)*

The Simon cache was found in 1961 when William Simon was scraping a roadway along a plowed field on his property in Camas county, Idaho. Believing the cache to be of archaeological significance, he brought it to the Idaho State College Museum for identification. B. Robert Butler identified the cache as Clovis and, with the help of the landowner, analyzed the context of the find as thoroughly as possible (Butler 1963).

Steve Kohntopp (2001:26-28) points out that several discrepancies in the number of artifacts present in the Simon cache have emerged since Butler's initial report. Butler (1963) originally reports 29 artifacts, but Butler and Fitzwater (1965) amend that count and state that two of the artifacts had broken off of a larger biface, bringing the total to 27. However, a subsequent study by Woods and Titmus (1985) describes 33 Simon

artifacts. Kohntopp (2001:27-28) explains that the addition of the six extra artifacts is most likely the result of the donation of a few previously-overlooked artifacts from the Simon family. The 33 artifacts of the Simon cache currently (as of 2001) reside in the Herrett Center for Arts and Science in Twin Falls, Idaho (Kohntopp 2001:28).

### *Fenn*

Out of the four caches in this study, the Fenn cache easily has the most mysterious history of discovery. Fortunately, archaeologists can use multiple lines of evidence to trace its origin. In 1988, Forrest Fenn acquired the cache collection in Santa Fe, New Mexico (Frison and Bradley 1999:22). The artifacts' similarity to those from the East Wenatchee cache prompted Fenn to contact George Frison and Bruce Bradley for an analysis of the collection. Based on the research that Fenn, Frison, and Bradley conducted, the cache was found around the turn of the 20<sup>th</sup> century either in a plowed field or inside a cave. Descendents of the finders state that the original location of the cache was near the borders of Utah, Wyoming, and Idaho. The finders had handed the cache down among their family, eventually giving it to a daughter-in-law for her wedding. The daughter-in-law then sold the collection in Santa Fe (Frison and Bradley 1999:22).

Three observations on the content of the cache indicate the likelihood that it came from near the Utah/Wyoming/Idaho border. First, 17 of the 56 artifacts are made from Green River chert from southwest Wyoming (Frison and Bradley 1999:107). Also, two of the fluted points from the Fenn cache bear a strong resemblance to the fluted points found at the Colby site in southeast Wyoming. These fluted points have very deep basal

concavities and rounded ears, representing a style that seems to be unique to Wyoming. Finally, one crescent is present in the Fenn cache. Since crescents are typical of the Western Stemmed complex of the Great Basin, it is reasonable to infer that the Fenn cache came from within or adjacent to the Great Basin.

## Definitions of the Variables

### *Artifact Types*

This study divides the artifacts from these cache sites into six categories: fluted points, bifaces, blades, flakes, bone rods, and other. Because this analysis is made up of pre-existing data collected by different archaeologists, the finer points of these definitions may vary from cache to cache. However, the archaeological community universally acknowledges these terms, and it is unlikely that individual interpretations have had a significant impact on the data. Fluted points are defined by the presence of flutes (channel flake scars from the base of the points) on both sides, a concave base, and a lanceolate midsection that comes to a triangular point. Bifaces consist of stone tools that have been flaked on two surfaces along a single edge. They are distinct from fluted points in that bifaces lack the presence of flutes and have straight or convex bases. Blades are large flakes that are at least twice as long as they are wide. Like flakes, a blade should exhibit a platform and a bulb of percussion. Additionally, a blade usually has one or two longitudinal ridges along the center of the artifact. Flakes are shards of stone that have been removed from a larger piece. As previously stated, a complete flake has a platform and a bulb of percussion. Additionally, ripples and hackle marks may be

present. Bone rods represent the only non-lithic items found in the cache sites. They are cylindrical shafts of bone that are beveled on one or both ends (Bonnichsen et al. 1995). Archaeologists may refer to them as bone foreshafts, although this definition is hypothetical. The final category is reserved for “other” artifacts that do not pertain to any of the previous categories. One example would be the crescent from the Fenn cache.

Fluted points, bifaces, and bone rods are the most vital artifact categories in this analysis because of their comparable sample sizes and accurate measurements. Blades and miscellaneous artifacts do not have significant sample sizes to be compared between these sample caches. Flakes are numerous in the East Wenatchee cache and present in the Anzick cache, but they are not accurately measured. However, the correspondence analysis accounts for all artifact categories.

### *General Variables*

Variables had to be carefully selected for use in this study. Because the analysis is based on data that have been collected independently from the four collections, the only applicable variables are ones that match across all the caches. Additionally, the methods that researchers used to obtain the measurements may differ from cache to cache, but such discrepancies should not impact the overall trends in the data. The variable descriptions provided here are based primarily on Bonnichsen et al.’s (1995) database schematic for the East Wenatchee cache. The measurement methods used for the Anzick cache are similar to East Wenatchee’s, but the methods for Simon and Fenn are not described (CSFA ca. 1974; Jones 1997; Kohntopp 2001; Frison and Bradley

1999). Additional variables may be used in comparisons of artifacts within individual caches.

*Maximum Length.* Bonnichsen et al. (1995) state that this variable is a measurement between the two most distant longitudinal points on an artifact. For the East Wenatchee cache, each artifact is traced onto graph paper and measured from lines drawn perpendicular to the most proximal and distal ends. Maximum length is the most basic and easily identified variable.

*Mid-Length Width.* This variable applies primarily to fluted points and bifaces. Bonnichsen et al. (1995) describe this method as drawing a bisecting line perpendicular to the length of the artifact at one half of the artifact's maximum length, and measuring the width along this bisection line. This variable applies well to East Wenatchee and Anzick caches, but Simon and Fenn have only a generic "width" measurement.

*Maximum Width.* The method for obtaining maximum width is the same as maximum length, except along the opposite axis. This variable applies best to blades and flakes.

*Thickness.* This is one of the more poorly defined variables. For the Anzick cache and the East Wenatchee bifaces, the thickness measurement represents an artifact's thickness at its mid-length point (Bonnichsen et al. 1995). However, the variable is not defined for the fluted points (it was mistakenly skipped over in the descriptions).

*Weight.* While it is important, the weight variable is not included in most portions of this study. This decision is based on the fact that the data from the Simon cache do not include weight measurements (Kohntopp 2001:33). However, because weight is such an important tool for estimating overall artifact size, this study includes a ratio substitute.

$(L*W*T)/1000$ . This is the first of three ratio variables used in this study. This variable consists of the multiplication of length, width, and thickness, divided by 1000. It acts as an assessment of overall artifact size and replaces the missing weight variable.

*Length/Width*. The second ratio is length divided by width. It is intended as an assessment of artifact shape.

*Width/Thickness*. The final ratio is width divided by thickness. Like length/width, it is an approximation of artifact shape.

## DESCRIPTIVE STATISTICS

### Individual Sites

#### *East Wenatchee*

The artifacts of the East Wenatchee cache fall into five broad categories: fluted points, bifaces, blades, flakes, and bone rods. Each of these categories has different overall measurements, so each category must be studied on its own terms. Fluted points and bone rods have a wide variety of measurement variables, while flakes often have only weight measurements. Therefore, it would be confusing and counterproductive to analyze the set of artifacts as a whole, except by using count data.

The fluted points of the East Wenatchee cache have an extensive array of variables to describe their sizes and shapes. Excavations at the site to this point have uncovered a total of 14 fluted points. Bonnichsen et al's (1995) East Wenatchee database provides 18 variables for studying fluted points. The variables (in millimeters) consist of maximum length, maximum width, distal width, proximal width, mid-length width, maximum thickness, maximum flute thickness, maximum base width, maximum basal depth, maximum length of basal grinding on the right and left edges of the stem, number of flutes on the obverse and reverse faces, maximum flute length on the obverse and reverse faces, maximum flute width on the obverse and reverse faces, and weight in grams. These measurements are much more extensive than those on most other artifact types, and no other cache site has published resources that detail so many fluted point variables. Therefore, I have narrowed down my descriptive analysis to the nine most

relevant variables: maximum length, mid-length width, maximum thickness, maximum basal depth, number of flutes on the obverse and reverse, flute length on the obverse and reverse, and weight. Additionally, I include ratios of (length\*width\*thickness)/1000, length/width, width/thickness, and length/maximum basal depth (Table 1).

Table 1: Descriptive statistics on artifact measurement variables for East Wenatchee fluted points.

	<b>MaxLen</b>	<b>MLWth</b>	<b>Thickness</b>	<b>MaxBsDpth</b>	<b>#FlutesOb</b>
<b>Mean</b>	175.29	50.86	10.43	5.79	1.14
<b>Median</b>	161	50.5	10	5.5	1
<b>Std. Dev.</b>	43.64	8.92	1.16	1.42	0.363

	<b>#FlutesRv</b>	<b>FltLengthOb</b>	<b>FltLengthRv</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	1.07	50.86	52.21	128.84	98.54
<b>Median</b>	1	51.5	47	129.5	82.27
<b>Std. Dev.</b>	0.267	15.27	18.97	60.4	44.59

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>	<b>L/MBD Ratio</b>
<b>Mean</b>	3.41	4.89	30.76
<b>Median</b>	3.35	4.98	30.23
<b>Std. Dev.</b>	0.38	0.73	5.79

The distribution of measurements on the fluted points is predominantly non-normal. Mid-length width, weight, (L\*W\*T)/1000, length/width, and length/basal depth are bimodal, and only maximum thickness and possibly obverse flute length come close to resembling normality.

The bifaces from the East Wenatchee cache do not have as many measurement variables as the fluted points, but the artifacts have enough measurements necessary to complete a statistical analysis. In the collection, there are a total of 18 bifaces, with all of them having measured attributes. Bonnichsen et al (1995) provide 12 variables for

measuring the size and shape of bifaces. These variables are essentially the same as the fluted point variables, with the exception that the bifaces have no variables for measuring flute attributes. For this research, I have chosen seven variables to describe the measurements of the bifaces: maximum length, mid-length width, maximum thickness, weight,  $(L*W*T)/1000$ , length/width, and width/thickness (Table 2).

Table 2: Descriptive statistics on artifact measurement variables for East Wenatchee bifaces.

	<b>MaxLen</b>	<b>MLWth</b>	<b>Thickness</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	134.28	56.22	13.61	124.46	107.56
<b>Median</b>	126.5	56	14	105.2	88.24
<b>Std. Dev.</b>	23.72	8.38	2.73	47.89	54.06

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	2.41	4.25
<b>Median</b>	2.42	4.17
<b>Std. Dev.</b>	0.35	0.97

Like fluted points, the measurements from the bifaces are mostly non-normally distributed. Mid-length width and thickness are the two variables that come closest to normality, while the rest tend to be skewed to the right.

Blades represent an often-overlooked portion of the East Wenatchee cache, but they are worth mentioning for the fact that few cache sites contain both blades and bifacial tools. Excavations at East Wenatchee have revealed 9 blades, 6 of which have measurements on all applicable variables. Bonnicksen et al (1995) devised four variables for measuring blades, and all four variables will be used here as well: maximum length, maximum width, maximum thickness, and weight (Table 3). I have also included the ratio variables as additional measurements.

Table 3: Descriptive statistics on artifact measurement variables for East Wenatchee blades.

	<b>MaxLen</b>	<b>MaxWth</b>	<b>Thickness</b>	<b>Wt(g)<sup>1</sup></b>	<b>L*W*T</b>
<b>Mean</b>	91.38	32.2	10.48	24.58	39.43
<b>Median</b>	84.1	30.55	8.65	11.75	21.45
<b>Std. Dev.</b>	26.34	9.37	5.34	29.85	39

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	2.87	3.47
<b>Median</b>	2.88	3.4
<b>Std. Dev.</b>	0.56	1.08

<sup>1</sup>The weight variable includes measurements from two blades that are excluded from the other variables. These two blades are probably fragmented and have blown up the standard deviation and skewed the mean and median.

Unfortunately, all of the variables for blades contain gaps in the data, and multiple modes exist for all variables as well. The only possible normal distribution is for the length/width ratio.

Flakes are relatively numerous in East Wenatchee considering that they are not present in most cache sites. The East Wenatchee cache has revealed 62 flakes so far, but only 6 of them have length, width, or thickness measurements, and only 3 have enough attributes to enable the (L\*W\*T)/1000 measurement. Whenever possible, analyses include the length, width, thickness, and ratio variables (Table 4). However, weight is the only variable that encompasses nearly all of the flakes.

Table 4: Descriptive statistics on artifact measurement variables for East Wenatchee flakes.

	<b>MaxLen</b>	<b>MaxWth</b>	<b>Thickness</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	99.5	53.87	13.9	11.54	172.95
<b>Median</b>	95.85	44.85	12.75	0.02	62.17
<b>Std. Dev.</b>	47.67	33.73	8.36	54.15	244.68

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	1.97	4.12
<b>Median</b>	1.83	3.95
<b>Std. Dev.</b>	0.51	1.01

The flakes' weight illustrates the extreme variance in the assemblage. The fact that the standard deviation is nearly five times larger than the mean weight of the flakes indicates that huge outliers are present, while the majority of the flakes are extremely small. The same statistical problem appears in the  $(L*W*T)/1000$  measurement, although the small sample size is the more likely factor in this case.

The bone rods represent the final class of artifacts that have come out of the East Wenatchee site. Excavations have uncovered twelve measurable bone rod artifacts. Bonnichsen et al (1995) have outlined 16 different variables for measuring the bone rods. These variables consist of maximum length, maximum width, maximum thickness, proximal bevel length, mid-proximal bevel width, mid-proximal bevel thickness, proximal bevel angle, pre-proximal bevel width, pre-proximal thickness, 1/3 shaft width, 1/3 shaft thickness, 1/2 shaft width, 1/2 shaft thickness, 2/3 shaft width, 2/3 shaft thickness, and distal bevel length. These exhaustive measurements are not necessary for this research, so the numbers of variables are reduced to maximum length, maximum width, maximum thickness, weight, and the ratio variables (Table 5).

Table 5: Descriptive statistics on artifact measurement variables for East Wenatchee bone rods.

	<b>MaxLen</b>	<b>MaxWth</b>	<b>Thickness</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	206.66	24.9	17.38	68.2	92.61
<b>Median</b>	210.2	25.6	17.4	69.5	100.49
<b>Std. Dev.</b>	41.08	4.36	2.47	22.31	31.09

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	8.39	1.43
<b>Median</b>	8.11	1.44
<b>Std. Dev.</b>	1.48	0.1

The measurements of the bone rods show a relative degree of uniformity, particularly for width and thickness. However, an abnormally small outlier is present. The outlier most likely represents a broken bone rod, but that does not explain why its width and thickness are also much smaller than average. Excluding the outlier, width and weight appear normally distributed, with length and  $(L*W*T)/1000$  being bimodal.

### *Anzick*

The assemblage from the Anzick site contains the same artifact classes as East Wenatchee, except that Anzick lacks blades. Instead, the Anzick assemblage represents a strong emphasis on bifacial technology. The measurements of the Anzick artifacts lack some of the more obscure variables that Bonnichsen et al (1995) applied to the East Wenatchee cache, but enough variables are available through Bonnichsen's personal measurements and Scott Jones' (1997) masters thesis to provide an accurate comparison to the East Wenatchee assemblage.

A total of eight fluted points are from the Anzick site. Seven of the points have measurements for each analyzed variable. The variables applied to the Anzick points are the same as those used on the East Wenatchee fluted points (Table 6).

Table 6: Descriptive statistics on artifact measurement variables for Anzick fluted points.

	<b>MaxLen</b>	<b>MLWth</b>	<b>Thickness</b>	<b>MaxBsDpth</b>	<b>#FlutesOb</b>
<b>Mean</b>	92.43	31.31	6.66	1.36	1
<b>Median</b>	84	30.25	6.6	1	1
<b>Std. Dev.</b>	29.68	4.18	1.11	0.9	0.9

	<b>#FlutesRv</b>	<b>FltLengthOb</b>	<b>FltLengthRv</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	1.29	22.14	19.07	23.88	21.57
<b>Median</b>	1	20	21	18.5	17.89
<b>Std. Dev.</b>	0.49	14.9	9.09	14.67	14.4

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>	<b>L/MBD Ratio</b>
<b>Mean</b>	2.87	4.76	103.5
<b>Median</b>	2.96	4.47	69
<b>Std. Dev.</b>	0.6	0.72	93.49

The Anzick fluted points are considerably smaller than the East Wenatchee points, but the proportions of their measurements seem comparable at a glance. The weight,  $(L*W*T)/1000$ , and length/basal depth variables have considerably high standard deviations, implying that a great degree of diversity exists in those measurements. With the possible exception of the length/width ratio, no variables have normal distributions, and most are skewed to the right.

Bifaces make up the vast majority of the Anzick cache, with a total of 69 cited specimens. Moreover, no less than 64 bifaces have attributes for every applicable variable. The same seven variables that applied to the East Wenatchee bifaces also work with the Anzick specimens (Table 7).

Table 7: Descriptive statistics on artifact measurement variables for Anzick bifaces.

	<b>MaxLen</b>	<b>MLWth</b>	<b>Thickness</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	143.88	62.82	11.74	165.29	127.81
<b>Median</b>	143	55	12	134	90.81
<b>Std. Dev.</b>	51.25	29.6	2.53	132.09	120.64

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	2.34	5.43
<b>Median</b>	2.25	5
<b>Std. Dev.</b>	0.62	2.11

The high standard deviations of the weight and  $(L*W*T)/1000$  are reminiscent of the Anzick fluted point measurements, but the bifaces' standard deviations are even more acute. There are no immediately observable outliers for these variables, but they are obviously skewed to the right. The only variables with normal distributions are thickness and length/width ratio.

There are only seven flakes from the Anzick site. Fortunately, all seven flakes have measurements for the seven basic variables (Table 8).

Table 8: Descriptive statistics on artifact measurement variables for Anzick flakes.

	<b>MaxLen</b>	<b>MaxWth</b>	<b>Thickness</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	121.29	65.21	11.79	158.5	111.95
<b>Median</b>	113	62	10	116	74.24
<b>Std. Dev.</b>	44.67	33.15	5.35	141.8	125.16

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	2.04	6.06
<b>Median</b>	1.93	5.67
<b>Std. Dev.</b>	0.67	3.47

Once again, the high standard deviations of weight and  $(L*W*T)/1000$  are apparent. Most of the variables are skewed to the right, but maximum length may be normally distributed. The small sample size makes the determination speculative, however.

The Anzick cache contains eight bone rods. All eight of the specimens have been measured, although a weight attribute is missing on one of the rods. The measurement variables are the same as those used on the rods from East Wenatchee (Table 9).

Table 9: Descriptive statistics on artifact measurement variables for Anzick bone rods.

	<b>MaxLen</b>	<b>MaxWth</b>	<b>Thickness</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	137.06	18.38	12.95	32.86	32.59
<b>Median</b>	130	18.5	13	27	31.2
<b>Std. Dev.</b>	80.24	1.59	1.12	22.7	19.75

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	7.71	1.43
<b>Median</b>	6.57	1.47
<b>Std. Dev.</b>	5.03	0.19

The standard deviations for weight and  $(L*W*T)/1000$  are not as high as on their stone tool counterparts, but they are still fairly large for the bone rods. A minor outlier appears to be present in the bone rod data for the weight and  $(L*W*T)/1000$  variables. The thickness variable is normally distributed.

### *Simon*

The Simon cache consists exclusively of fluted points and bifaces. The collection is made up of 33 known specimens. In his 2001 master's thesis, Steve Kohntopp records

measurements of the artifacts from the cache. He includes length, width, and thickness (and I include the ratio variables), but he does not have weight measurements for the artifacts.

The Simon cache contains only five fluted points. Therefore, the descriptive statistics on the points are inexact (Table 10).

Table 10: Descriptive statistics on artifact measurement variables for Simon fluted points.

	<b>MaxLen</b>	<b>MLWth</b>	<b>Thickness</b>	<b>L*W*T</b>	<b>L/W Ratio</b>
<b>Mean</b>	145.2	38.8	8.2	47	3.71
<b>Median</b>	160	40	8	51.2	4
<b>Std. Dev.</b>	44.3	1.79	0.45	17.32	1

	<b>W/Th Ratio</b>
<b>Mean</b>	4.74
<b>Median</b>	4.75
<b>Std. Dev.</b>	0.26

Due to the small sample size, normal distributions are nearly impossible to discern. Length and width appear to be skewed to the left, and thickness and  $(L*W*T)/1000$  are skewed to the right.

The bifaces of the Simon cache are more numerous, with a total of 26 measured artifacts (measurements from two other bifaces were unavailable to Kohntopp). The bifaces have the same variables as the fluted points (Table 11).

Table 11: Descriptive statistics on artifact measurement variables for Simon bifaces.

	<b>MaxLen</b>	<b>MLWth</b>	<b>Thickness</b>	<b>L*W*T</b>	<b>L/W Ratio</b>
<b>Mean</b>	154.3	80	13.77	212.18	2.07
<b>Median</b>	160	63	12.5	130.87	2.01
<b>Std. Dev.</b>	48.5	37.23	4.68	242.81	0.58

	<b>W/Th Ratio</b>
<b>Mean</b>	6.05
<b>Median</b>	5.38
<b>Std. Dev.</b>	2.65

Biface measurements are skewed to the right, but only slightly for length, thickness, and the length/width ratio. Length is also bimodal. The standard deviation for  $(L*W*T)/1000$  is extremely high. A significant outlier is present, but some unknown factor appears to be involved in this measurement as well.

### *Fenn*

The Fenn assemblage also consists almost entirely of fluted points and bifaces. A total of 56 artifacts comprise the collection, with 54 of them being studied in this analysis. The remaining two artifacts are a single blade and a crescent. Because only one of each of these artifacts is present in the Fenn assemblage, statistical analyses would be ineffective. The measurements used in this study come from Frison and Bradley's (1999) book, *The Fenn Cache: Clovis Weapons and Tools*.

The Fenn cache has 21 known fluted points. Frison and Bradley utilize four variables (length, width, thickness, and weight) to describe the artifacts. This analysis also uses Frison and Bradley's variables, with the addition of the ratios (Table 12).

Table 12: Descriptive statistics on artifact measurement variables for Fenn fluted points.

	<b>MaxLen</b>	<b>MLWth</b>	<b>Thickness</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	107.96	36.98	7.86	39.59	34.14
<b>Median</b>	101.4	36.5	7.9	31.3	26.65
<b>Std. Dev.</b>	32.7	5.74	1.12	30.29	25.35

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	2.91	4.71
<b>Median</b>	2.95	4.71
<b>Std. Dev.</b>	0.6	0.37

Like the points from the Anzick site, the Fenn fluted points have high standard deviations for weight and  $(L*W*T)/1000$ . An outlier exists in all variables, and this outlier is more pronounced in the weight and  $(L*W*T)/1000$  variables. Most variables are skewed to the right, but the length/width and width/thickness ratios are more evenly distributed.

The 33 bifaces from the Fenn cache have been measured according to the same variables as the fluted points (Table 13). Although higher standard deviations for weight and  $(L*W*T)/1000$  are apparent in the bifaces, they are not as pronounced as the standard deviations of the fluted points. Most variables are skewed to the right, although thickness is normal and length is slightly skewed to the left.

Table 13: Descriptive statistics on artifact measurement variables for Fenn bifaces.

	<b>MaxLen</b>	<b>MLWth</b>	<b>Thickness</b>	<b>Wt(g)</b>	<b>L*W*T</b>
<b>Mean</b>	175.8	70.78	14.86	230.02	195.74
<b>Median</b>	172	65.6	14.6	196.3	170.84
<b>Std. Dev.</b>	25.61	19.35	3.23	117.92	101.85

	<b>L/W Ratio</b>	<b>W/Th Ratio</b>
<b>Mean</b>	2.56	4.86
<b>Median</b>	2.56	4.6
<b>Std. Dev.</b>	0.42	1.22

## Discussion

### *Analysis*

The following box and whisker plots enable comparisons of each variable across all four caches. Fluted points, bifaces, and bone rods are the most useful because they are found in significant numbers in more than one cache. The first set of plots explores the maximum length variable (Figure 3). These data show that the lengths of fluted points, bifaces, and bone rods vary according to site. However, no single site has a monopoly on large tools. For example, East Wenatchee has the longest fluted points but also the shortest bifaces.

The width data show that more variation is present, particularly in bifaces, than in the length data. Again, East Wenatchee has the largest fluted points and the smallest bifaces (Figure 4).

Thickness is extremely homogenous among the bifaces points from all caches, indicating its importance in bifacial reduction (Figure 5). Fluted points and bone rods tend to be more variable (relative to their overall sizes), although the thickness measurements on nearly all the points from the Simon cache are almost exactly the same.

$(L*W*T)/1000$ , the ratio assessment of overall artifact size, reflects the dramatic difference between the fluted points and bone rods from East Wenatchee when compared to other caches (Figure 6). On the other hand, the bifaces have relatively homogenous sizes, with the exceptions of the outlying points from each cache.

The length/width ratio variable tends to even out the variation among the caches (Figure 7). Although fluted point ratios still differ between each cache, the differences are not as extreme as in the other variables. The significantly larger variation in Anzick's bone rods when compared to East Wenatchee is probably due to breakage.

The width/thickness ratio is useful for flintknappers as an assessment of the overall quality of a finished stone artifact. Interestingly, East Wenatchee and Anzick have relatively high variabilities in their fluted points (Figure 8). The bifaces are expected to have lower ratios, although several extreme outliers have very high values.

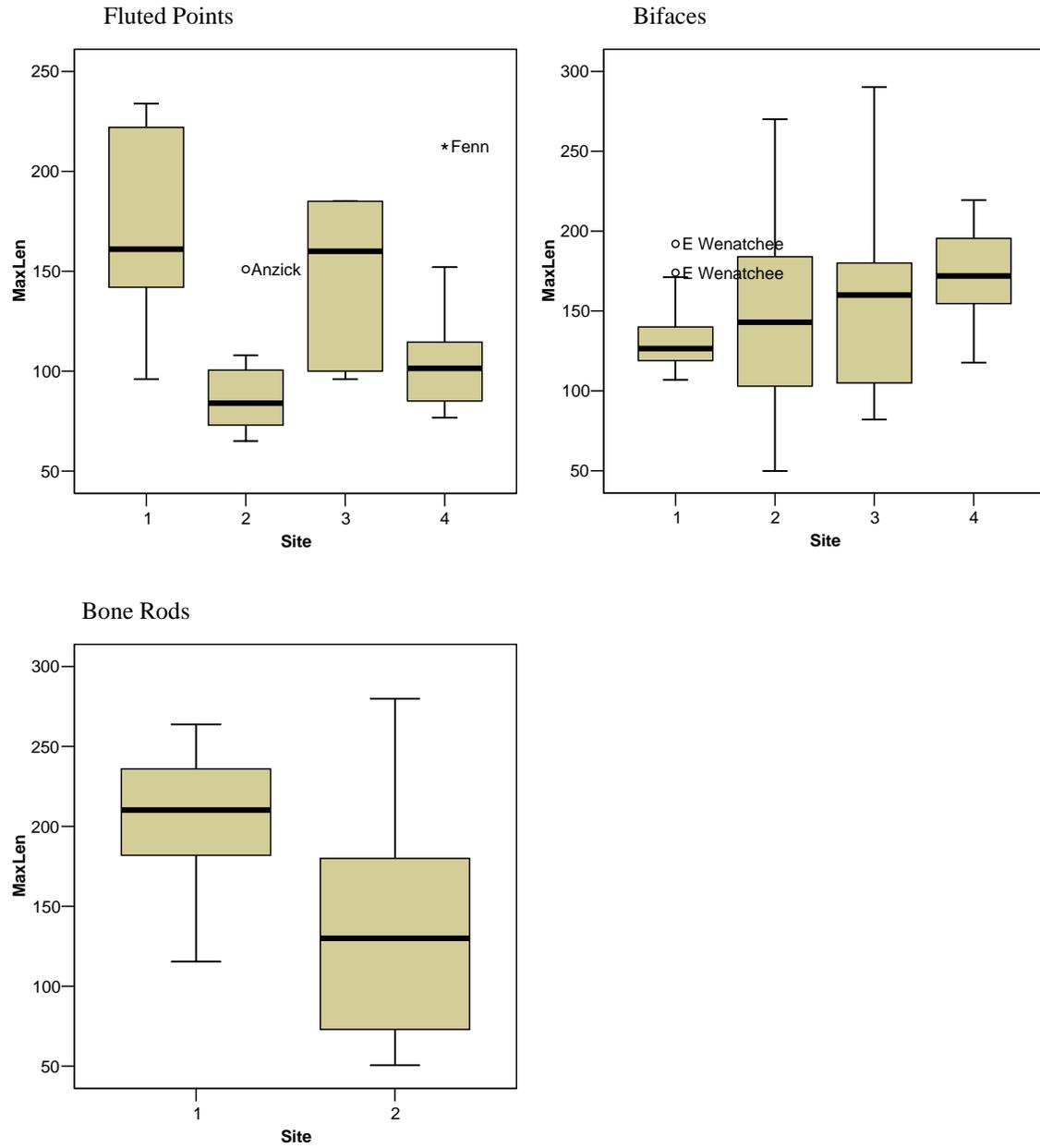


Figure 3: Box and whisker plots of the maximum length variable for fluted points, bifaces, and bone rods from the four sample cache sites. 1=East Wenatchee, 2=Anzick, 3=Simon, 4=Fenn.

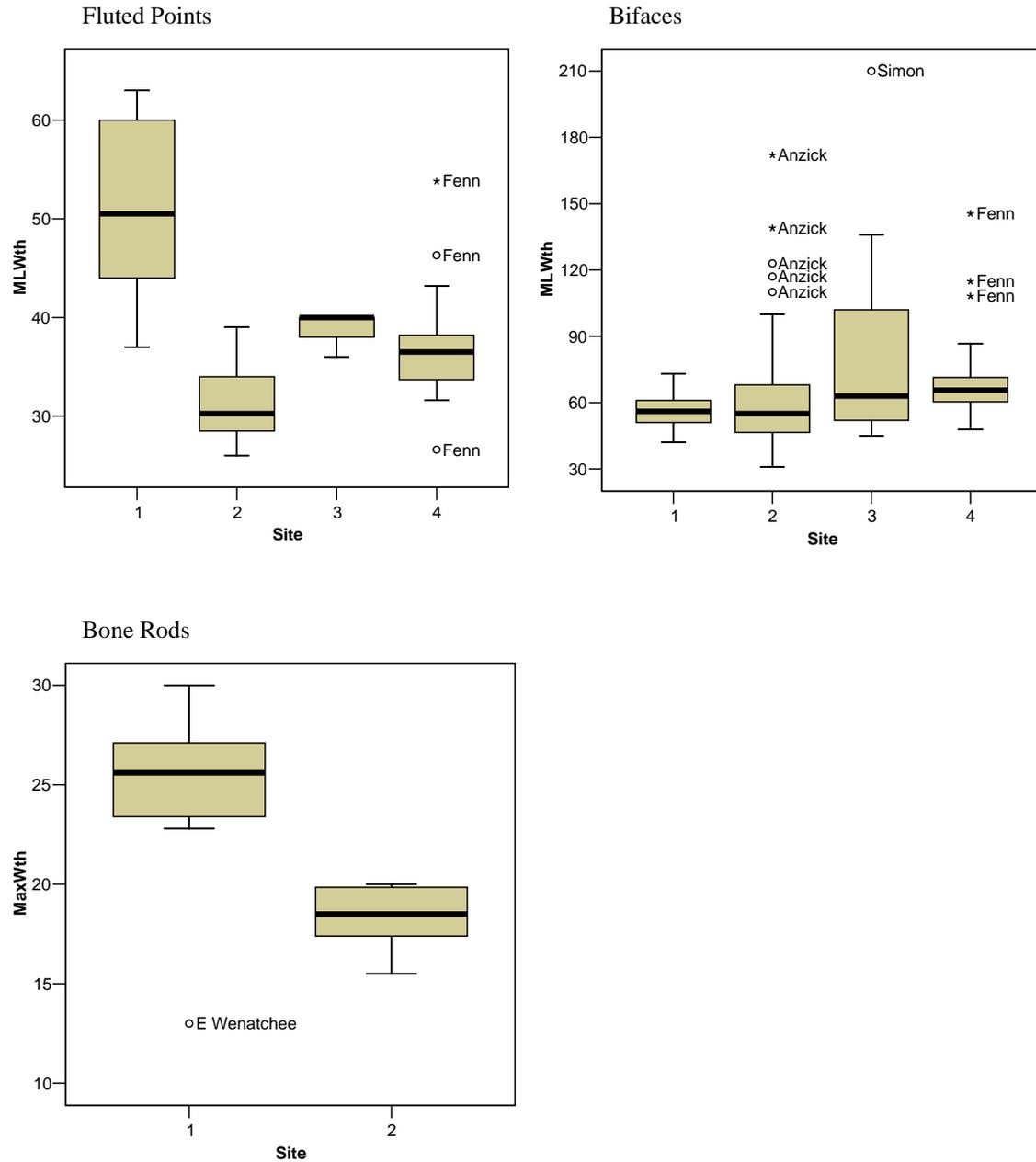


Figure 4: Box and whisker plots of the width variables for fluted points, bifaces, and bone rods from the four sample cache sites. 1=East Wenatchee, 2=Anzick, 3=Simon, 4=Fenn.

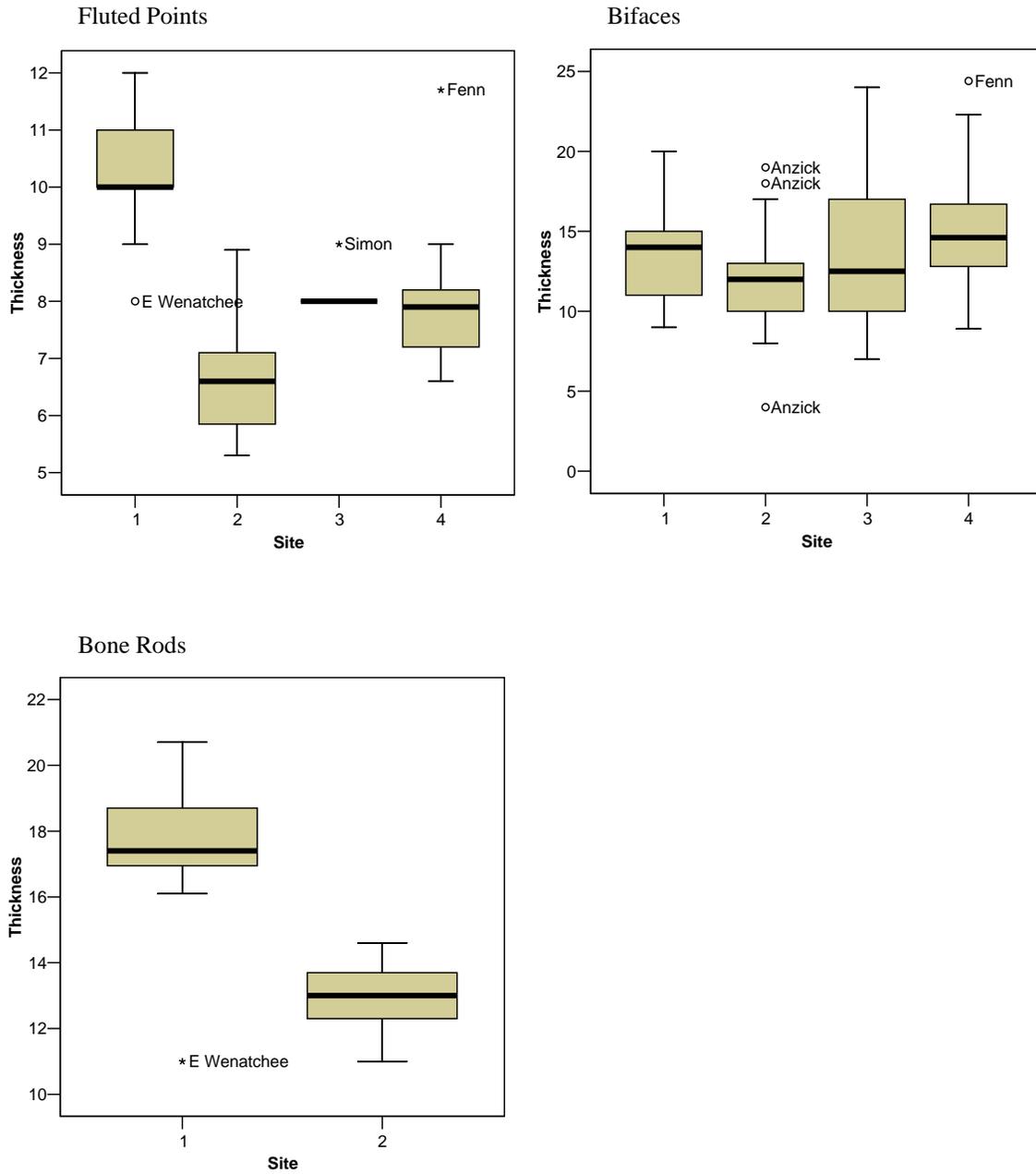


Figure 5: Box and whisker plots of the thickness variable for fluted points, bifaces, and bone rods from the four sample cache sites. 1=East Wenatchee, 2=Anzick, 3=Simon, 4=Fenn.

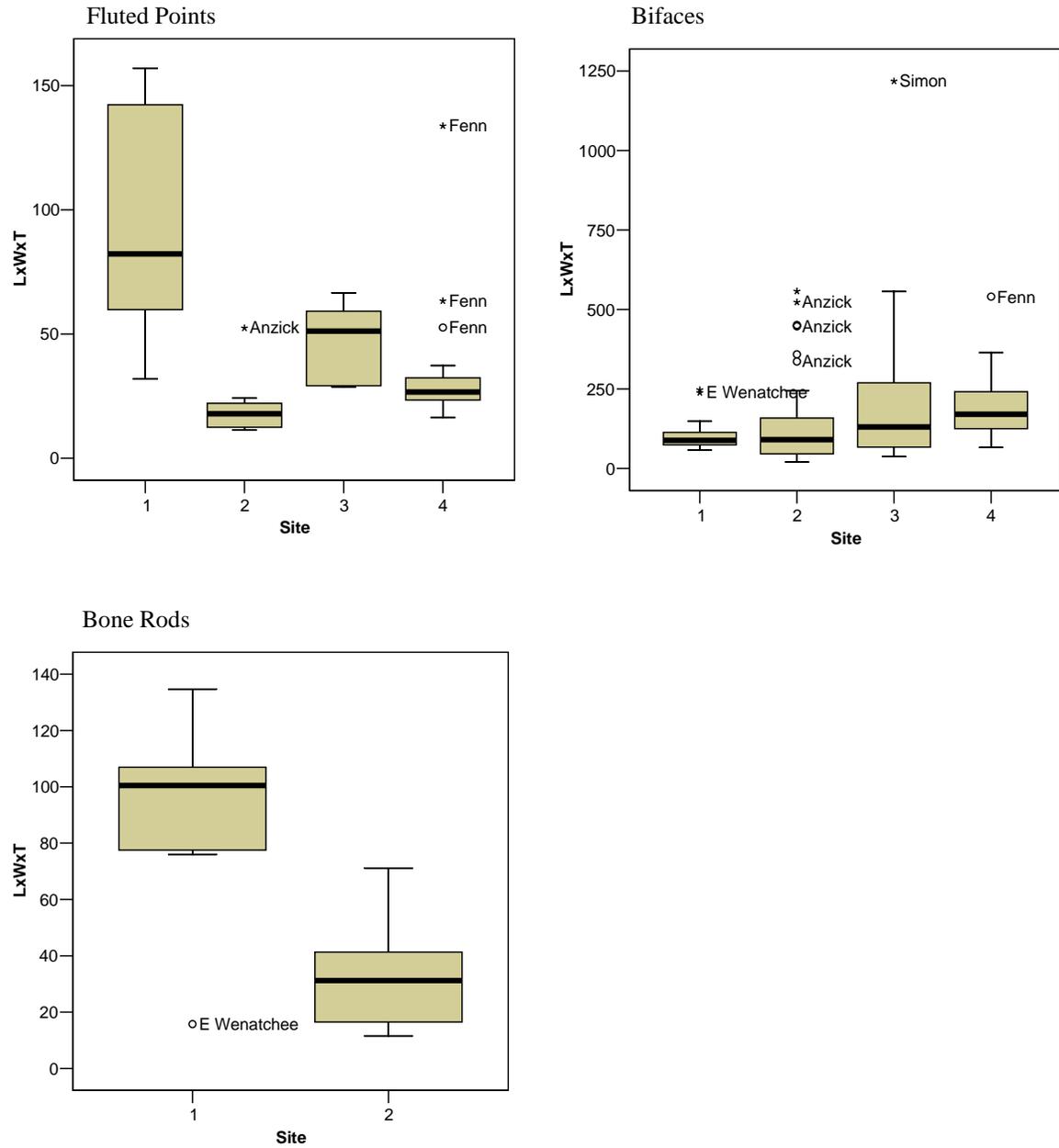


Figure 6: Box and whisker plots of the  $(L*W*T)/1000$  variable for fluted points, bifaces, and bone rods from the four sample cache sites. 1=East Wenatchee, 2=Anzick, 3=Simon, 4=Fenn.

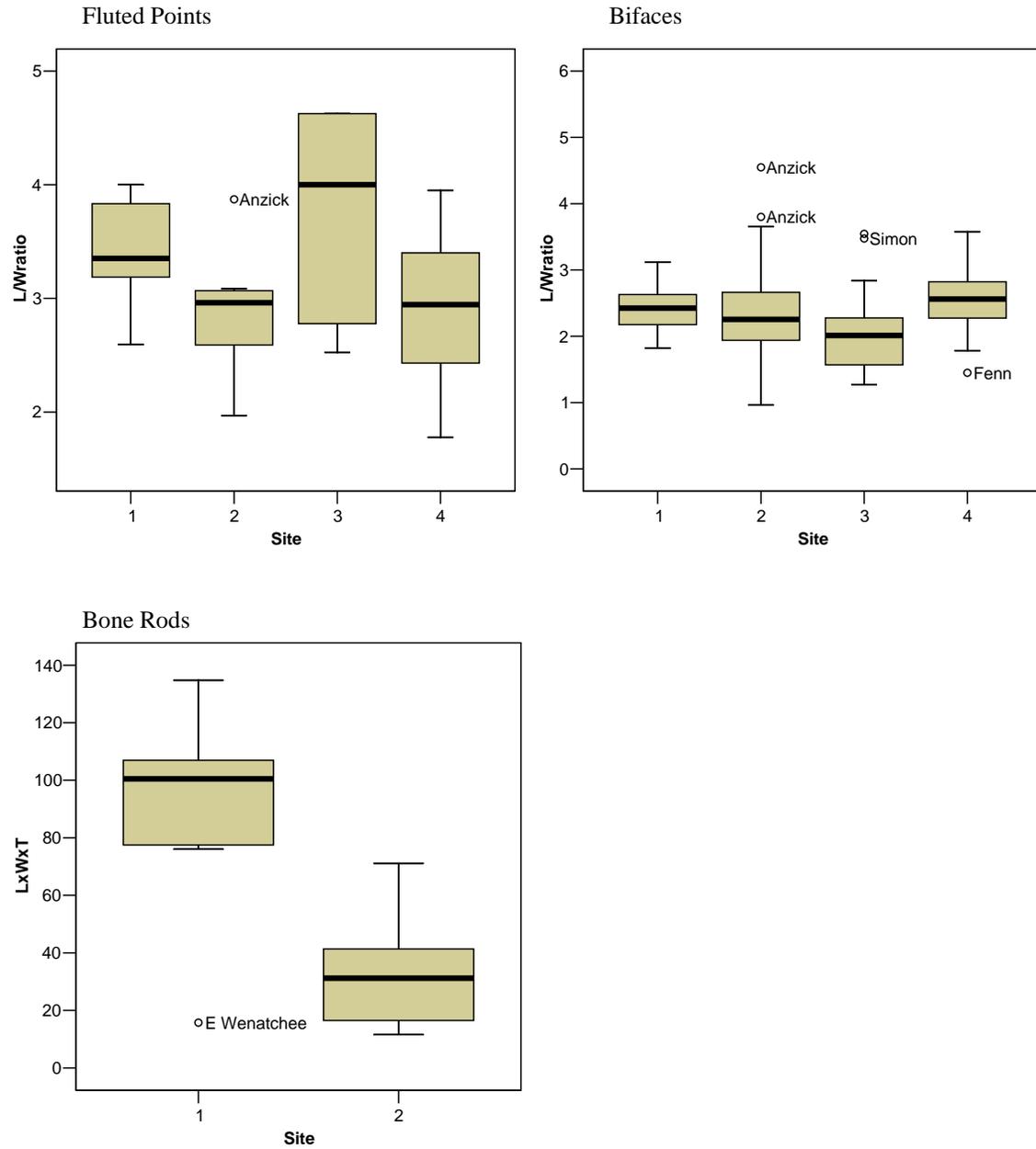


Figure 7: Box and whisker plots of the length/width ratio variable for fluted points, bifaces, and bone rods from the four sample cache sites. 1=East Wenatchee, 2=Anzick, 3=Simon, 4=Fenn.

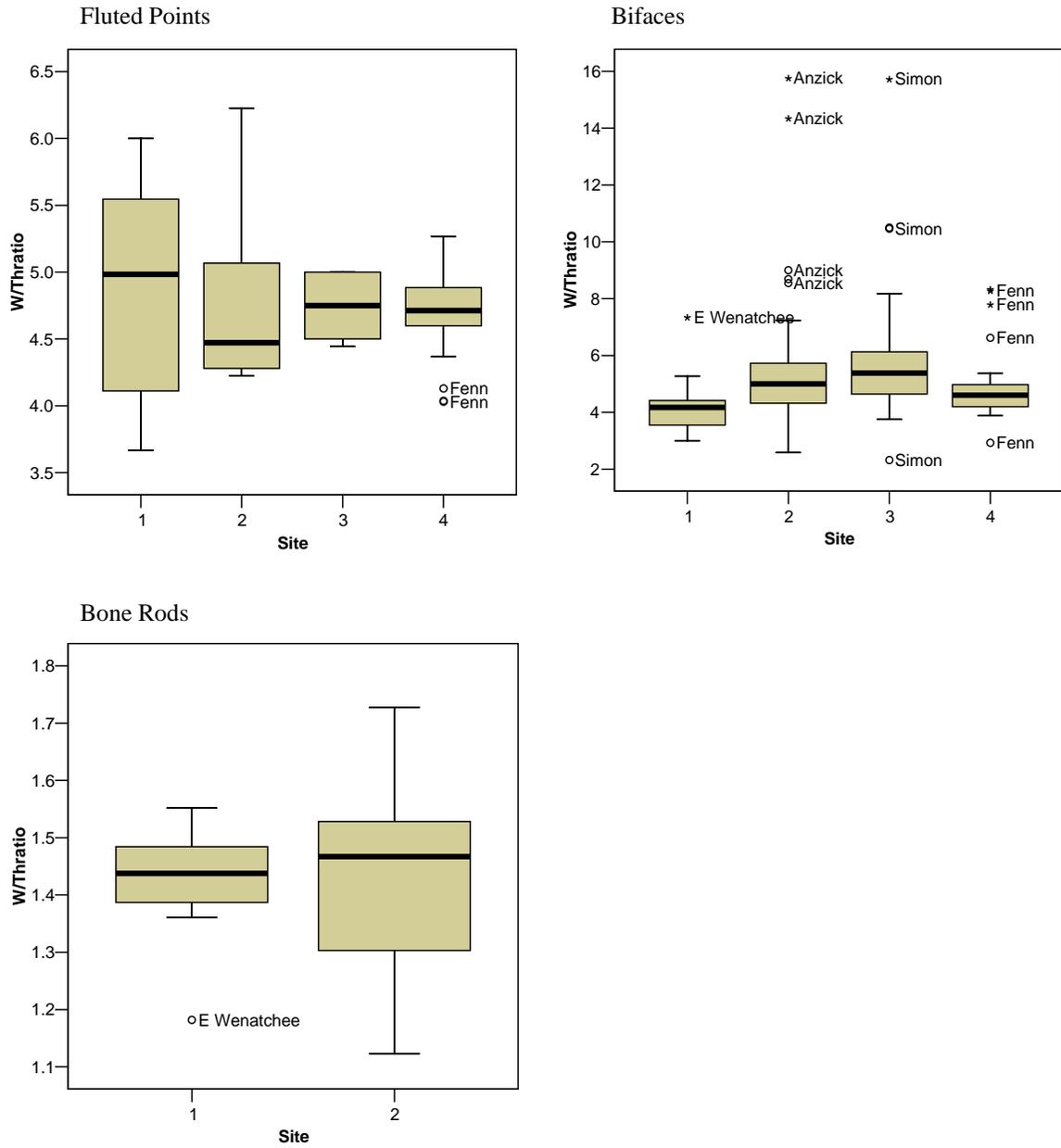


Figure 8: Box and whisker plots of the width/thickness ratio variable for fluted points, bifaces, and bone rods from the four sample cache sites. 1=East Wenatchee, 2=Anzick, 3=Simon, 4=Fenn.

### *Variable Transformations*

Based on the descriptive statistics on these four cache sites, it is apparent that transformations would be necessary to normalize most measurement distributions. Unfortunately, neither the base 10 logarithm nor the natural logarithm provide values that normalize all of the variables. Some variables benefit from the transformations, but many do not change significantly, and others worsen.

For the descriptive statistics from the East Wenatchee cache, the fluted points remain largely unchanged by the transformations. Moreover, the thickness variable becomes less normal. Biface measurements also do not change drastically, although width becomes slightly more normal with the natural logarithm. Blades have a normal width distribution using at base 10 logarithm, but nothing else changes. The same is true for flakes, though the weight distribution also becomes somewhat more normal with a natural log. In varying degrees, the bone rod measurements all become less normal after the transformations.

For the Anzick cache, fluted point measurements become more normal in terms of width and thickness after transformations. The natural logarithm works best for width, and the base 10 logarithm is best for thickness. The transformations normalize all the biface variables to varying degrees. For the most part, the natural logarithm improves the data the most, although the base 10 logarithm is better for biface length. The transformations for the flakes only normalize the weight variable, while the other variables do not show much improvement. The bone rods also do not become normally distributed after the transformations, and the thickness variable becomes less normal.

The fluted points from the Simon cache are too few in number to form accurate transformations. The logarithms do not normalize the fluted point variables. The bifaces from the Simon cache also do not normalize after the transformations.

For the Fenn cache, the fluted point variables become slightly more normal after transformations. However, most variables (except width) remain skewed to the right. The bifaces show similar results, but the weight and  $(L*W*T)/1000$  variables become normal after the transformations.

Using the base 10 and natural logarithms to normalize the distributions of the measurement variables of the cache sites does not work in most cases. The sample size for most variables is too small for the transformations to work well. Larger samples may fill in gaps in the data in ways that mathematical transformations cannot. In cases where the sample size is higher ( $n > 20$ ), the transformations have more success with normalizing the distributions.

## FACTOR ANALYSES

An integral part of this research is to compare Clovis cache artifacts on the basis of both size and shape. As variables, “size” and “shape” are too broad to be measured directly. However, other variables can approximate the values of size and shape. Factor analysis is a useful statistical tool for differentiating variables based on more generalized concepts.

Factor analysis links variables together based on correlations. If two or more variables change predictably when the other changes, then those variables are said to have the same principal component, an independent generalized variable that links the measurable variables together. For example, length and width tend to increase and decrease together, but length obviously does not cause width. Instead, the overall factor of size determines the relation between length and width. Factor analysis places related variables into groups based on these correlations. The inference is that a different principal component determines the measures of the variables in each group. However, SPSS does not specify the nature of the principle components; instead, the researcher must examine the interrelatedness of the variables in each component to determine the identity of the components. In this respect, factor analysis is a somewhat subjective science (Shenman 1997: 265-307).

As stated previously, the goal of this section is to distinguish between variables that are indicative of size from those that signify shape. Afterwards, each group of variables can be measured on its own terms so that both aspects of the Clovis cache artifacts can be accurately studied. The SPSS version 12.0 factor analysis program

provides the results in this study. The results are based on the factor analysis function being set to extract components for eigenvalues that are above 1.

The factor analysis function is set to analyze each artifact type separately: fluted points, bifaces, blades, flakes, and bone rods. The sample sizes vary greatly between artifact types, and not all types are present in each cache. Despite these differences, the results of this initial analysis are fairly consistent across most artifact types. The factor analysis utilizes the variables of maximum length, mid-length or maximum width, maximum thickness,  $(L*W*T)/1000$ , length/width ratio, and width/thickness ratio. My hypothesis is that the factor analysis should reveal two components for each artifact type, with length, width, thickness, and  $(L*W*T)/1000$  being the most prominent variables in the first component (size); and with the length/width and width/thickness ratios being most prominent in the second component (shape). As hypothesized, the variables always condense into two components, regardless of artifact type (although bifaces are a potential exception), but the influence of the variables within each component changes according to artifact type.

For fluted points, the factor analysis yields two components with eigenvalues above 1 (Table 14). The maximum length, mid-length width, thickness, and  $(L*W*W)/1000$  variables have the strongest representation in the first component. For the second component, the width/thickness ratio is the only strong variable, with the length/width ratio being a distant second (Table 15). The length/width and width/thickness ratios are inversely related. In all, the two components account for 87.6% of the original variation of the fluted points.

Table 14: Total variance explained for fluted points.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.135	68.911	68.911	4.135	68.911	68.911
2	1.121	18.690	87.600	1.121	18.690	87.600
3	.699	11.642	99.242			
4	.037	.623	99.865			
5	.006	.106	99.971			
6	.002	.029	100.000			

Table 15: Component matrix for fluted points.

	Component	
	1	2
MaxLen	.981	-.055
MLWth	.945	.222
Thickness	.869	-.266
LxWxT	.981	.041
L/Wratio	.672	-.399
W/Thratio	.332	.915

The factor analysis of the bifaces provides two components with eigenvalues over 1 (3.256 and 1.587), but the next eigenvalue is .977, just slightly below the cutoff point (Table 16). This third eigenvalue implies that a third, slightly subtler component exists in the biface data. In the first component, length, width, and  $(L*W*T)/1000$  are the most prevalent variables. The second component gives almost equal weight to both the length/width ratio and to the width/thickness ratio, with thickness being the next most influential variable (Table 17). Like the fluted point results, the length/width ratio and the width/thickness ratio are inversely related. The third component has thickness, length/width ratio, and width/thickness ratio as its prevailing variables, though none of them have values higher than .6. In the third component, the length/width and width/thickness ratios are not inversely related. The first two components account for

about 80.7% of the variation, and adding the third component brings the percentage up to 97.

Table 16: Total variance explained for bifaces.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.256	54.271	54.271	3.256	54.271	54.271
2	1.587	26.451	80.722	1.587	26.451	80.722
3	.977	16.279	97.000	.977	16.279	97.000
4	.111	1.858	98.858			
5	.054	.899	99.758			
6	.015	.242	100.000			

Table 17: Component matrix for bifaces.

	Component		
	1	2	3
MaxLen	.805	.406	.401
MLWth	.975	-.193	.002
Thickness	.618	.547	-.526
LxWxT	.963	.101	-.078
L/Wratio	-.267	.761	.582
W/Thratio	.527	-.704	.440

Blades are a rather uncommon artifact type among the four cache sites, as all but one of them are from the East Wenatchee cache. However, running a factor analysis on the blades is still necessary in order to observe continuities between the artifact types. The results of the analysis yield two components, with eigenvalues of 4.449 and 1.462 (Table 18). The most prominent variables in the first component are length, width, and oddly enough, the width/thickness ratio. The most important variables in the second component are the length/width ratio, followed by width and the width/thickness ratio (Table 19). The two components account for 98.5% of the variation in the data.

Table 18: Total variance explained for blades.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.449	74.153	74.153	4.449	74.153	74.153
2	1.462	24.364	98.517	1.462	24.364	98.517
3	.060	1.003	99.520			
4	.023	.383	99.903			
5	.006	.096	99.999			
6	4.707E-05	.001	100.000			

Table 19: Component matrix for blades.

	Component	
	1	2
MaxLen	.998	-.002
MLWth	.793	.605
Thickness	.992	-.004
LxWxT	.954	.267
L/Wratio	.382	-.917
W/Thratio	-.885	.428

Flakes are only present in the East Wenatchee and Anzick caches, and most of the East Wenatchee flakes are too small to be analyzed in this study. The factor analysis of measurable flakes reveals two components, with eigenvalues of 3.58 and 1.641 (Table 20). The most prominent variables of the first component are width, thickness, and  $(L*W*T)/1000$ . In the second component, the width/thickness ratio, length, and thickness are the most important (Table 21). Interestingly, the length/width and width/thickness ratios are positively related in the second component. The two components account for about 87% of the variation in flakes.

Table 20: Total variance explained for flakes.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.580	59.664	59.664	3.580	59.664	59.664
2	1.641	27.353	87.017	1.641	27.353	87.017
3	.627	10.452	97.469			
4	.108	1.801	99.270			
5	.042	.693	99.963			
6	.002	.037	100.000			

Table 21: Component matrix for flakes.

	Component	
	1	2
MaxLen	.766	.561
MaxWth	.984	.169
Thickness	.801	-.542
LxWxT	.948	-.098
L/Wratio	-.660	.408
W/Thratio	.220	.910

Like the flakes, bone rods are also present only in the East Wenatchee and Anzick caches. The bone rod variables have two components, with high eigenvalues of 3.471 and 2.09 (Table 22). The division among the components is the most obvious in the bone rod data. The four variables of length, width, thickness, and  $(L*W*T)/1000$  are all very prominent in the first component; while the length/width and width/thickness ratios have a strong influence in the second component (Table 23). As usual the length/width and width/thickness ratios are inversely proportional. The two components comprise about 92.7% of the bone rods' variation.

Table 22: Total variance explained for bone rods.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.471	57.843	57.843	3.471	57.843	57.843
2	2.090	34.837	92.680	2.090	34.837	92.680
3	.414	6.898	99.578			
4	.019	.312	99.890			
5	.005	.084	99.974			
6	.002	.026	100.000			

Table 23: Component matrix for bone rods.

	Component	
	1	2
MaxLen	.872	-.422
MaxWth	.816	.573
Thickness	.932	.255
LxWxT	.988	.110
L/Wratio	.440	-.859
W/Thratio	-.077	.876

Based on these factor analysis data, the artifact types show a fair degree of uniformity in terms of the number of components and the makeup of the first component. The second component has more variability among artifact types, with the differences appearing primarily in blades and flakes. The fact that two components are present for each artifact type indicates that a distinction between size and shape exists. The third component in the biface data is something of an anomaly. Its meaning has yet to be determined. Across all the artifact types in the first (size) component, the length/width and width/thickness variables are never more prominent than maximum length, width, thickness, or  $(L*W*T)/1000$ . Therefore, these latter four variables play a larger role in estimating artifact size than do the two ratio variables. On the other hand, the length/width and width/thickness ratio variables are more prominent in the second

(shape) component for fluted points, bifaces, and bone rods. In the second component of blades, the length/width ratio has the largest value, but width/thickness is the third largest. For flakes, width/thickness has the largest value, but the length/width ratio is the fourth highest. Furthermore, flakes have the only shape component in which the two ratios are not inversely related. It appears that the greater the technological control that the toolmaker has over an artifact type, the more likely they are to fall into two evenly divided components. Flakes and blades are the least refined of the artifacts, so their components are not as defined.

A factor analysis run on the total assemblages from all four caches can provide a perspective on the overall trends in the artifacts. As expected, the factor analysis finds two components with eigenvalues over 1 (Table 24). Moreover, the most influential variables in the first component are length, width, thickness, and  $(L*W*T)/1000$ ; while the second component has the highest values for the length/width and width/thickness ratios, with the two ratios being inversely related (Table 25). Length and thickness are also fairly high in the second component. This overall trend in the principal components of the cache artifacts supports the hypothesis of size and shape categories.

Table 24: Total variance explained for all artifacts.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.022	50.369	50.369	3.022	50.369	50.369
2	1.921	32.012	82.382	1.921	32.012	82.382
3	.774	12.899	95.280			
4	.140	2.334	97.614			
5	.121	2.011	99.626			
6	.022	.374	100.000			

Table 25: Component matrix for all artifacts.

	Component	
	1	2
MaxLen	.690	.541
MLWth	.959	-.249
Thickness	.603	.605
LxWxT	.955	.097
L/Wratio	-.261	.831
W/Thratio	.531	-.707

Rotation may enable us to better understand the makeup of the components. According to Kachigan's (1991) description, rotation keeps the original positions of the variables but rotates the axes of the components around them, balancing the values in each component so that high and low values are always represented. Under regular principal component analysis, the variables within each component have lower values than their preceding components. Rotation ensures that the values will remain proportional within each successive component. Additionally, rotation typically eliminates middle-range values, leaving only high or low variables within each component. The procedure therefore allows data to be more interpretable. However, rotation is not without its problems. According to Baxter (1994), rotation is an arbitrary technique that only adds more speculation to an already subjective procedure. Moreover, different methods of rotation can give different results. For the purposes of this study, I use Varimax Rotation with Kaiser Normalization.

For fluted points, the rotation makes no significant changes in the first component (Table 26). Thickness becomes more significant than width, but little else changes. The second component exhibits more changes. Although the width/thickness ratio is still the strongest, the length/width ratio is no longer significant. It is instead outweighed by

width,  $(L*W*T)/1000$ , and length. However, there is still a negative relationship between the length/width and width/thickness variables in the second component.

Table 26: Rotated component matrix for fluted points.

	Component	
	1	2
MaxLen	.954	.234
MLWth	.839	.488
Thickness	.909	-.001
LxWxT	.926	.326
L/Wratio	.759	-.186
W/Thratio	.050	.972

Rotation does not significantly alter the first component for bifaces either (Table 27). However, it does make some changes in the second component's variables that are similar to the fluted point rotation. Without rotation, the length/width and width/thickness ratios were the strongest variables in the second component. After rotation, width/thickness becomes stronger, but thickness, width, and length are all more significant than length/width. Finally, the third component shows that thickness and length/width are the strongest variables without rotation. The rotated third component, on the other hand, shows that the length/width ratio is easily the most prominent, while the next highest variable, length, is only half the value of length/width.

Table 27: Rotated component matrix for bifaces.

	Component		
	1	2	3
MaxLen	.838	.251	.458
MLWth	.853	.441	-.257
Thickness	.821	-.523	-.103
LxWxT	.946	.185	-.118
L/Wratio	-.077	-.206	.970
W/Thratio	.214	.935	-.218

Blades are an artifact type with which rotation appears to work particularly well in terms of the expectations of this research (Table 28). Before rotation, the first component is mostly typical, but it has a width/thickness variable that is greater than expected. After rotation, the width/thickness variable is reduced, while the rest remain relatively the same. The second component already shows fairly strong length/width and width/thickness variables before rotation, although width is also anomalously high. The rotation reduces the width variable and emphasizes the length/width and width/thickness ratios.

Table 28: Rotated component matrix for blades.

	Component	
	1	2
MaxLen	.910	.411
MLWth	.971	-.227
Thickness	.903	.410
LxWxT	.980	.148
L/Wratio	-.028	.993
W/Thratio	-.632	-.753

On the other hand, flakes are not any more easily interpretable after rotation (Table 29). Originally, the first component is typical, but rotation greatly reduces the length variable and puts more emphasis on the length/width ratio. For the second component, the rotation maintains the significance of the width/thickness ratio while increasing the length and width variables.

Table 29: Rotated component matrix for flakes.

	Component	
	1	2
MaxLen	.388	.865
MLWth	.760	.649
Thickness	.963	-.078
LxWxT	.875	.385
L/Wratio	-.775	.029
W/Thratio	-.257	.900

Of all the artifact types in this analysis, bone rods are the least in need of rotation. Moreover, rotation does not significantly alter the values of the variables within the components (Table 30). Length, width, thickness, and  $(L*W*T)/1000$  remain the most prominent variables in the first component, and the length/width and width/thickness ratios are the strongest in the second component. The only change that occurs after rotation is that the differences between strong and weak variables generally become more pronounced, particularly in the first component.

Table 30: Rotated component matrix for bone rods.

	Component	
	1	2
MaxLen	.697	.673
MLWth	.943	-.314
Thickness	.966	.046
LxWxT	.972	.203
L/Wratio	.152	.954
W/Thratio	.197	-.855

Rotation does not clarify all the results for all the artifacts; instead it enhances some types and obscures others. For fluted points and bifaces, the first component maintains its proportions after rotation, but the second component changes beyond

expectations, particularly in the length/width ratio variable. For the flakes, rotation completely alters the proportions of the variables in both components. On the other hand, rotating the components for blades and bone rods emphasizes both of the components' predicted proportions. Additionally, rotating the components for all artifacts as a group supports the original hypothesis, although width is slightly lower in the first and higher in the second component (Table 31).

Table 31: Rotated component matrix for all artifacts.

	Component	
	1	2
MaxLen	.872	-.094
MLWth	.682	.719
Thickness	.832	-.195
LxWxT	.862	.422
L/Wratio	.218	-.843
W/Thratio	.077	.881

## CLUSTER ANALYSES

Archaeologists often refer to the similarity of the four Clovis caches, but cluster analyses can investigate exactly how the caches relate to each other. This research utilizes hierarchical cluster analyses using Ward's method to sort artifacts of each individual type into groups based on morphological similarity. The cluster analyses are first run on each artifact type within each cache to determine the number of clusters that emerge per assemblage. Then, the total number of artifacts within each type are analyzed to determine how the artifacts cluster independently of their cache association. The research also separates cluster analyses that are run on size variables (usually length, width, thickness, and  $(L*W*T)/1000$ ) from those that are run on shape variables (usually the length/width and width/thickness ratios). Then, this section examines clusters that are derived from a combination of the size and shape factor scores.

Finally, the East Wenatchee site offers the opportunity to study cached Clovis tools based on their *in situ* provenience. The null hypothesis is that the positioning of the artifacts in their context is not related to their morphological similarities. On the other hand, comparing the arrangement of the artifacts with the statistical clusters based on artifact measurements could demonstrate a purposeful sorting of the artifacts within their context. The final portion of this section examines this possibility.

Different variables can measure different aspects of the tools under study. The majority of the variables provide measurements based on size. A few others, particularly ratio variables such as width/thickness, measure aspects of shape. The factor analysis provides a method for determining which measurable variables correspond to the

“implied” variables of size and shape. Table 32 categorizes the variables based on the results of the factor analysis.

Table 32: Variables sorted into their respective components of size and shape.

<b>Component 1: Size</b>	<b>Component 2: Shape</b>
Maximum Length	Length/Width
Maximum/Mid-Length Width	Width/Thickness
Thickness	
$(L*W*W)/1000$	

### Cluster Analyses Based on Size

For the overall category of size, variables that contribute to the cluster analysis vary depending on the type of artifacts being analyzed and on the site from which they are excavated. To begin, I analyze the different artifact types from each site independently and compare the results, with particular emphasis on the East Wenatchee artifacts as they compare to their proveniences within the cache. The next step is to analyze the different artifact types between caches and observe any patterns in the clusters. The null hypothesis is that the artifacts will cluster independently of the site to which they belong.

In order to determine the number of clusters for each set of variables, I create charts based on the agglomeration values that result from the cluster analysis. The cluster analysis progresses through stages, with each stage increasing the number of possible clusters until all specimens are grouped apart. Each stage contains an agglomeration value. This value decreases with each stage, but the decreases become less substantial towards the final stages. In an ideal situation, there will be one stage at which the

agglomeration value dives to a level that is lower than expected. Counting the number of stages at the end of the dive provides the most suitable number of clusters for the data.

### *East Wenatchee*

For the East Wenatchee site, I analyze fluted points, bifaces, blades, and bone rods. The cluster analysis could not apply to the flakes because of their lack of applicable variables and of accurate weight measurements. In applying the analysis, I use a hierarchical cluster analysis and standardize the variables using z-scores.

The East Wenatchee fluted points have the most variables available for the cluster analysis, which consists of maximum length, mid-length width, maximum thickness, maximum basal depth, weight, and  $(L*W*T)/1000$ . The results show that fluted points form two size clusters, which may further subdivide into four or five minor clusters, although one of them consists of a solitary outlier. However, the two large clusters appear to be very significant based on the agglomeration table, and an examination of photos and casts of the fluted points proves that the artifacts do separate into two distinct size categories (Figure 9).

The bifaces cannot be clustered using quite as many variables as the fluted points. Instead, the analysis leaves out basal depth and focuses on maximum length, mid-length width, maximum thickness, weight, and  $(L*W*T)/1000$ . The results suggest that five size clusters are apparent in the East Wenatchee biface data (Figure 10). However, two of these clusters consist of only two bifaces.

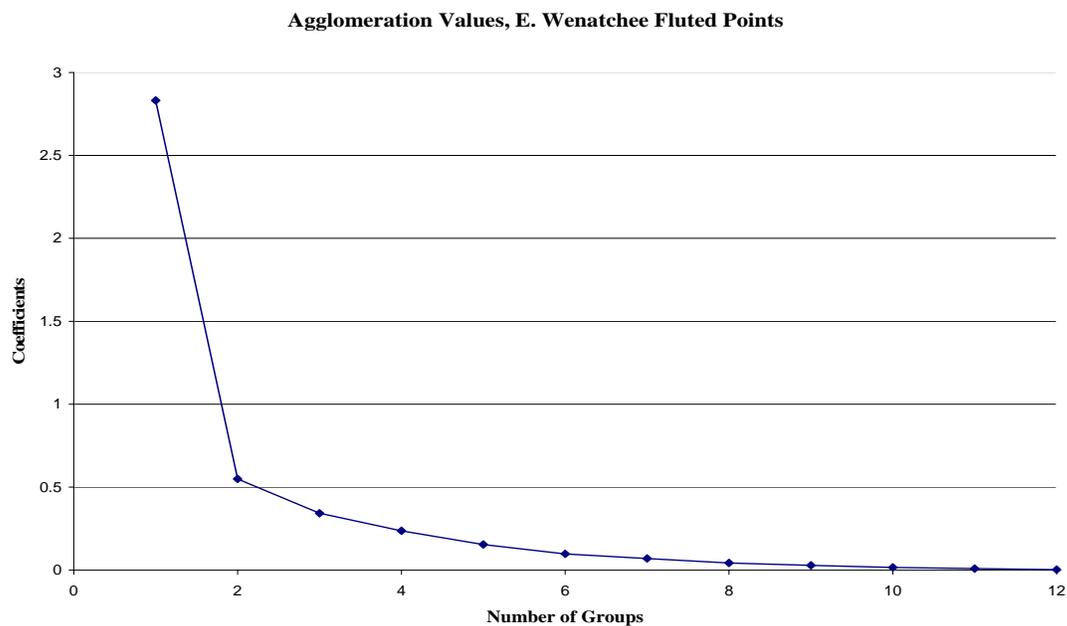


Figure 9: Graph that displays possible size cluster arrangements for East Wenatchee fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

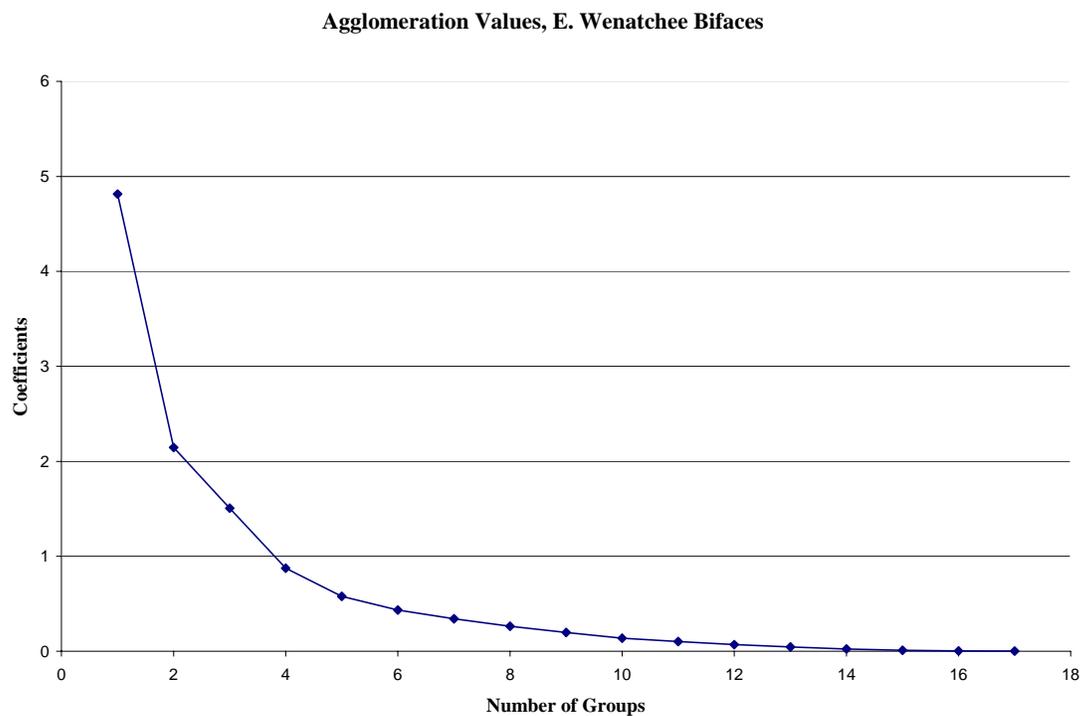


Figure 10: Graph that displays possible size cluster arrangements for East Wenatchee bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

The East Wenatchee cache consists of only six valid blades that can be applied to a cluster analysis. Similar to bifaces, variables for blades consist of maximum length, maximum width, maximum thickness, weight, and  $(L*W*T)/1000$ . The blades cluster into two groups, one with four members, and the other with two (Figure 11). However, the small sample size calls the validity of these clusters into question.

The twelve bone rods from the East Wenatchee cache are also analyzed based on maximum length, maximum width, maximum thickness, weight, and  $(L*W*T)/1000$ . They cluster easily into three groups, although one group is made up of only one anomalous bone rod (WSHS #1992.24.47), probably the same outlier that appears in the descriptive statistics (Figure 12).

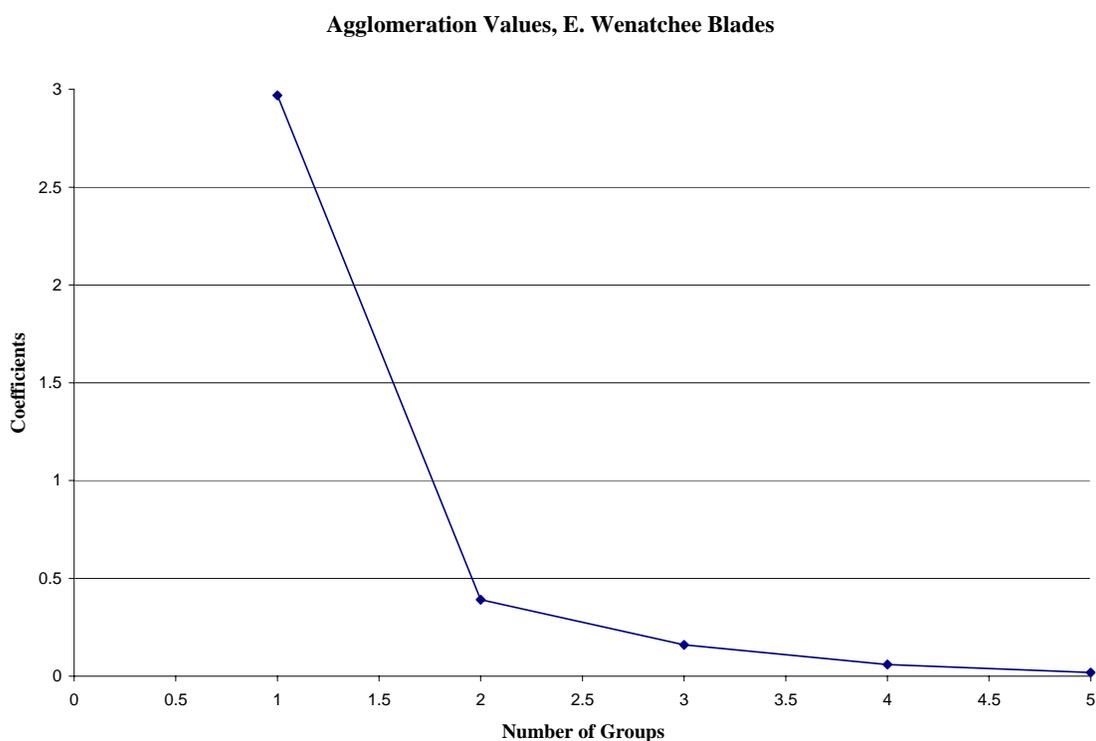


Figure 11: Graph that displays possible size cluster arrangements for East Wenatchee blades. The group number with the steepest change in slope indicates the optimal number of clusters.

### Agglomeration Values, E. Wenatchee Bone Rods

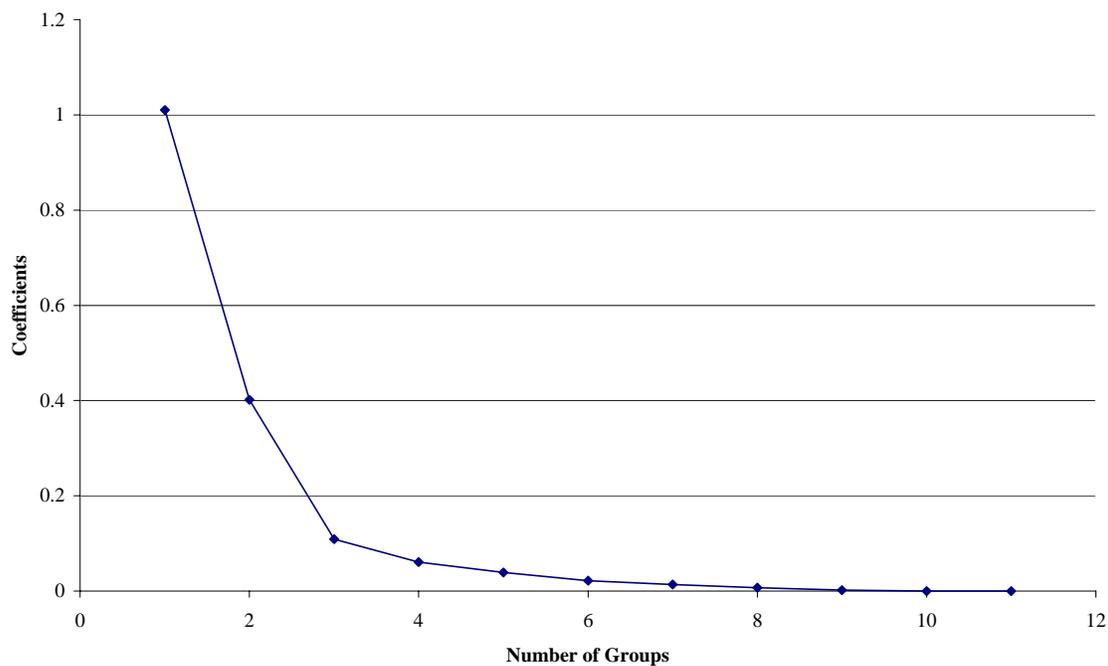


Figure 12: Graph that displays possible size cluster arrangements for East Wenatchee bone rods. The group number with the steepest change in slope indicates the optimal number of clusters.

### *Anzick*

The Anzick cache contains basically the same artifact types as East Wenatchee (minus the blades), but Anzick has a much greater number of bifaces with fewer fluted points and bone rods.<sup>1</sup>

The seven fluted points from the Anzick cache can be analyzed using the same size variables as those from East Wenatchee: maximum length, mid-length width, maximum thickness, maximum basal depth, weight, and  $(L*W*T)/1000$ . Unlike the East Wenatchee fluted points, the Anzick analysis reveals four subtle clusters (Figure 13). The small sample size probably plays a role in the lack of more obvious clusters.

<sup>1</sup>Because the East Wenatchee site has not been fully excavated, comparisons of artifact counts with other caches are tentative.

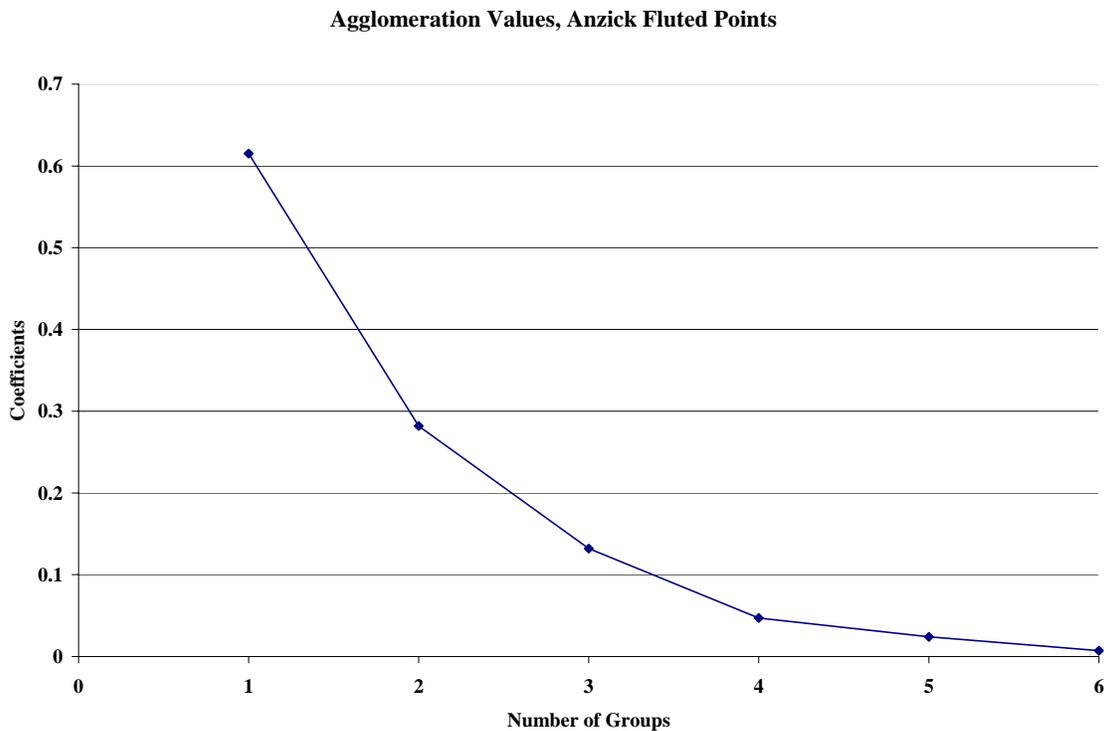


Figure 13: Graph that displays possible size cluster arrangements for Anzick fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

The 63 measurable bifaces from the Anzick cache provide a much larger sample for a cluster analysis. The size variables used in this cluster analysis include maximum length, mid-length width, maximum thickness, weight, and  $(L*W*T)/1000$ . The coefficients on the agglomeration table indicate that the Anzick bifaces form six clusters based on size (Figure 14). The results are comparable to the four clusters from the East Wenatchee bifaces, given that Anzick has a considerably larger sample size.

Generating size clusters for the bone rods from Anzick faces the same problem as the fluted points and the flakes: only seven bone rods belong to the Anzick assemblage. The size variables for the bone rods include maximum length, maximum width, thickness, weight, and  $(L*W*T)/1000$ . As expected, the analysis suggests only two clusters, with any further separation being indistinct (Figure 15). The results may

compare to the bone rod clusters from East Wenatchee, excluding East Wenatchee's anomalous bone rod outlier. However, the Anzick bone rod clusters are more likely arbitrary.

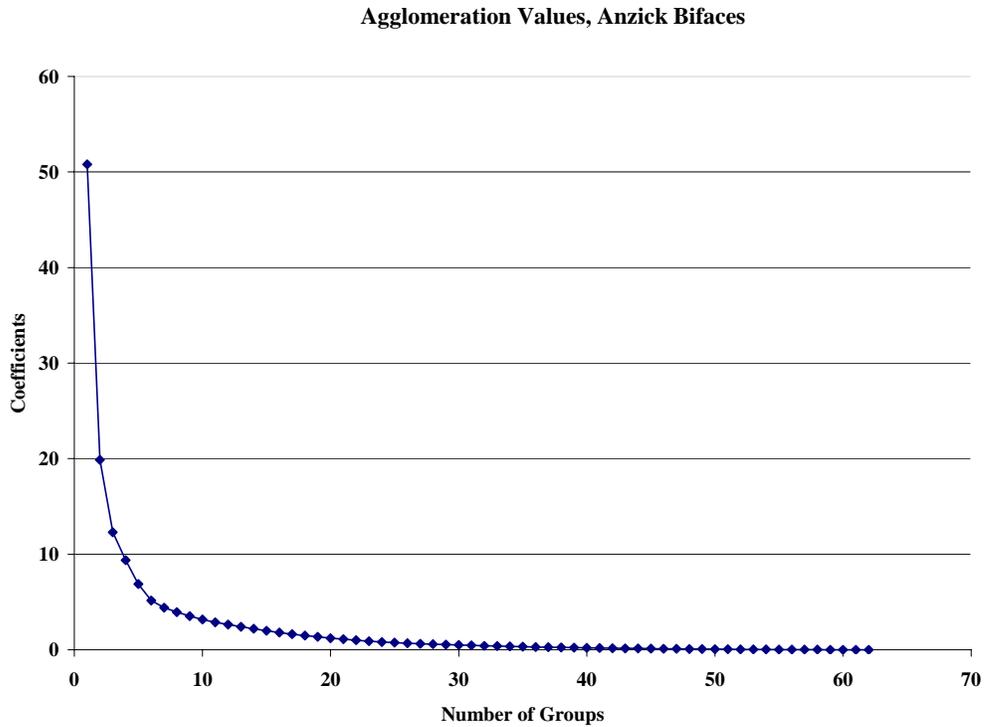


Figure 14: Graph that displays possible size cluster arrangements for Anzick bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

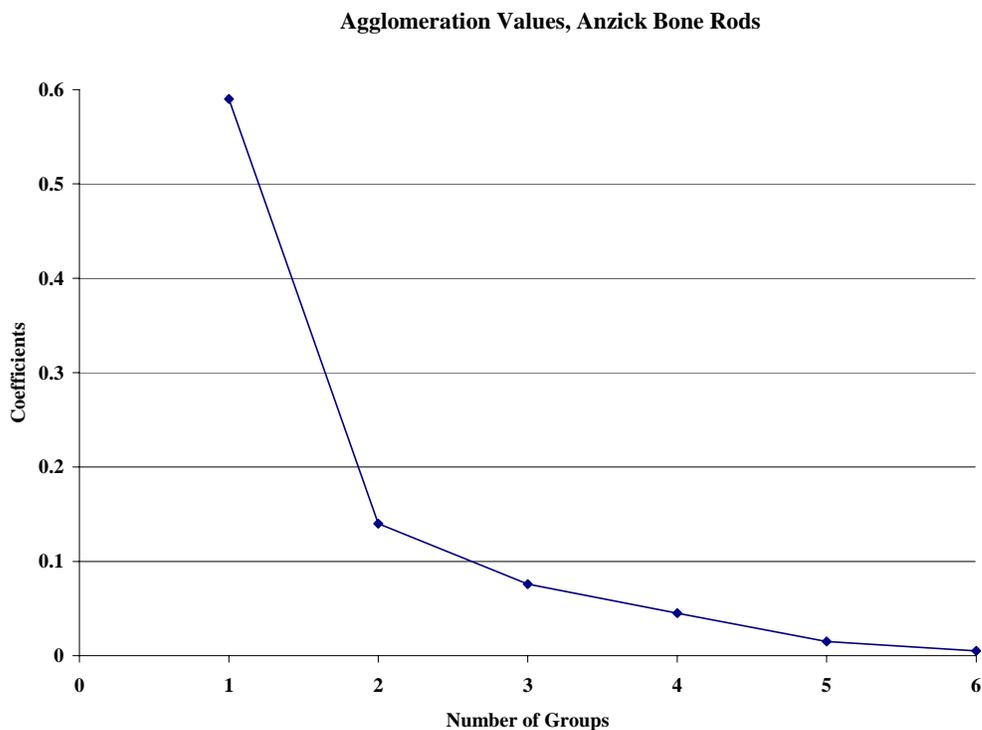


Figure 15: Graph that displays possible size cluster arrangements for Anzick bone rods. The group number with the steepest change in slope indicates the optimal number of clusters.

### *Simon*

Unlike East Wenatchee and Anzick, the Simon cache consists entirely of fluted points and bifaces. The cache is similar to Anzick though, in that the fluted points are underrepresented compared to the bifaces. The Simon cache contains 28 bifaces but only five fluted points.

The cluster analysis for the fluted points based on size suggests that two clusters exist (Figure 16). Illustrations of the points also portray two distinct size groups. Kohntopp's (2001) thesis does not include as many measurement variables as the sources for the East Wenatchee and Anzick fluted points, so the cluster analysis may be less

accurate. Kohntopp's measurements include maximum length, width, thickness, and  $(L*W*T)/1000$ , but not weight.

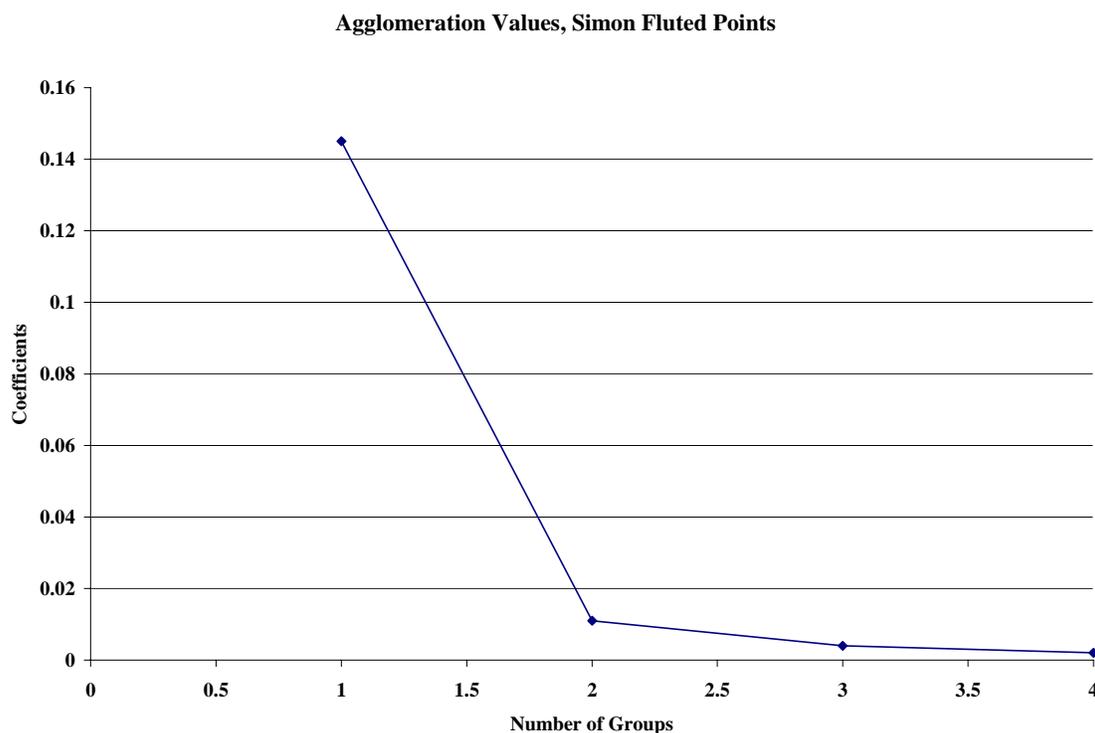


Figure 16: Graph that displays possible size cluster arrangements for Simon fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

The bifaces from the Simon cache are much more numerous, with 26 measurable specimens and 28 in total. Using the same variables as the fluted points, the size analysis divides the bifaces into six clusters (Figure 17). The Simon bifaces are neatly grouped according to the agglomeration table, so the six size clusters appear to be valid.

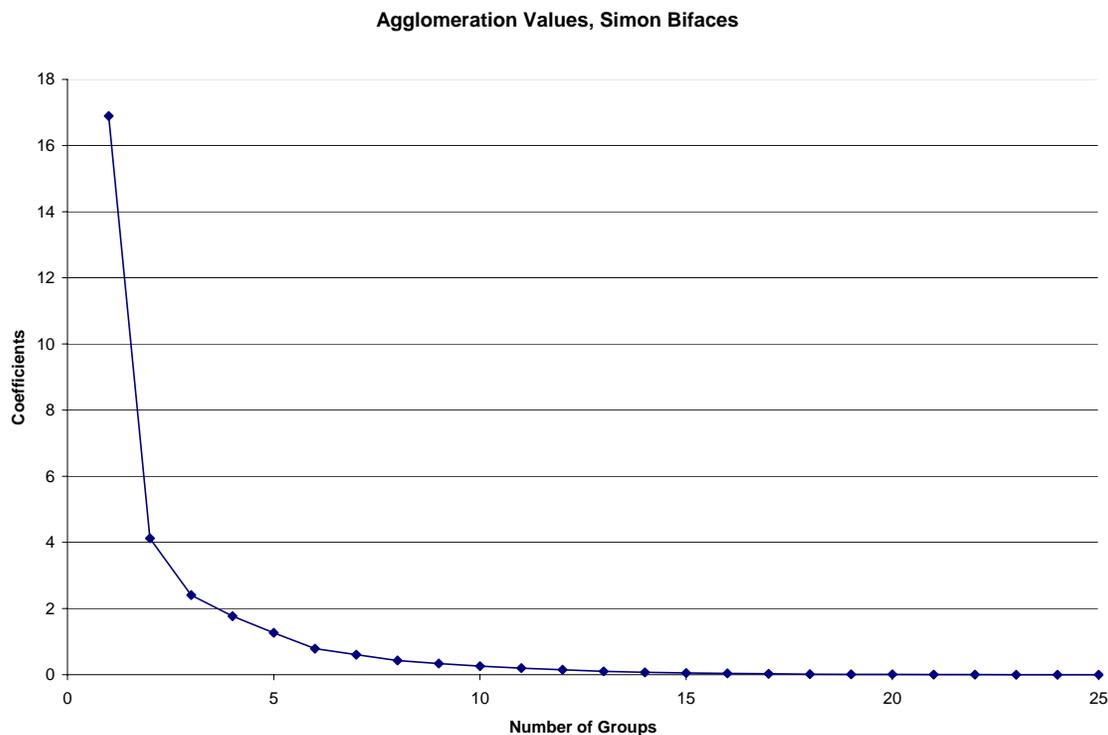


Figure 17: Graph that displays possible size cluster arrangements for Simon bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

### *Fenn*

Similar to the Simon cache, the Fenn cache is primarily made up of fluted points and bifaces. However, unlike the Simon cache, Fenn contains nearly as many fluted points as bifaces. Therefore, a comparison between clusters among fluted points and bifaces within one cache is possible. The variables used in both artifact types include maximum length, width, thickness, weight, and  $(L*W*T)/1000$ .

All 21 fluted points from the Fenn cache have valid measurements for cluster analyses. The results indicate that four size clusters are present in the fluted points (Figure 18). However, two clusters make up the bulk of the fluted points; while the next only has two members, and the last cluster is a single outlying fluted point.

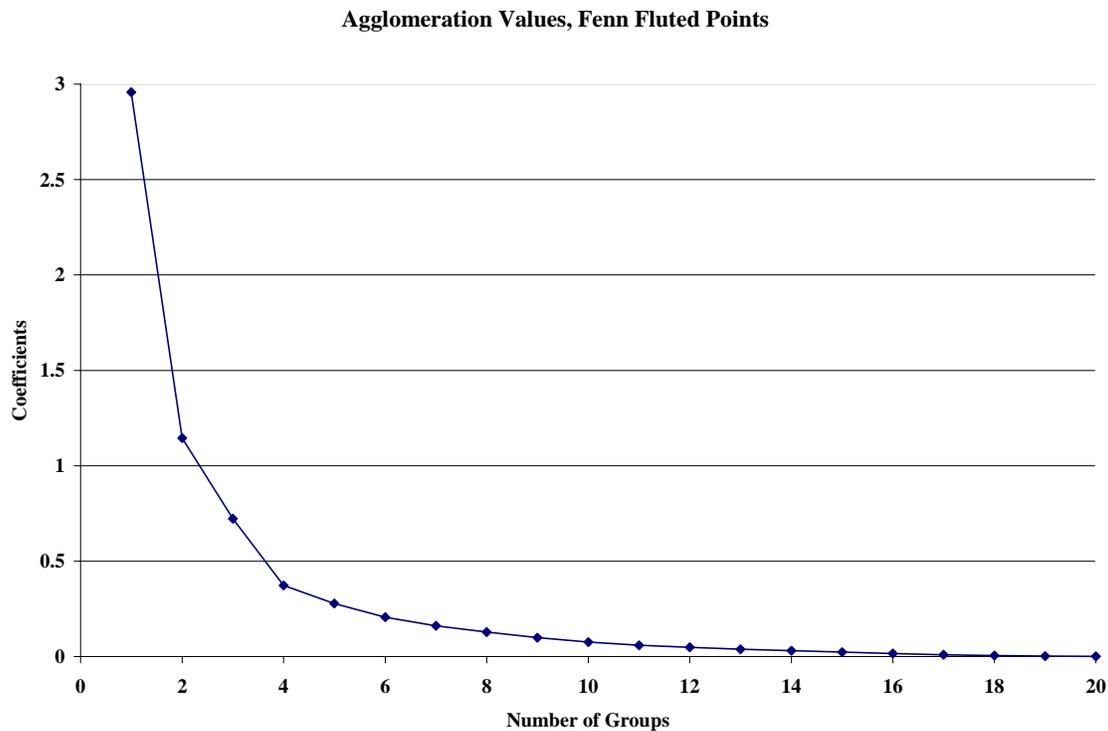


Figure 18: Graph that displays possible size cluster arrangements for Fenn fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

The 33 bifaces from the Fenn cache do not cluster as specifically as the fluted points, but the analysis shows that four size clusters appear to be present (Figure 19). Because they are usually the most numerous artifacts in a cache site, bifaces tend to form the most clusters. However, the Fenn cache shows that fluted points can form as many size clusters given a high sample size.

### Agglomeration Values, Fenn Bifaces

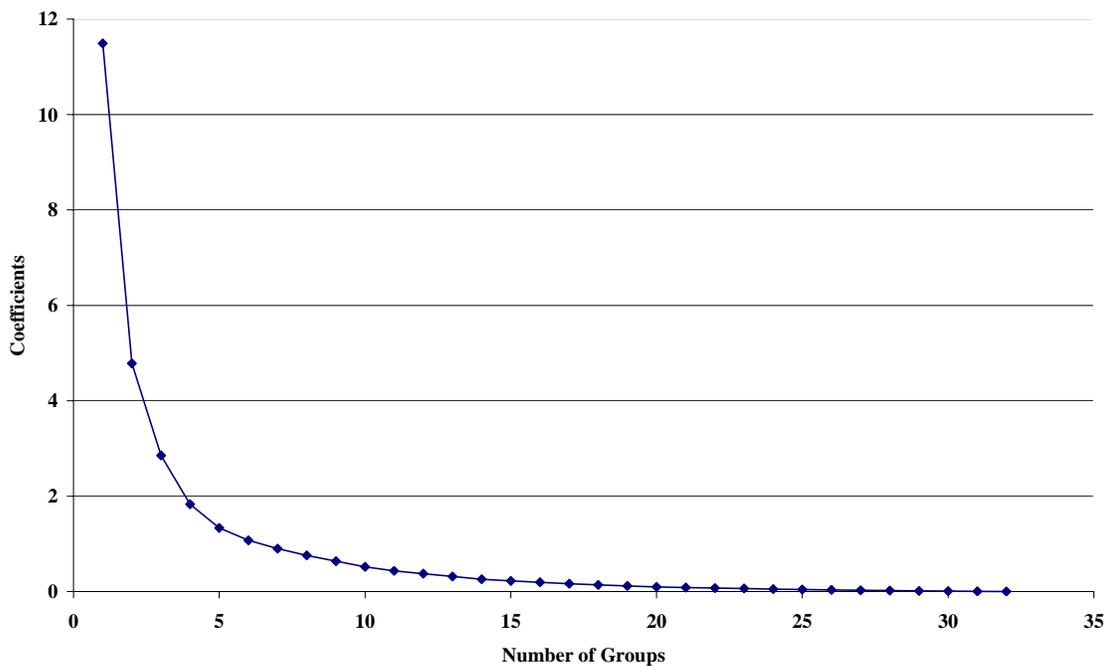


Figure 19: Graph that displays possible size cluster arrangements for Fenn bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

### *Cluster Analyses for Size – All Sites*

An overall cluster analysis of artifact totals for each type provides an understanding of the general trends within the data set. The hypothesis is that the artifact types form size clusters that are divided by site. This hypothesis would suggest that although each cache utilizes the same “Clovis” technology, the differences in size indicate differences in caching purpose, cultural preferences, raw material utilization, and/or flintknapping skills.

Fluted points are the most potentially useful indicators of differences among caches, as they represent the finished form of a meticulously created stone tool. The drawback to the fluted points is that not every cache has the same sample size. East

Wenatchee and Fenn have relatively large samples compared to the sparseness of fluted points from Anzick and Simon.

The 47 valid fluted points fall into three obvious size clusters (Figures 20 and 21). The East Wenatchee points tend to cluster together almost exclusively, which is expected due to their excessively large size. Another cluster consists mostly of Fenn and Anzick points, and the third is a combination of all caches (although Fenn is underrepresented).

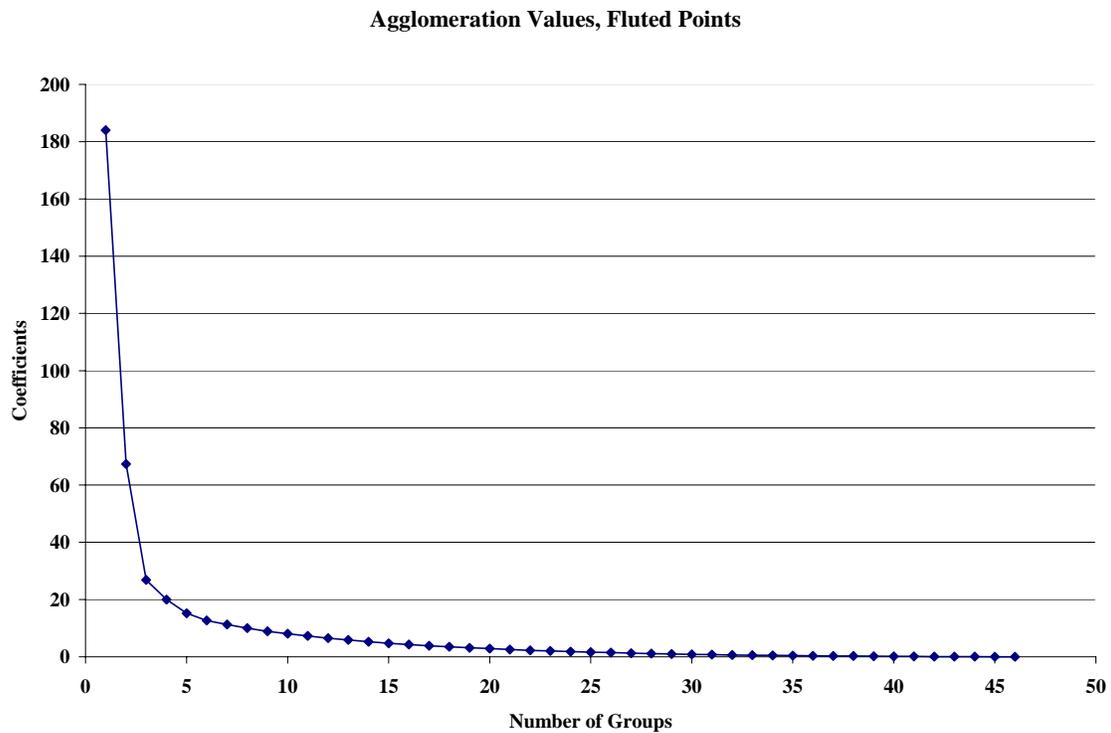


Figure 20: Graph that displays possible size cluster arrangements for all fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.



The next artifact type that can be measured in a total size cluster analysis is bifaces. Although bifaces have much more variation in their measurements than fluted points, they are ubiquitous in every cache site. Their constant presence and large sample size makes bifaces ideal for statistical analyses.

The bifaces form seven clusters, based on the agglomeration values (Figures 22 and 23). However, two of these clusters are particularly small considering the sample size of 141 valid artifacts. One cluster is made up of four bifaces (two from Simon and two from Fenn) and the other cluster consists of one solitary biface from the Simon cache. The other clusters generally divide between Anzick and Fenn, although some overlap is present.

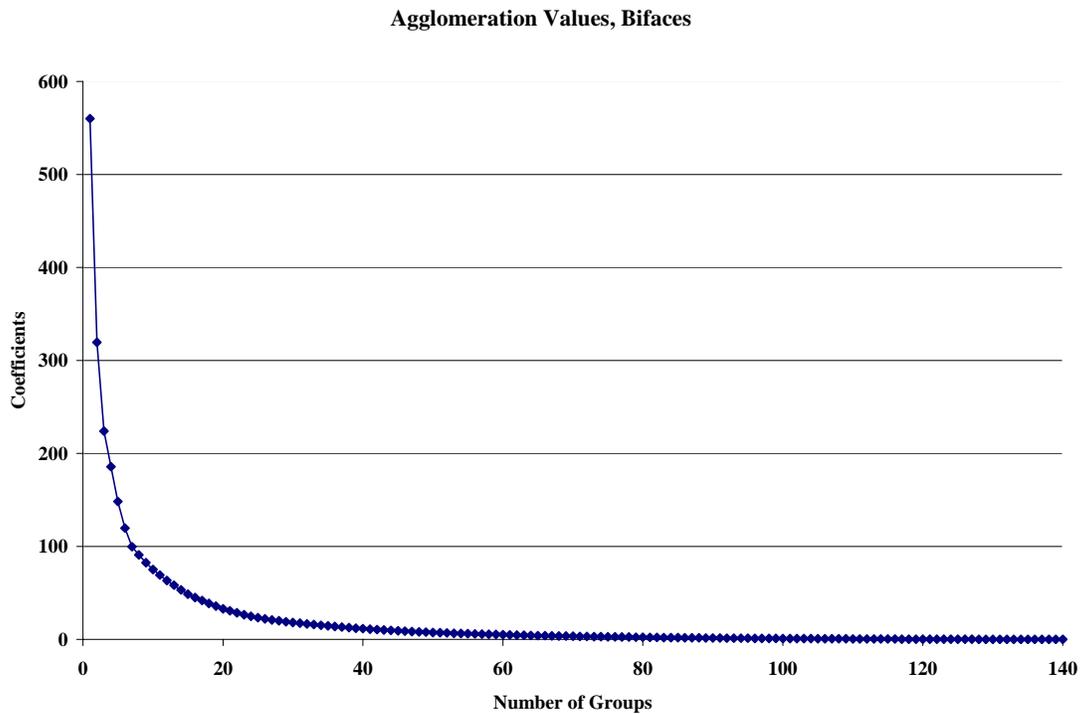


Figure 22: Graph that displays possible size cluster arrangements for all bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

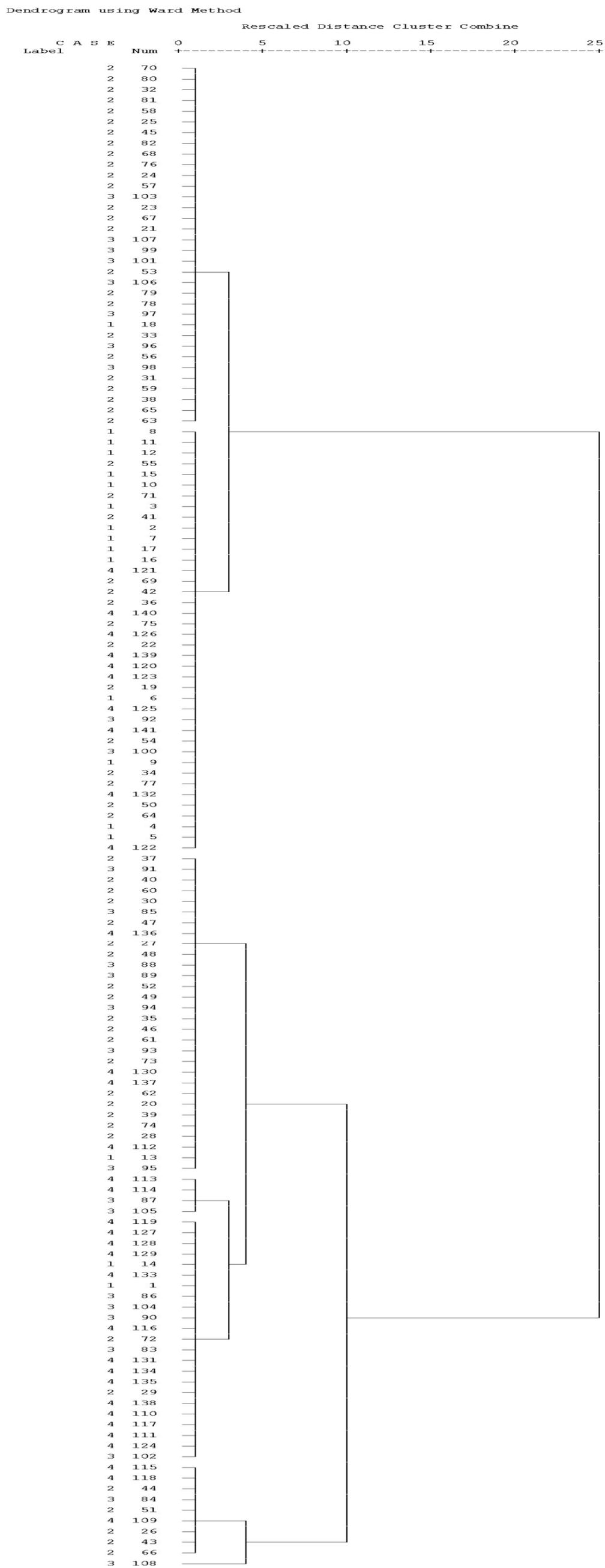


Figure 23: Dendrogram displaying the results of the size cluster analysis for all bifaces. 1=East Wenatchee, 2=Anzick, 3=Simon, and 4=Fenn.

Bone rods are not represented in every cache, but their presence shows a vital aspect of Clovis technology. Therefore, the rods from the East Wenatchee and Anzick caches deserve to be studied in a cluster analysis. The bone rods form three or four size clusters based on the agglomeration values and dendrogram (Figures 24 and 25). The most notable aspect of these clusters, however, is that they are divided almost perfectly by site. The only exception is the East Wenatchee outlier, which is more closely related to the Anzick rods than to those from its own cache.

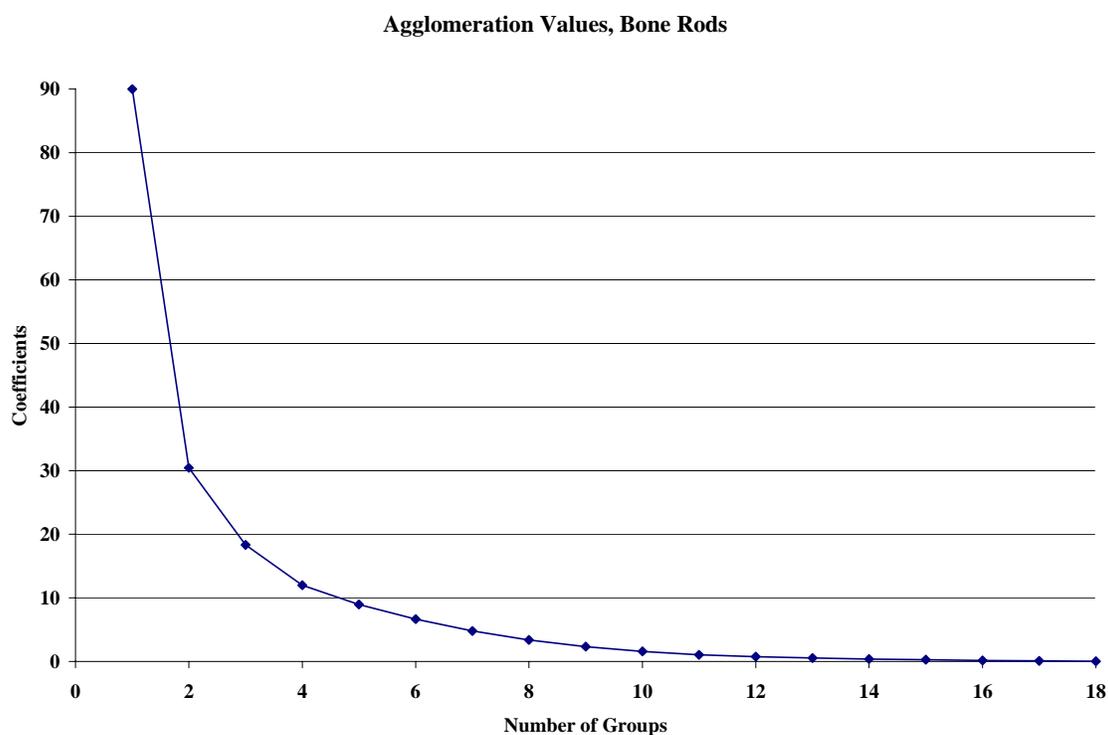


Figure 24: Graph that displays possible size cluster arrangements for all bone rods. The group number with the steepest change in slope indicates the optimal number of clusters.

## Dendrogram using Ward Method

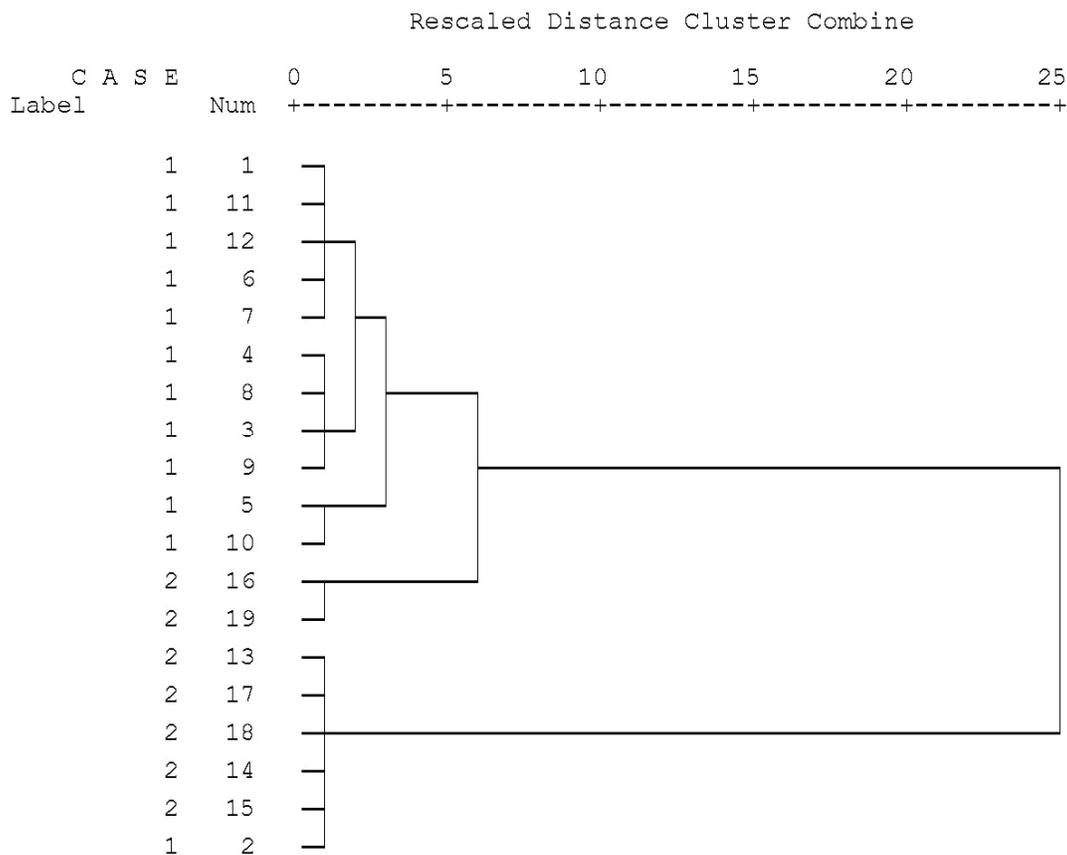


Figure 25: Dendrogram displaying the results of the size cluster analysis for all bone rods. 1=East Wenatchee and 2=Anzick.

### *Conclusions on the Cluster Analyses for Size*

The size analyses on artifacts from individual sites are often fraught with problems of sample size. With the exception of the Fenn fluted points, bifaces are the only reliable artifact type for performing site-specific size analyses. Based on the biface data, each site tends to have five or six size clusters.

The overall cluster analysis for artifact size suggests that certain caches tend to dominate certain artifact types. For fluted points, the East Wenatchee specimens stand

out in particular. For bifaces, the artifacts tend to cluster around either the Anzick or Fenn assemblages. Bone rods are distinctly divided according to site, but the fact that they are only present in two of the caches precludes any further conclusions.

### Cluster Analyses Based on Shape

Although the same SPSS procedures can perform the cluster analyses on shape variables as they did on size, selecting the appropriate variables to determine shape is a challenge within itself. The factor analysis shows that length, width, thickness, and  $(L*W*T)/1000$  are consistently useful in determining size for all artifact types. However, the variables that determine shape vary according to artifact type. Moreover, some artifact types have a more defined shape component without rotation, while others must be rotated before the shape variables stand out. As such, each artifact type from each site is analyzed according to the shape component, but the shape component is defined differently for each type.

#### *East Wenatchee*

To analyze the shape of the fluted points from each Wenatchee, the width/thickness ratio, length/width ratio, and thickness are the selected variables. No rotation was necessary for the selection of these variables. Unlike the cluster analysis for the size of East Wenatchee's fluted points, the shape analysis does not provide a definitive number of clusters. A wide variety of clustering possibilities seem possible

when analyzing their shape (Figure 26). Unfortunately, the lack of an obvious cutoff point prevents the determination of an appropriate number of clusters.

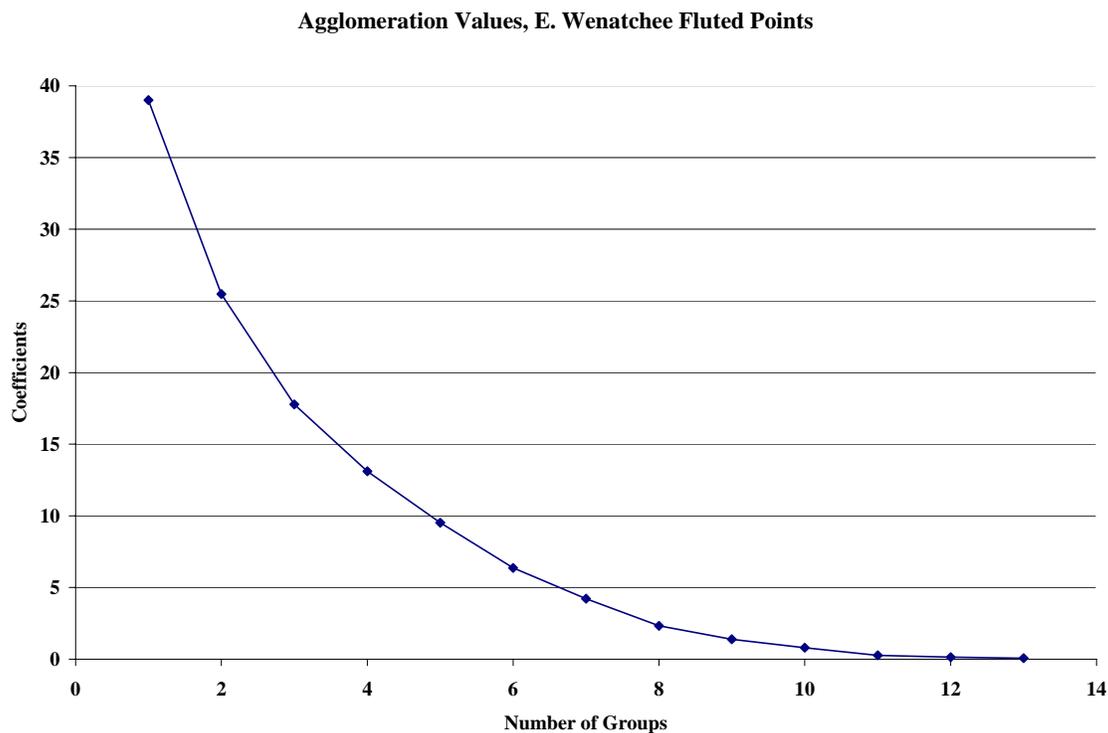


Figure 26: Graph that displays possible shape cluster arrangements for East Wenatchee fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

The bifaces from East Wenatchee utilize the same variables as the fluted points, just in a different order: length/width ratio, width/thickness ratio, and thickness. The components were not rotated to determine these shape variables. The East Wenatchee bifaces cluster much more easily than the fluted points and reveal five shape clusters (Figure 27). These shape clusters are similar to, but not exactly the same as, the five biface size clusters. For example, one noticeable outlier appears in the shape analysis,

WSHS #1992.24.38. The same biface was not segregated to such a degree in the size analysis.

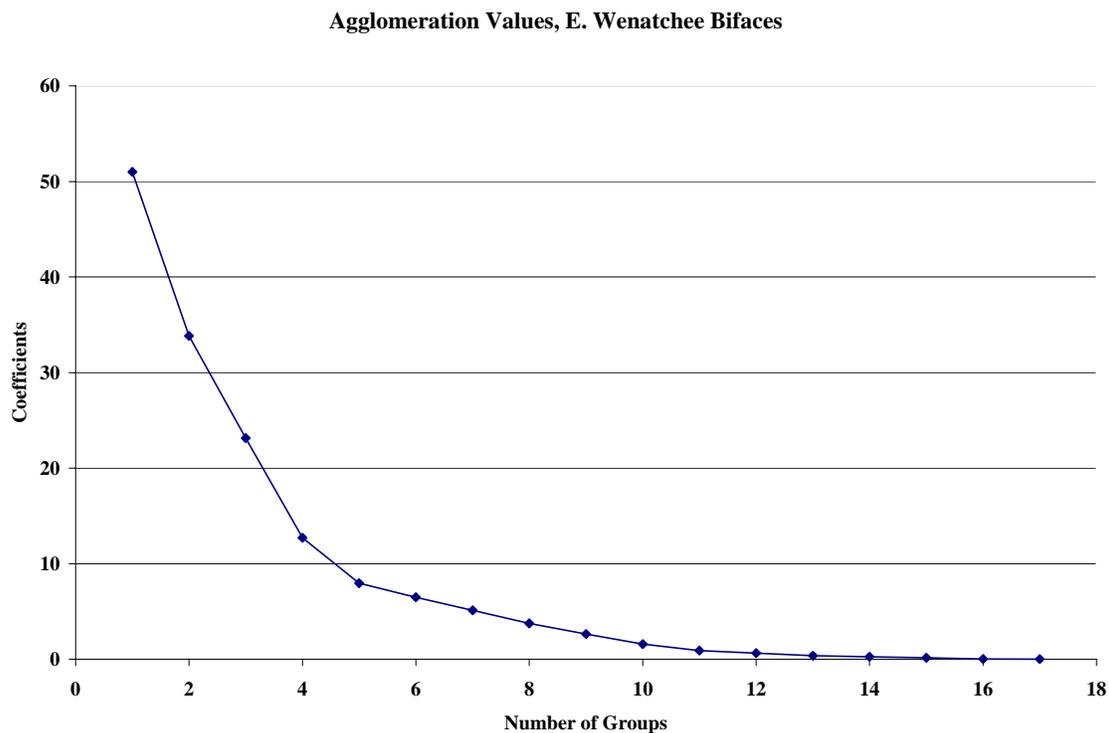


Figure 27: Graph that displays possible shape cluster arrangements for East Wenatchee bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

The blades from East Wenatchee are one of two artifact types that require rotation for the factor analysis results to be interpretable. The variables used in clustering the blade data for shape are length/width ratio, width/thickness ratio, and length. The blades cluster very differently for shape than for size. While size appears to have no blade clusters, shape has four (Figure 28). Of course, the tiny sample size fails to verify these clusters.

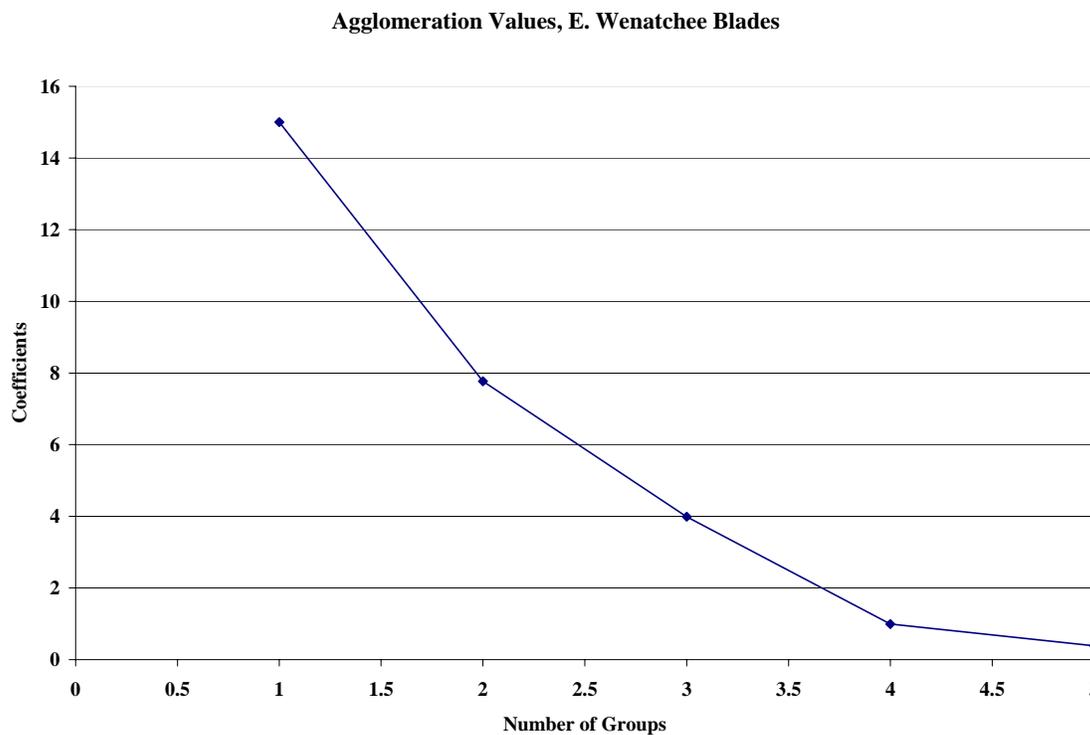


Figure 28: Graph that displays possible shape cluster arrangements for East Wenatchee blades. The group number with the steepest change in slope indicates the optimal number of clusters.

The bone rod components did not need to be rotated for their shape analysis. The variables used to determine shape in bone rods are width/thickness ratio, length/width ratio, and width. The bone rods form four clusters, but they are not as well defined as the three size clusters (Figure 29). The outlier does not have as large an effect on the shape data.

### Agglomeration Values, E. Wenatchee Bone Rods

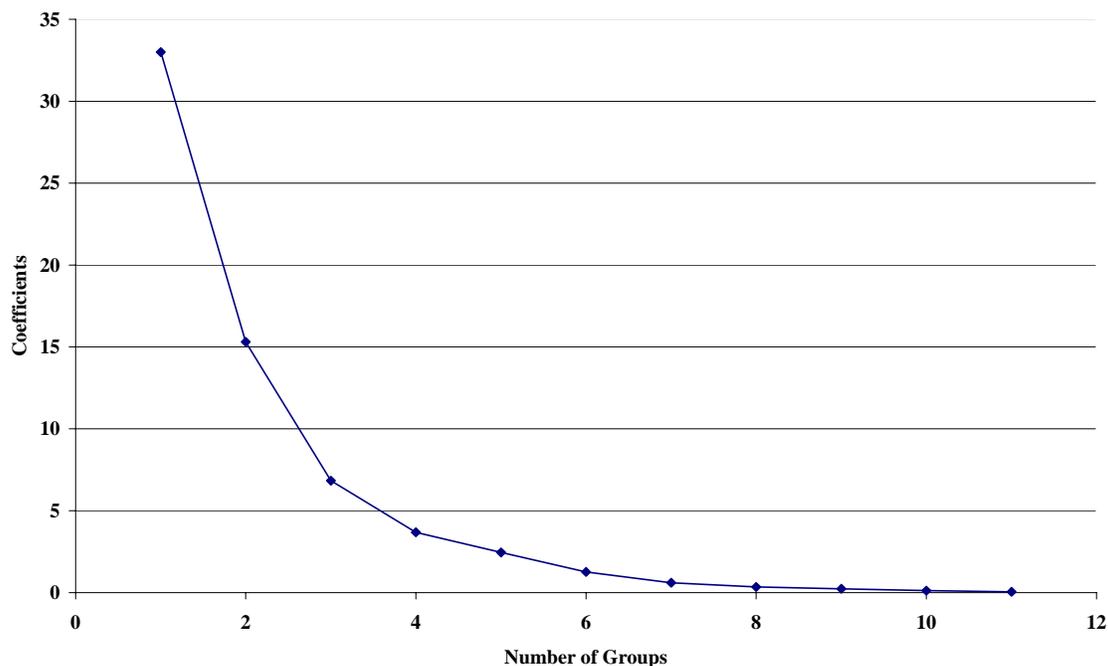


Figure 29: Graph that displays possible shape cluster arrangements for East Wenatchee bone rods. The group number with the steepest change in slope indicates the optimal number of clusters.

### *Anzick*

The fluted points from the Anzick cache are not numerous, but they do form about four clusters (Figure 30). The results are remarkably similar to the size analysis.

Anzick's bifaces are the most numerous of any artifact type from any cache, so these data are a useful tool for examining the difference between the size and shape of these artifacts. The data reveal five shape clusters for the Anzick bifaces, which is similar to but not quite the same as the size analysis (Figure 31). The change in the agglomeration values is more subtle for shape.

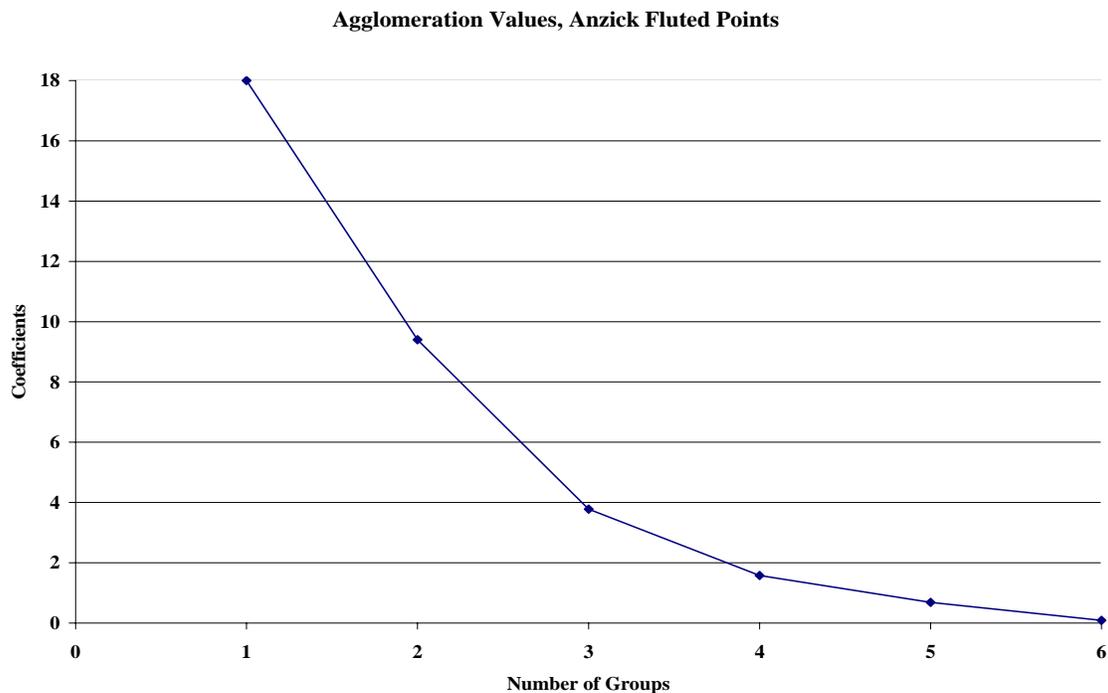


Figure 30: Graph that displays possible shape cluster arrangements for Anzick fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

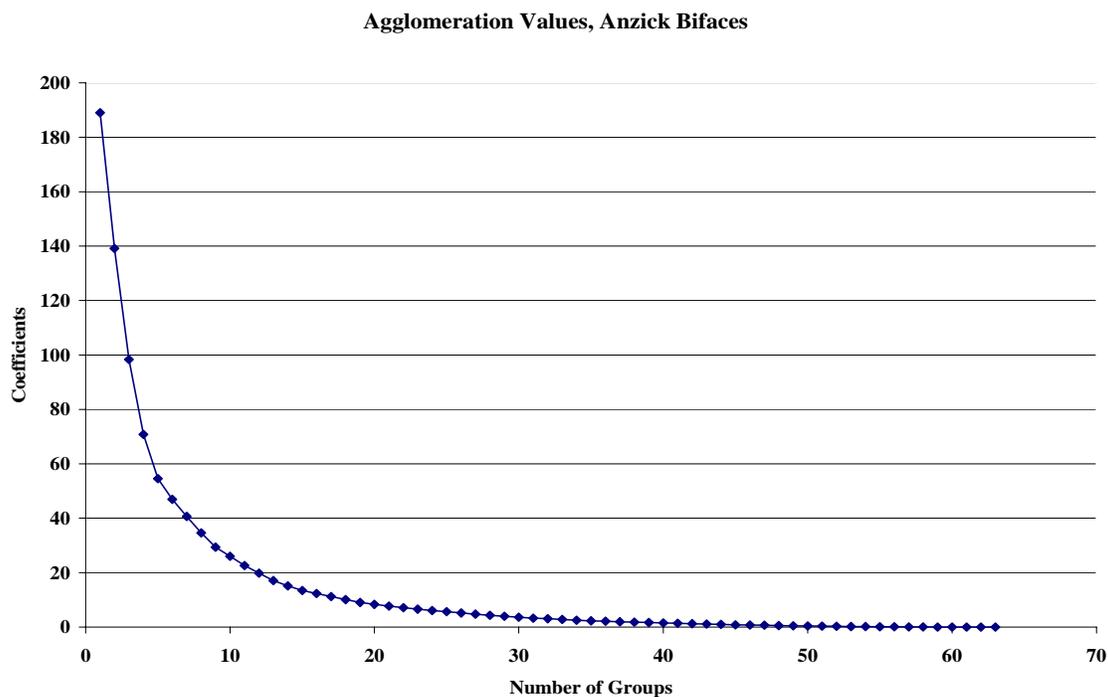


Figure 31: Graph that displays possible shape cluster arrangements for Anzick bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

Bone rods from Anzick are less numerous and smaller than those from East Wenatchee, but their shape analysis reveals two possible clusters among them (Figure 32). The bone rods seem to cluster similarly among themselves in both Anzick and East Wenatchee. These shape results are also the same as the size data for Anzick's bone rods.

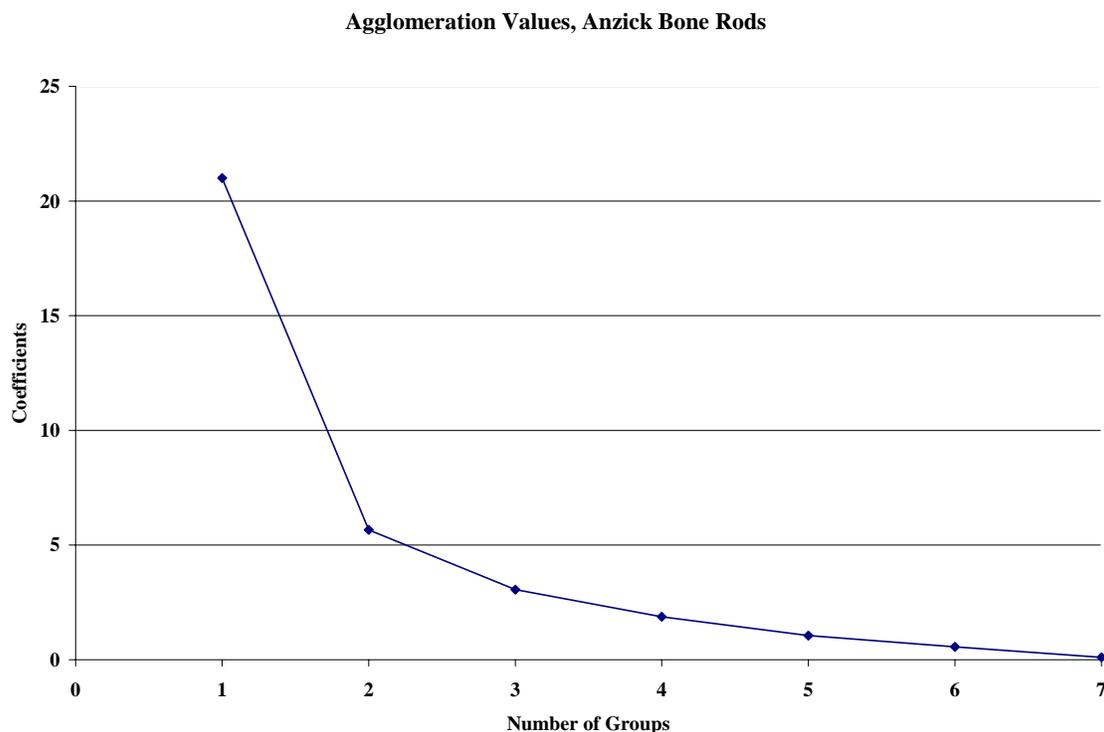


Figure 32: Graph that displays possible shape cluster arrangements for Anzick bone rods. The group number with the steepest change in slope indicates the optimal number of clusters.

### *Simon*

The fluted points from Simon have the smallest sample size for this artifact type, but they appear to form three shape clusters (Figure 33). These results are quite different

from the fluted points' size analysis, which reveals no significant clusters. However, the sample size probably makes this distinction appear more dramatic than it actually is.

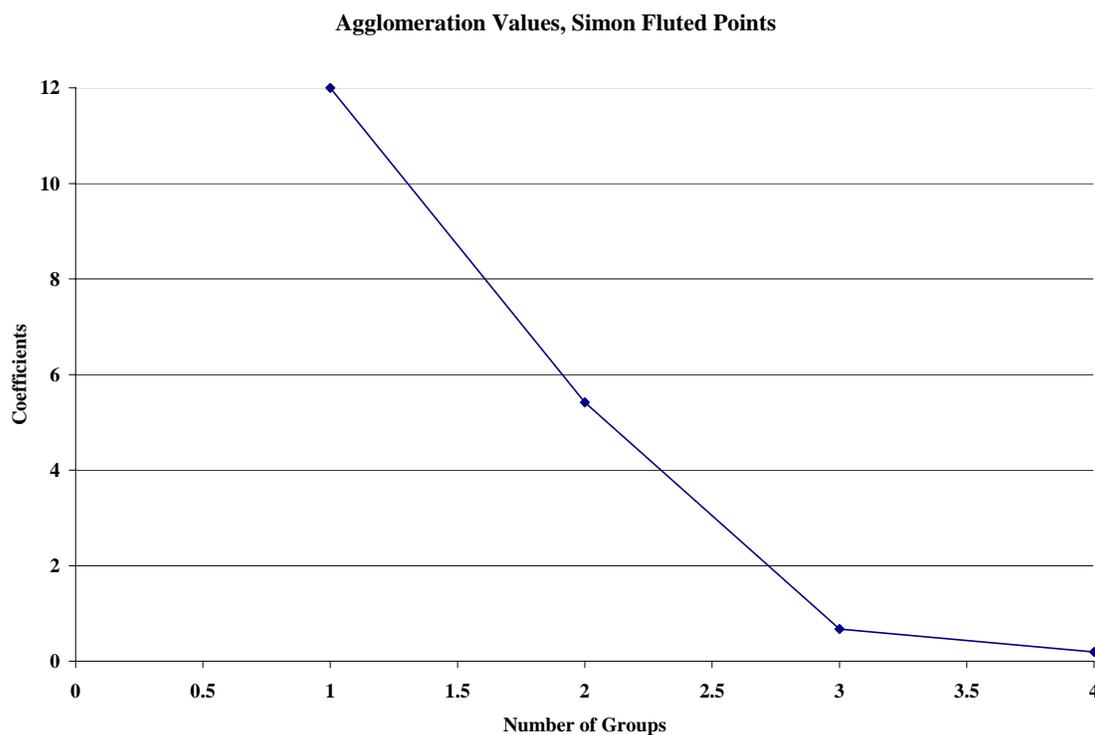


Figure 33: Graph that displays possible shape cluster arrangements for Simon fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

The bifaces from the Simon cache are much more numerous and can be used to check the results of the shape analysis of the fluted points. The cluster analysis for shape reveals a gently sloping agglomeration curve, with four clusters being the best cutoff point (Figure 34). The size analysis reveals six clusters for the Simon bifaces.

Interestingly, these results are counter to those implied by the fluted point assemblage.

The fluted points seem to be homogenous in size but more varied in shape, but the bifaces have more size clusters than shape clusters. Because the Simon cache has been

interpreted as a collection of artifacts from all stages of bifacial reduction (Kohntopp 2001), the bifaces are likely to be more varied in size than in shape.

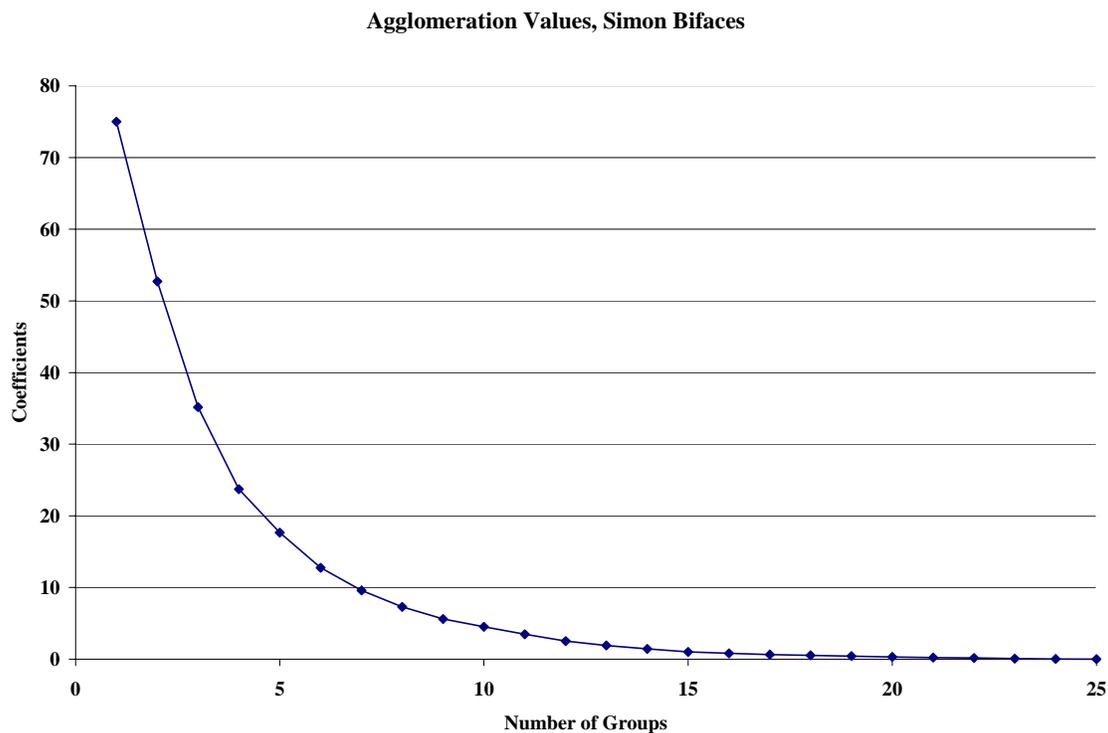


Figure 34: Graph that displays possible shape cluster arrangements for Simon bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

### *Fenn*

The numerous fluted points from the Fenn cache make it an excellent collection for comparing the size and shape differences for Clovis points within one site. Similar to the size clusters, the shape analysis for the Fenn fluted points yields four clusters (Figure 35). These clusters are more evenly dispersed than the size analysis, although one cluster is made up of only one aberrant point.

The shape analysis for the Fenn bifaces is open to interpretation. A lumpner would suggest that three clusters are present, while a splitter may say there are five (Figure 36). Regardless of the specific interpretation of the data, the number of shape clusters is comparable to the number of size clusters for the same artifacts. The shape clusters are less neatly divided, however.

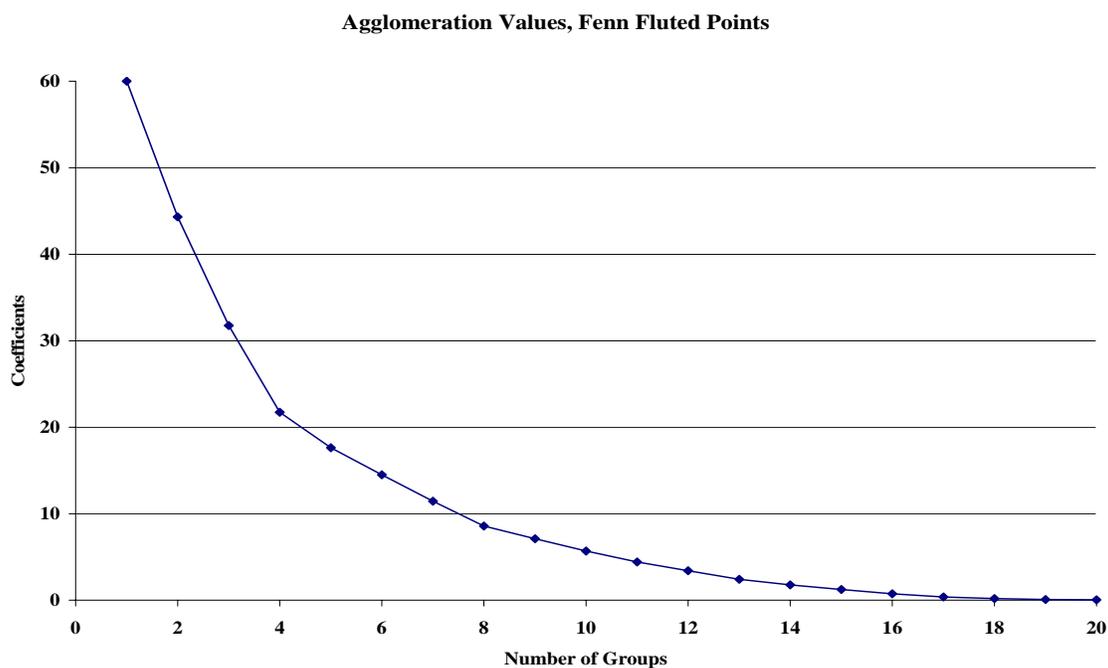


Figure 35: Graph that displays possible shape cluster arrangements for Fenn fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

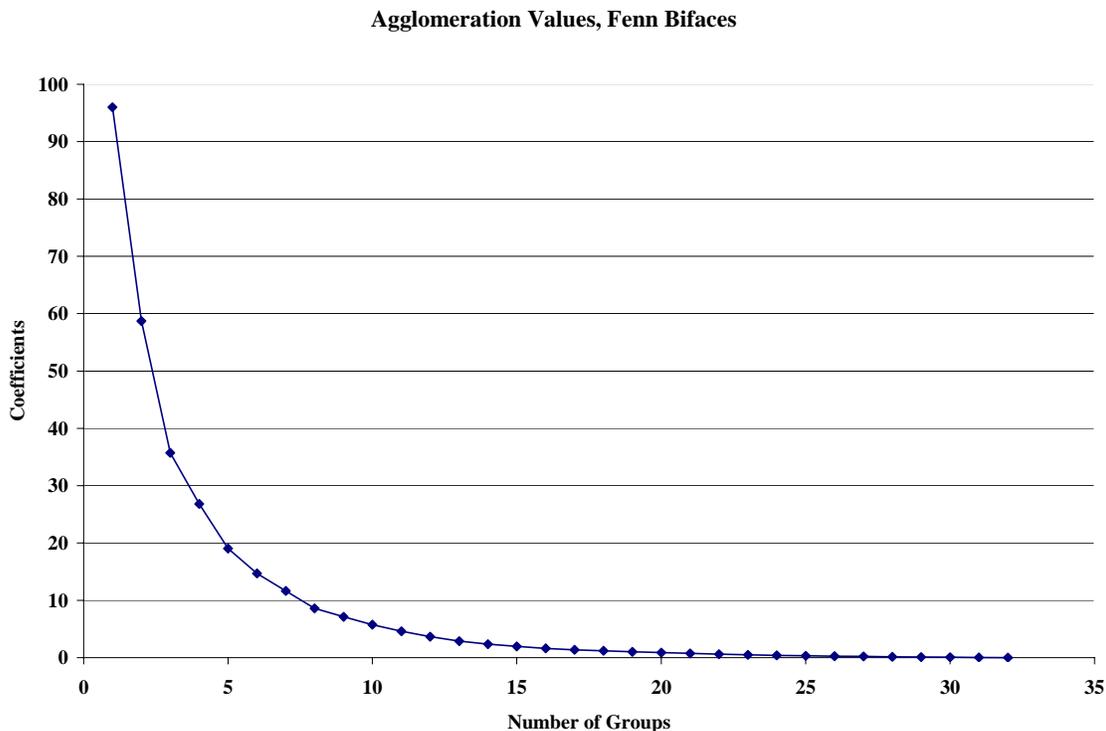


Figure 36: Graph that displays possible shape cluster arrangements for Fenn bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

#### *Cluster Analyses for Shape – All Sites*

While a site-by-site distinction appears to be valid in terms of artifact size, the question remains as to whether this interpretation holds true for artifacts' shapes. Among fluted points and bone rods, shape seems to be a defining factor, so hypothetical clusters for the shape of these artifacts should not be divided by site. Bifaces, on the other hand, should exhibit more variability. If bifaces cluster by shape according to their respective sites, it could imply that the toolmakers for each cache utilized different reduction strategies to arrive at similar technological results.

Fluted points fall into about four clusters for shape, although the cutoff point for determining the number of clusters is not certain (Figures 37 and 38). Given that four

clusters are present, the first two show a dominance of fluted points from the Fenn cache, while the last two are dominated by the East Wenatchee points. The Anzick and Simon points, being smaller in number, are more difficult to determine. The trend appears to be that the shape of the Anzick points corresponds more closely to the Fenn clusters, and the Simon points' shapes are more related to the East Wenatchee clusters.

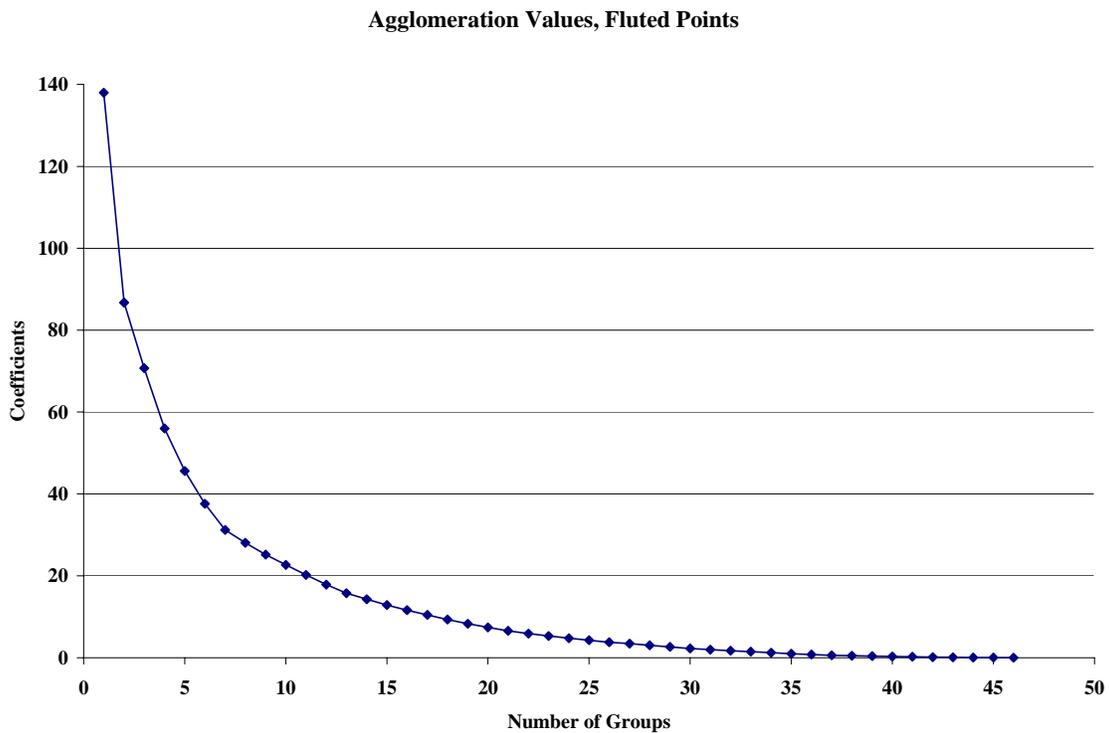


Figure 37: Graph that displays possible shape cluster arrangements for all fluted points. The group number with the steepest change in slope indicates the optimal number of clusters.

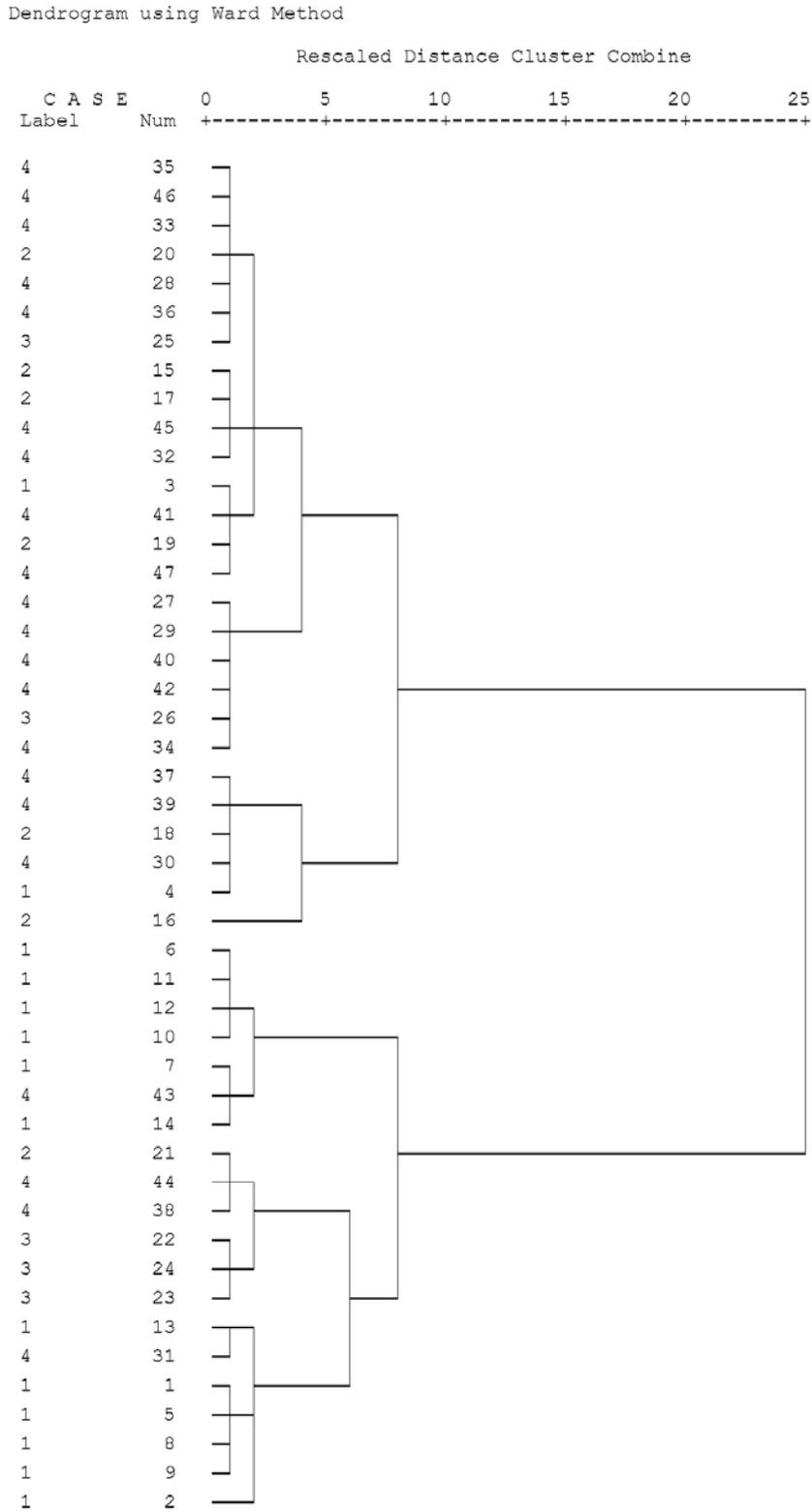


Figure 38: Dendrogram displaying the results of the shape cluster analysis for all fluted points. 1=East Wenatchee, 2=Anzick, 3=Simon, and 4=Fenn.

Being more numerous and statistically variable, bifaces may either elucidate or confuse the data from the analysis of fluted point shape. The biface data yield as many as nine clusters, making the analysis much more complicated than for the fluted points (Figures 39 and 40). The biface shape data do not seem to cluster according to site, although several bifaces from the Fenn cache do cluster closely together.

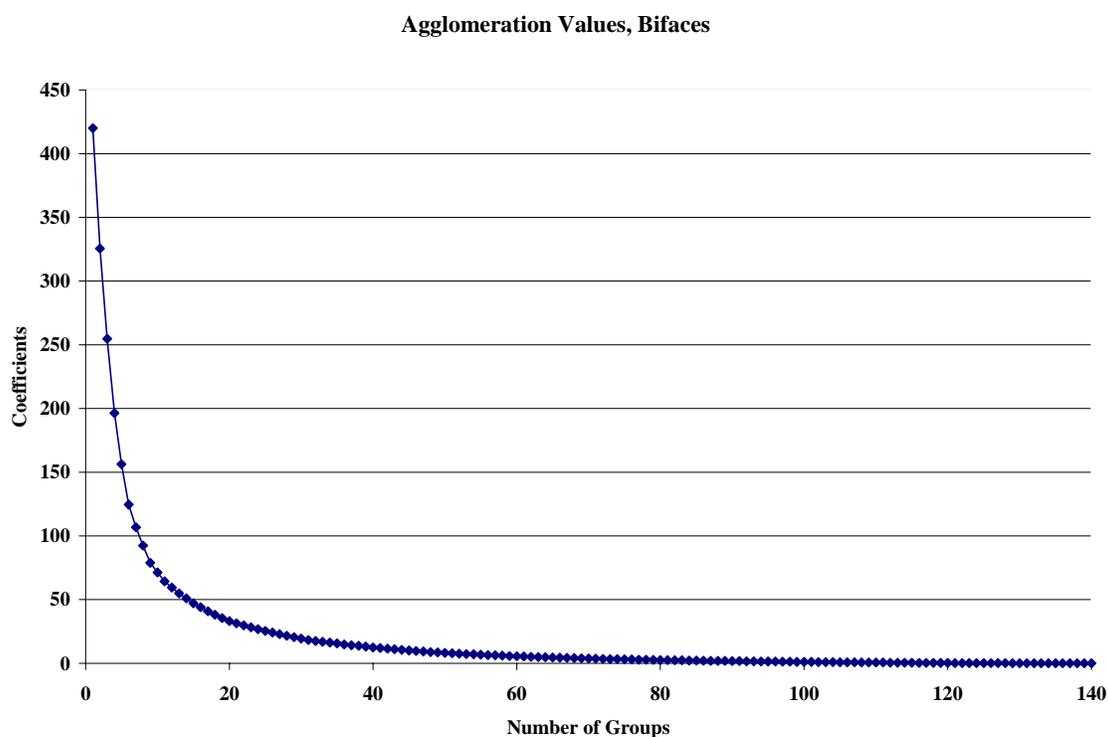


Figure 39: Graph that displays possible shape cluster arrangements for all bifaces. The group number with the steepest change in slope indicates the optimal number of clusters.

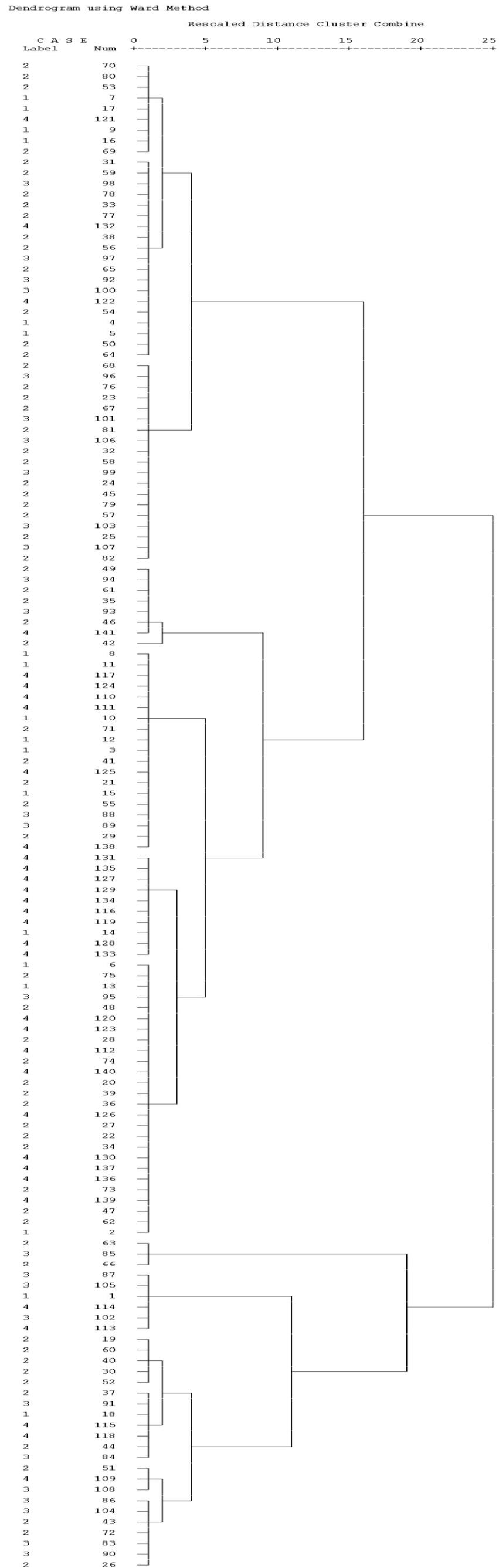


Figure 40: Dendrogram displaying the results of the shape cluster analysis for all bifaces. 1=East Wenatchee, 2=Anzick, 3=Simon, and 4=Fenn.

Finally, the bone rods from the East Wenatchee and Anzick caches remain to be analyzed by shape. The shape data cluster more obviously into three groups than the size data, but the makeup of the clusters is exactly the same (Figures 41 and 42). With the exception of the outlier, the East Wenatchee bone rods cluster exclusively among themselves (forming the first cluster), and the Anzick rods form two exclusive clusters. Especially when combined with the size cluster analysis, the shape analysis shows that significant differences exist among the bone rods from the two sites.

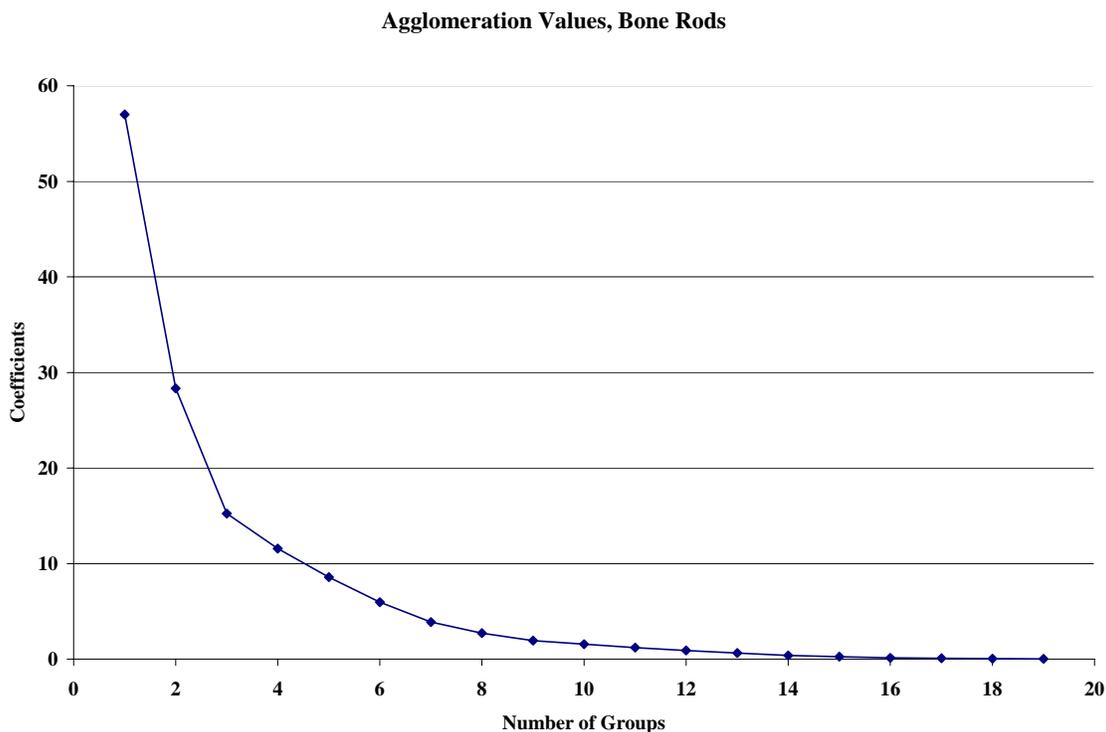


Figure 41: Graph that displays possible shape cluster arrangements for all bone rods. The group number with the steepest change in slope indicates the optimal number of clusters.

## Dendrogram using Ward Method

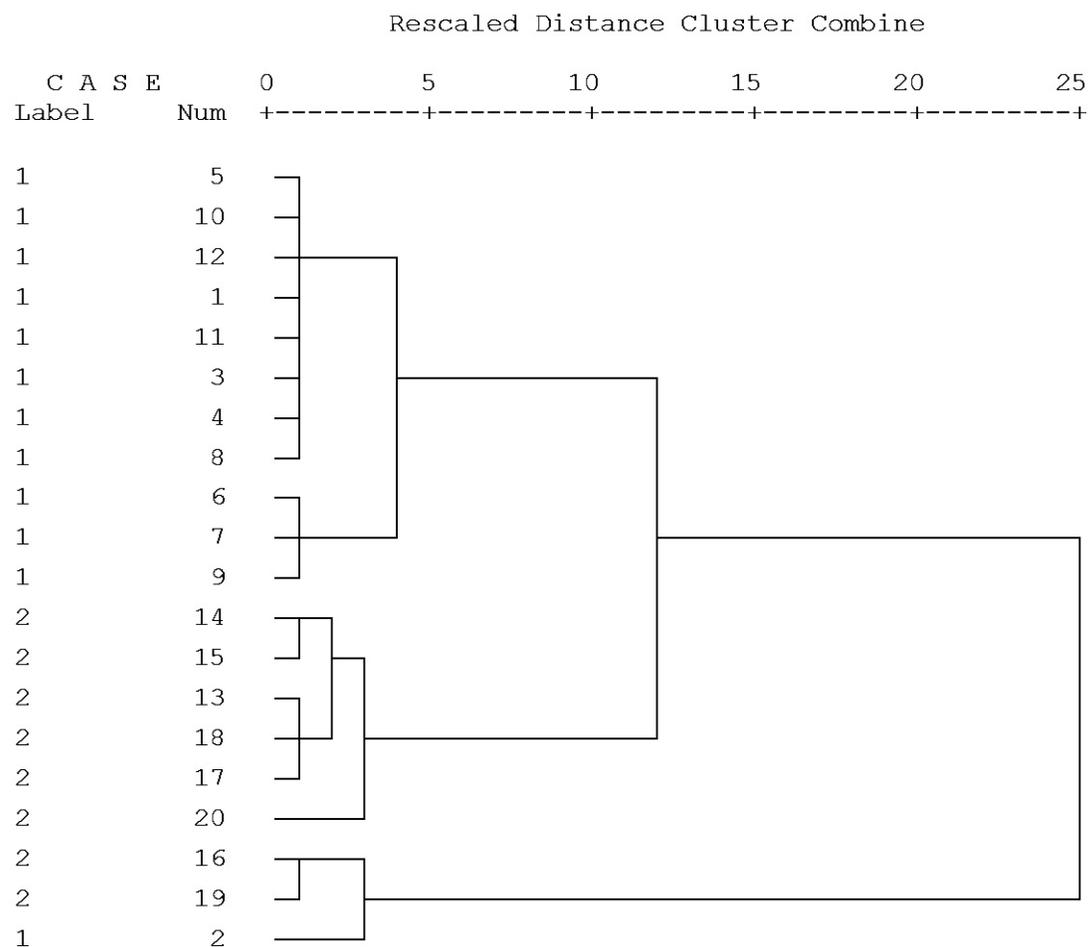


Figure 42: Dendrogram displaying the results of the shape cluster analysis for all bone rods. 1=East Wenatchee and 2=Anzick.

### *Conclusions on the Cluster Analyses for Shape*

In terms of the site-by-site artifact analysis, the shape clusters are often fairly similar to the size clusters. These results are to be expected when the sample is small, such as the fluted point data from Anzick or Simon, but these similarities also affected the biface data as well.

The shape analysis for the overall artifact type does yield results that are different from the shape analysis, however. The dichotomy between the East Wenatchee and Fenn

fluted points is more obvious in the shape data, while the biface shapes do not seem to divide at all according to site. The exception to these results is the bone rod data, whose striking similarity to the size data deserves explanation. The reason for this difference is most likely the difference in bone preservation between sites. The bone rod outlier from East Wenatchee is most likely broken or in a more deteriorated state than the other rods. The Anzick bone rods may be in similar states of breakage or decay.

### Cluster Analyses for Size and Shape, All Sites

The final cluster analyses involve comparing both the sizes and the shapes of each artifact type with each other. The factor analysis function in SPSS allows one to save the results of the analysis as variables. These variables are then applicable to the cluster analysis. For the most part, these cluster analyses are far simpler than those utilized before. Only two factors were revealed in most artifact types, so simple scatterplots can portray the data as easily as the mathematical analysis.

For fluted points, the numerical data reveal four clusters. The scatterplot also shows that four clusters exist, although one of those clusters is made up of one outlying point from the Anzick cache (Figure 43). The most notable aspect of the analysis is that the artifacts appear to cluster according to size but not shape. On the plot, the clusters only exist along the x-axis. Therefore, shape does not vary across the caches, but size certainly does. The cluster of the smallest fluted points consists primarily of Anzick and Fenn artifacts, the central cluster is made up of mostly East Wenatchee and Simon points, while the cluster with the largest points belongs almost entirely to East Wenatchee.

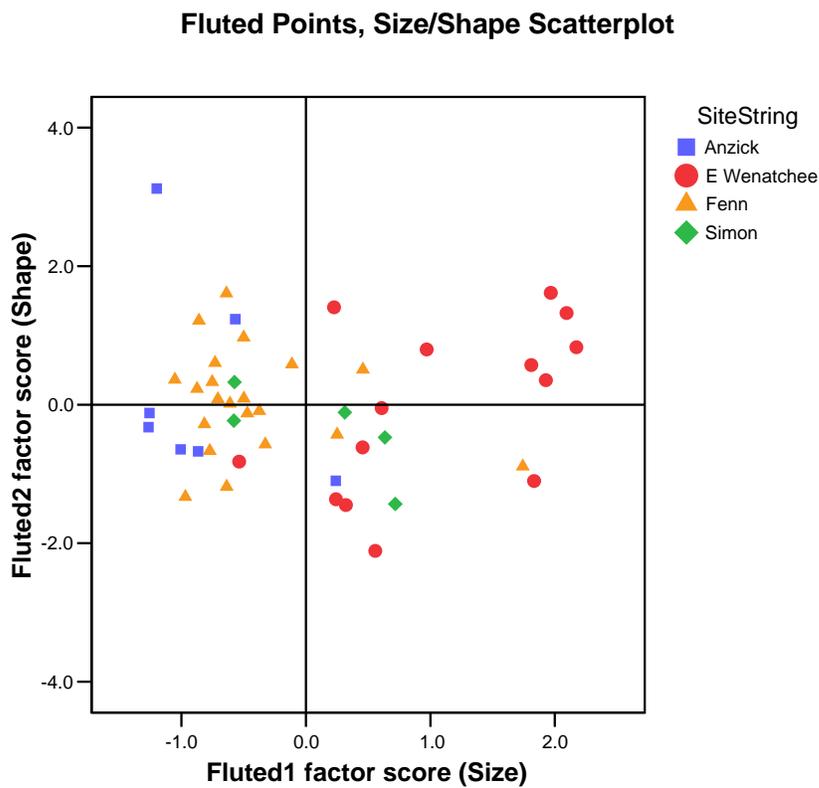


Figure 43: Scatterplot of all fluted points by size (x-axis) and shape (y-axis).

For the size and shape analysis of bifaces, the clusters are not as obvious. Two separate cluster analyses are run on the bifaces, with the first including only the size and shape factors, and the following analysis includes the third, more questionable factor. With the analysis of the first two factors, the numerical data suggest that five indistinct clusters exist. With the third factor included, the results become more vague, and it appears that up to nine clusters are present. The scatterplot for the two-factor cluster analysis shows that the bifaces form a roughly homogenous group, although different caches exhibit different trends (Figure 44). East Wenatchee has the most uniform biface collection, with the artifacts clustered in the center of the points. The Fenn bifaces are only slightly more variable than East Wenatchee. However, the Anzick and Simon

bifaces have a wide range of size and shape, and nearly all of the outlying points belong to either of these caches. The differences in these biface distributions may reflect cultural or utilitarian differences between the caches. The caches that have an abundance of fluted points (East Wenatchee and Fenn) also have bifaces of homogenous size and shape. On the other hand, caches that have few fluted points (Anzick and Simon) have bifaces of many sizes and shapes that relate to their reduction sequence (Kohntopp 2001).

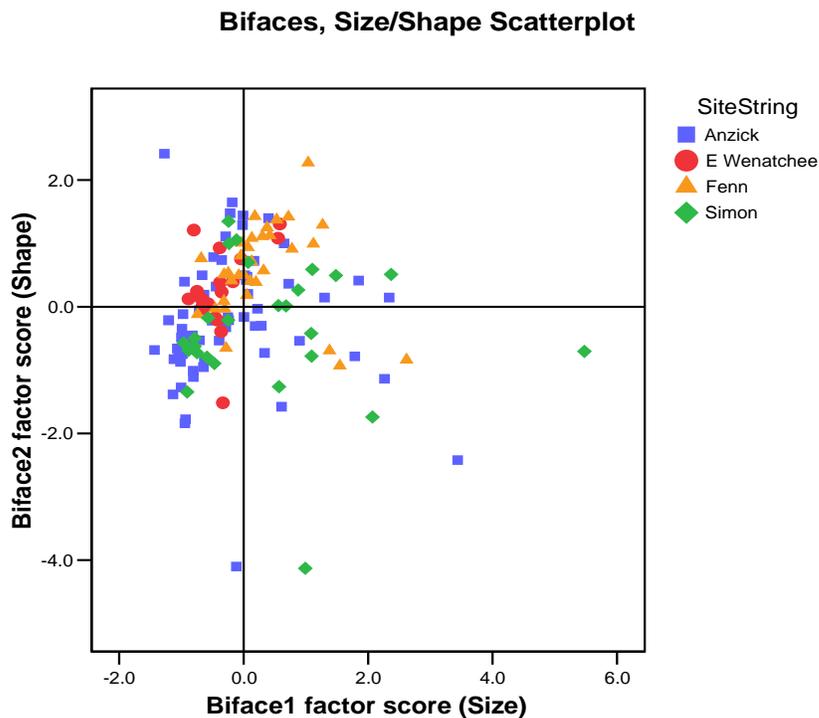


Figure 44: Scatterplot of all bifaces by size (x-axis) and shape (y-axis).

The bone rod size and shape data from the East Wenatchee and Anzick sites form three obvious clusters. Like the previous analyses, these clusters are divided almost exclusively according to site (Figure 45). The third and smallest cluster contains three

rods (one from East Wenatchee and two from Anzick) that do not match with their corresponding sites. The anomalous East Wenatchee rod more closely resembles most of the Anzick rods in terms of size but not shape. The two outlying Anzick rods are close to East Wenatchee's size characteristics but with a vastly different shape. Within the outlying cluster, the rods' shapes are fairly similar, but the East Wenatchee rod is considerably smaller in size than Anzick's two outliers.

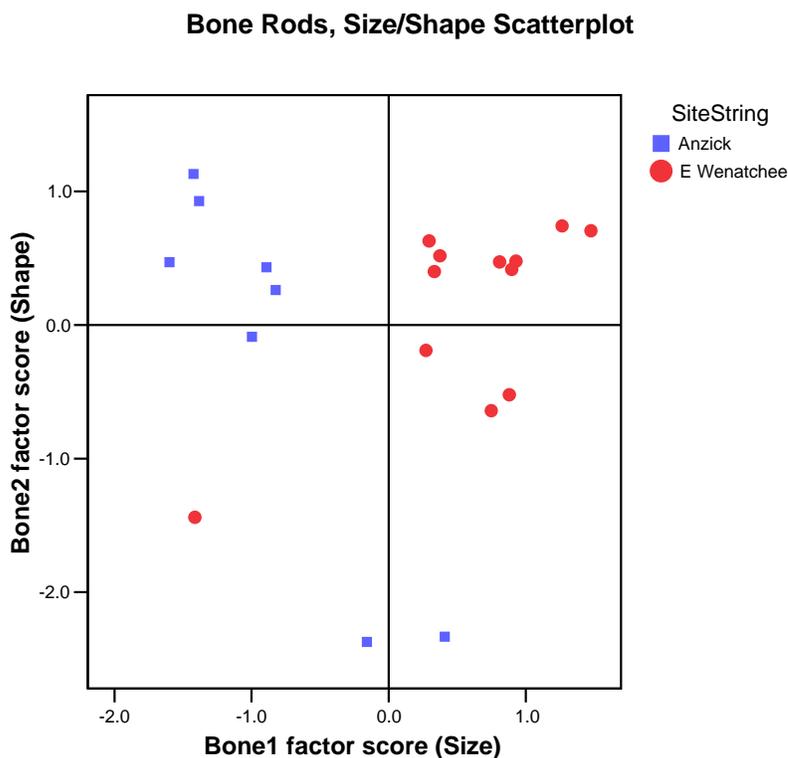


Figure 45: Scatterplot of all bone rods by size (x-axis) and shape (y-axis).

Interestingly, the bone rods appear to be related to fluted points based on count data. A total of 14 bone rods (12 of which have been measured) have been found at East Wenatchee, and 8 rods are present in the Anzick cache. Perhaps coincidentally, there are

14 fluted points from East Wenatchee and 8 from Anzick. Also the size differences in the bone rods may reflect the fact that East Wenatchee has the largest fluted points out of all the caches, while Anzick has the smallest.

In sum, the cluster analyses of size and shape characteristics from the East Wenatchee, Anzick, Simon, and Fenn caches show that statistical differences do exist among their respective artifacts. For fluted points, size is an important distinguishing characteristic. For bifaces, the overall variability provides a contrast among the caches. Both size and shape play a role in distinguishing bone rods, although preservation factors must be taken into account. Lastly, the sample size for each artifact type per cache is telling. East Wenatchee and Fenn have a proportionately large number of fluted points compared to bifaces, and these caches also hold a few other lithic tools, such as blades. Anzick and Simon, on the other hand, represent caches that are almost strictly bifacial, with proportionately few fluted points, and no additional lithic tools.

Overall, three different kinds of groupings are available. The count data on the fluted points and bifaces suggest that the sites group into caches of finished tools (East Wenatchee and Fenn) and caches that represent production sequences (Anzick and Simon). The cluster analyses of the bifaces support this distinction as well, but the analyses of the fluted points do not. According to the fluted point size data, East Wenatchee and Simon form one loosely defined group of large fluted points, and Anzick and Fenn are a group that is dominated by smaller points. Finally, the presence or absence of bone rods could be another grouping factor. Of course, the size and shape data between the East Wenatchee and Anzick's bone rods are so different that it seems premature to group them together based simply on the artifacts' presence.

## East Wenatchee Clusters and Proveniences

One unique aspect of the East Wenatchee cache is that the majority of the artifacts were excavated *in situ*. None of the other cache sites in this study have recorded proveniences. Therefore, one can analyze the clusters of the artifacts' measurements and compare the results to the artifacts' proveniences. Unfortunately, the records of the exact proveniences for many of the artifacts have become lost over time. Bonnicksen et al's (1995) database provides some proveniences, but the majority of the fluted points and bifaces still lack accurate data. Instead of using the database, I consult Gramly's (1993:25) plan view map of the cache site (Figure 46). The map portrays 36 of the East Wenatchee artifacts in their original positions. The map also illustrates the first 24 artifacts that the orchard workers uncovered in 1987, but their proveniences are undeterminable. I obtain the proveniences from Gramly's map by measuring the midpoint of each artifact and then calculating the northing and westing of the midpoint by measuring it against the walls of the excavation unit. One fact to bear in mind is that Gramly's plan view is upside down: the north wall is at the bottom and the south wall is at the top of the map.

Having obtained the proveniences for all the illustrated artifacts, the specimens must also be linked to the Washington State Historical Society's catalog numbers. The numbering system on Gramly's plan view map lists the artifacts in spatial order, but these numbers are unrelated to any of the cataloging systems. Fortunately, the Washington State Historical Society managed to match the catalog numbers to the artifact illustrations

on Gramly's map. Therefore, a comparison of the mathematical artifact clusters to their original positions is possible.

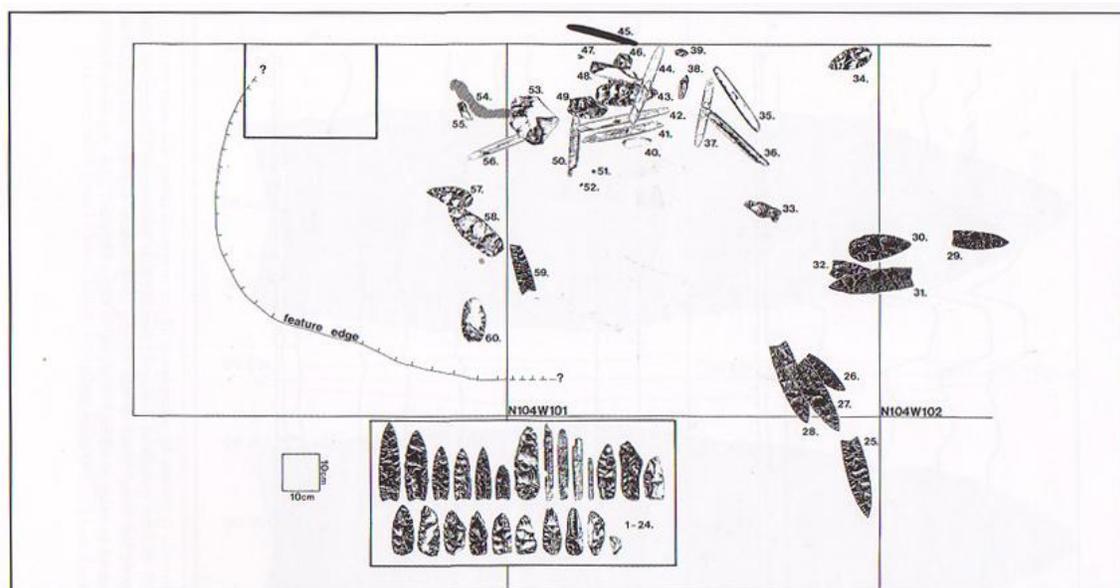


Figure 46: Plan view of Richey Clovis Cache (Feature 1), East Wenatchee Clovis site (Gramly 1993:25).

For fluted points from East Wenatchee, the separate cluster analyses of size and shape are sketchy at best. However, a cluster analysis using the factor scores for size and shape works well. The results of the statistical analysis for the 14 fluted points provide four clusters.

Gramly's plan view map does not include the proveniences for all the East Wenatchee artifacts because 24 of them were removed by the orchard workers prior to archaeological investigations. Of the 14 fluted points, eight of them have recorded proveniences. They form three clusters, and the following table (Table 33) compares these statistical and spatial clusters.

Table 33: Fluted point cluster assignments based on size/shape statistics (rows) and on provenience data (columns). Only artifacts that have provenience data are included.

	<b>Map Group 1</b>	<b>Map Group 2</b>	<b>Map Group 3</b>
<b>Cluster 1</b>			1
<b>Cluster 2</b>		2	
<b>Cluster 3</b>	1		
<b>Cluster 4</b>	3	1	

The statistical clusters match fairly closely to the provenience clusters.

Comparing the two cluster sets reveals that only two fluted points cluster differently by provenience and by size and shape. However, one must keep in mind that those two fluted points make up 25% of the sample size for the provenience clusters.

For the sake of continuity, the bifaces are also clustered statistically according to their size and shape factor scores. The cluster analysis reveals four clusters. Gramly's plan view map includes eight bifaces that are *in situ*, and they form three clusters. Table 34 is the result of comparing of these two cluster sets.

Table 34: Biface cluster assignments based on size/shape statistics (rows) and on provenience data (columns). Only artifacts that have provenience data are included.

	<b>Map Group 1</b>	<b>Map Group 2</b>	<b>Map Group 3</b>
<b>Cluster 1</b>	2	1	
<b>Cluster 2</b>		1	
<b>Cluster 3</b>		1	1
<b>Cluster 4</b>	1		1

Unlike the fluted points, the provenience clusters for the bifaces do not match the measurement clusters at all. One interpretation may be that each provenience cluster consists of a variety of bifaces that may have served different purposes.

Finally, the bone rods have consistently clustered the same way according to both size and shape, so the combined cluster analysis has the three expected clusters.

Additionally, eight of the bone rods have known proveniences according to Gramly's map, and these proveniences form three clusters as well. Table 35 compares these cluster sets.

Table 35: Bone rod cluster assignments based on size/shape statistics (rows) and on provenience data (columns). Only artifacts that have provenience data are included.

	<b>Map Group 1</b>	<b>Map Group 2</b>	<b>Map Group 3</b>
<b>Cluster 1</b>	2	1	3
<b>Cluster 2</b>	1	1	
<b>Cluster 3</b>			

Based on these data, no continuity is evident between clusters based on measurements and clusters based on provenience for bone rods. Gramly (2004, 1993) states that gnaw marks are present on most of the bone rods, so biogenic disturbances may have shifted the rods out of their original positions.

To conclude, comparing statistical clusters to provenience clusters yields positive results only for the fluted points. The overall picture of the plan view map shows that fluted points, bifaces, and bone rods are grouped somewhat separately. The fluted points lie primarily in the northwest corner and in the west wall of unit N104W101. The bone rods are tightly grouped in the south portion of unit N104W101. The bifaces are the most scattered of the artifacts, and they are often mixed with the fluted points or the bone rods. A small, nearly exclusive cluster of three bifaces and one fluted point lies near the west wall of N104W100. If the fluted points were grouped in the cache based on size and shape characteristics, it is possible that bioturbation accounts for the lack of order among

the bone rods and bifaces. Assuming that mammals dug into the site and gnawed on the bone rods, it is likely that the positions of the rods and some of the bifaces near the rods changed. The fluted points are far enough from the bone rods to remain unaffected.

## CORRESPONDENCE ANALYSES

Correspondence analysis is a statistical method that can compare assemblages from different sites on the basis of artifact counts. Archaeologists have used this method in previous studies as a seriation technique to sort the proportions of artifact types into a chronological scale (Kendall 1970). In this study, I use correspondence analysis to arrange infer artifact proportions on a geographical scale. In other words, the closer two cache sites are located to each other, then the more similar the types and amount of artifacts should be among the assemblages.

Each permutation of the following correspondence analyses is run twice. The first run includes the data from the four cache sites from this study. The subsequent run includes the four caches, plus up to five additional Clovis caches that have available count data. The five additional caches are as follows:

The Drake cache is from north central Colorado and was found by Orvil Drake in 1978. It consists of 13 fluted points and one hammerstone. Additionally, small pieces of ivory are associated with the points, but the fragments are too small to yield any definitive cultural information (Stanford and Jodry 1988).

The Crook County cache from northeastern Wyoming contains two fluted points and seven bifaces. Harold Erickson originally uncovered it in 1963 during an oil and gas exploration. According to Tankersley's account, Erickson states that the cache was buried in a pit of red ochre and also held two possible bone foreshafts, whose whereabouts today are unknown (2002).

The Keven Davis cache is apparently a different kind of Clovis cache, as this assemblage consists entirely of 14 blades from north-central Texas. Keven Davis discovered the cache in 1988 while surveying (Collins 1999).

The Busse cache from northwestern Kansas was found in 1968 by Dan Busse. It is made up of 13 bifaces, 25 blades, 50 flakes, a jasper cobble, and an abrader (Hofman 1995).

Another blade assemblage, the Green cache was found at Blackwater Draw, New Mexico in 1963 during a gravel mining operation. F. E. Green reports on the 17 blades and assigns them as Clovis tools (1963).

### How It Works

One purpose of correspondence analysis is to explore the relationships between the rows and the columns on a two-way table. The method can compress the data from the table so that it can be expressed in a graph of lower dimensions (usually two or three, with each axis representing a dimension). Therefore, instead of imagining a graph in which each variable of a row or column represents a dimension, the correspondence analysis compresses the data so that all the variables on a row or column become a single dimension. Naturally, some data may be lost in this process. Each dimension in a correspondence analysis has an inertia value that provides a value describing the percentage of data accounted for by that dimension. Adding those inertia values together provides a cumulative inertia value for the entire graph (StatSoft 2003). This research utilizes the correspondence analysis program in Statistica 6.

## Results

The first correspondence analysis is a plot of the six tool types and the four sample Clovis caches (Figure 47). Tool types located close to the origin (0,0) represent categories that are found in all or most caches, and caches plotted near the origin are assemblages that contain a large quantity of these ubiquitous tools and few or none of the more extraneous types.

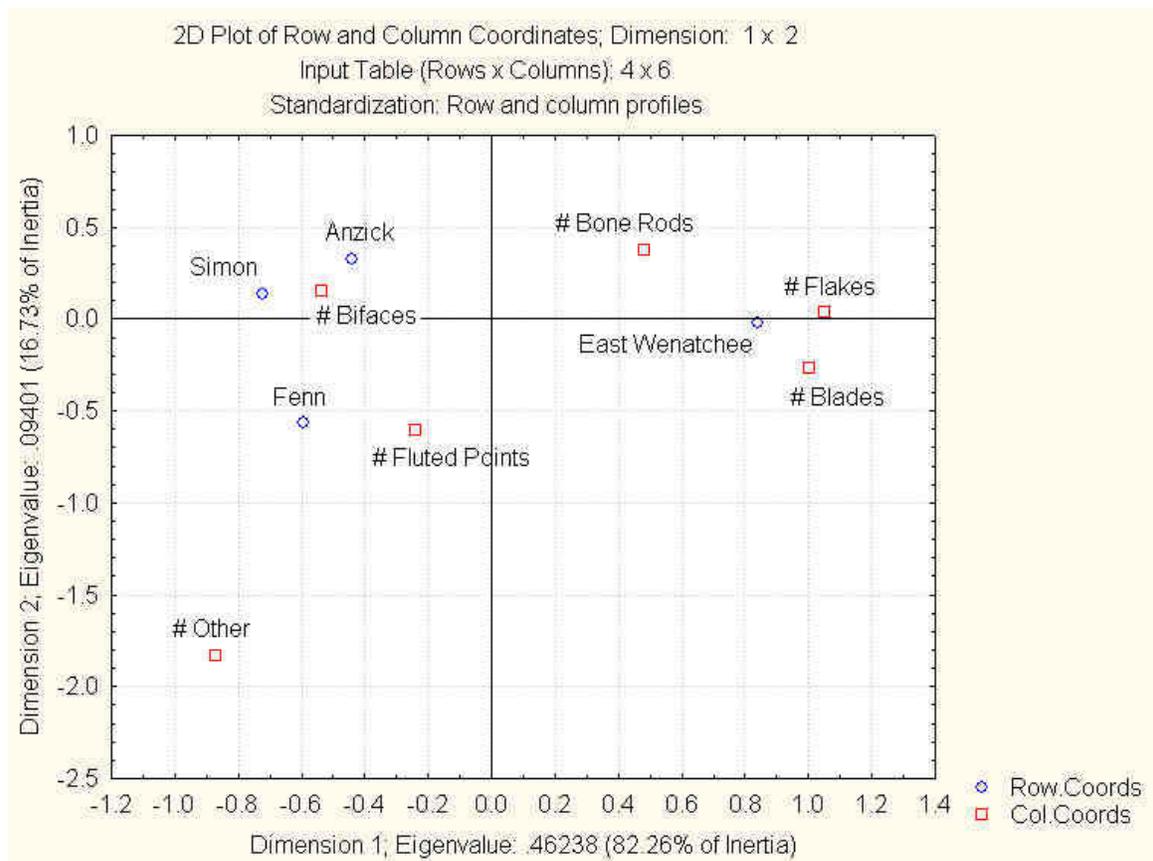


Figure 47: Correspondence analysis results displaying the four sample caches and their relation to six artifact types based on count data.

This correspondence analysis shows that fluted point and biface types are closest to the origin point. The Anzick and Simon caches cluster closely around the biface category, and Fenn is closest to the fluted point category. One might expect Anzick to be situated closer to the bone rod category, but the cache has an overwhelming number of bifaces. Fenn has the most fluted points of the four caches, so it is naturally closest to this category. The miscellaneous “other” category is an outlier, but it does pull Fenn away slightly from the fluted points because the cache contains one miscellaneous artifact (a crescent). Finally, East Wenatchee is surrounded by the bone rod, blade, and flake categories. Although East Wenatchee has a substantial number of fluted points, it has the most bone rods, blades, and flakes out of the four sample caches. The fact that East Wenatchee has 63 flakes (nearly ten times as many as the other caches) explains why the cache does not lie close to the origin. The high number of flakes may be the result of a sampling bias, as East Wenatchee is the only site in the sample that underwent an archaeological excavation.

The next correspondence analysis uses the same artifact types but adds artifact counts from the five additional Clovis caches (Figure 48). The caches and artifact types form three general groups. The first group is blade-dominated, with the Green and Keven Davis caches. This artifact type and these caches are the most outlying of the plots. The next group is flake-dominated, with East Wenatchee and Busse. Although these caches have substantial amounts of other artifact types, they have far more flakes than the rest of the Clovis caches. Finally, the fluted point and biface-dominated caches are Anzick, Simon, Fenn, Drake, and Crook County. With the exception of Anzick, these caches can be noted by their absence of other artifact types rather than the presence of fluted points

and bifaces. The bone rod and “other” categories are situated in between the flake-dominated and the fluted point and biface-dominated groups. This occurrence is due to the fact that one or more caches from each group contains either bone rods or miscellaneous artifacts.

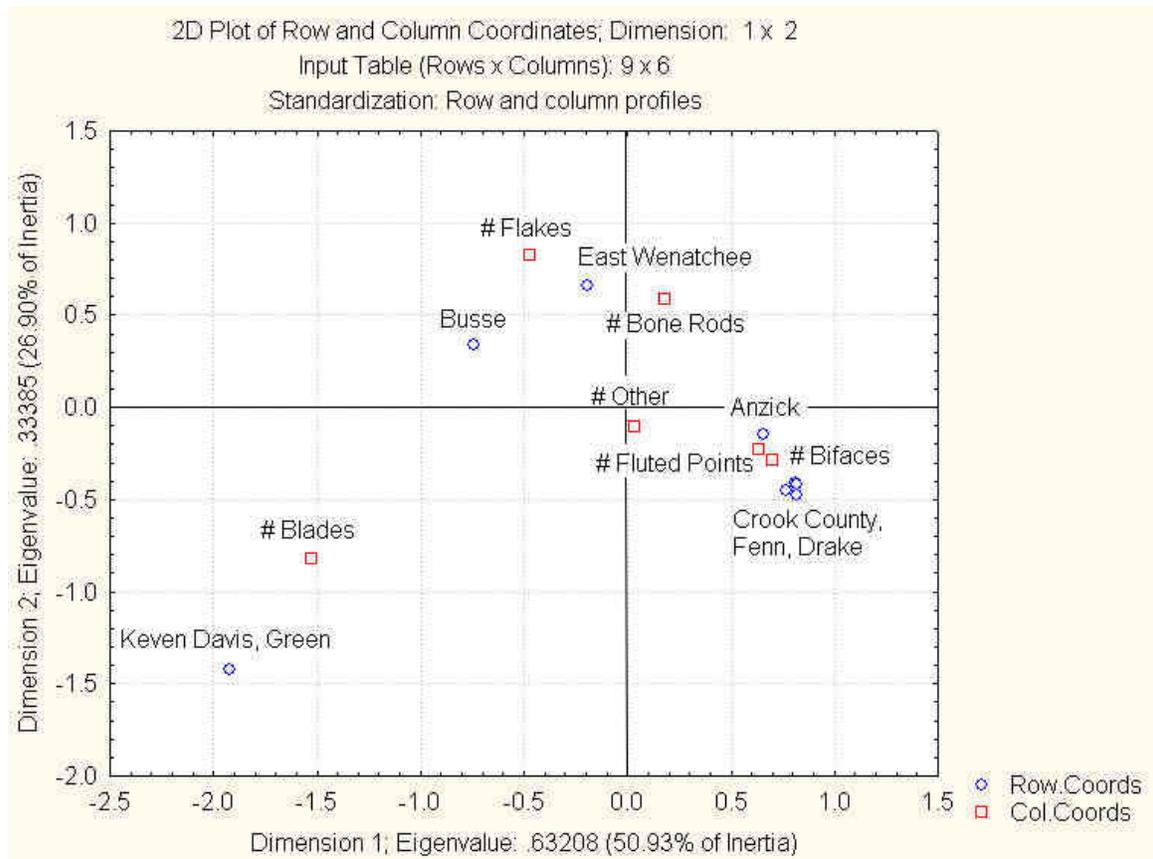


Figure 48: Correspondence analysis results displaying nine Clovis caches and their relation to six artifact types based on count data.

Two more correspondence analyses compare four original and seven total cache assemblages after removal of the blade and flake variables. First, the analysis of the four sample caches reveals three groups: fluted point-dominated, biface-dominated, and bone rod-dominated caches (Figure 49). Fenn represents the fluted point-dominated

assemblage, although it is pulled somewhat by its substantial biface assemblage and the crescent. Anzick and Simon, the biface-dominated assemblages, are grouped closely with the biface artifact type. East Wenatchee is the bone rod-dominated assemblage, although the fluted point type pulls the cache closer to the center.

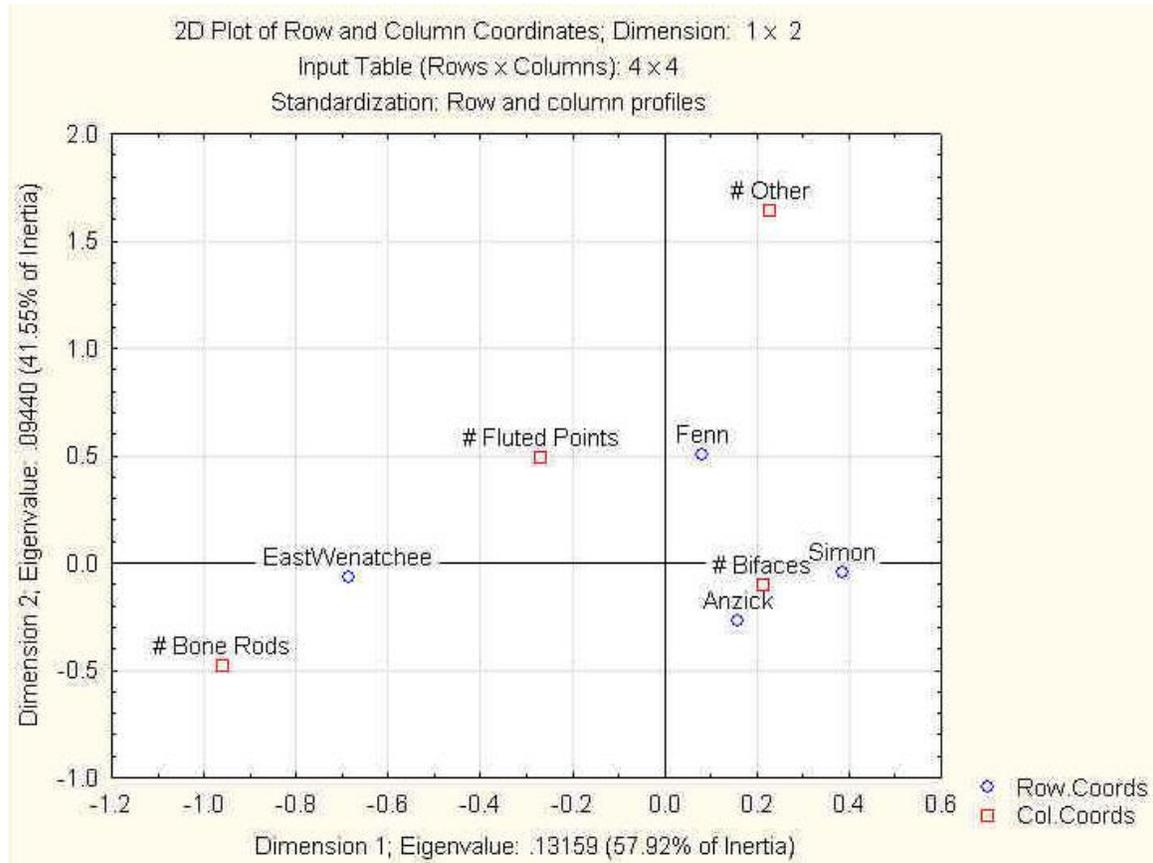


Figure 49: Correspondence analysis results displaying the four sample caches and their relation to four artifact types based on count data (blade and flake data are removed).

The second analysis adds the Drake, Crook County, and Busse caches (Figure 50). The Keven Davis and Green caches were left out because they are strictly blade assemblages. The layout of the original caches does not change much, except Fenn is now located halfway between the fluted point and biface types. Drake is a fluted point-

dominated cache, and it pulls the variable away from Fenn due to the fact that Drake consists almost entirely of fluted points. Crook County and Busse are grouped with the biface-dominated caches but not as tightly as Anzick and Simon.

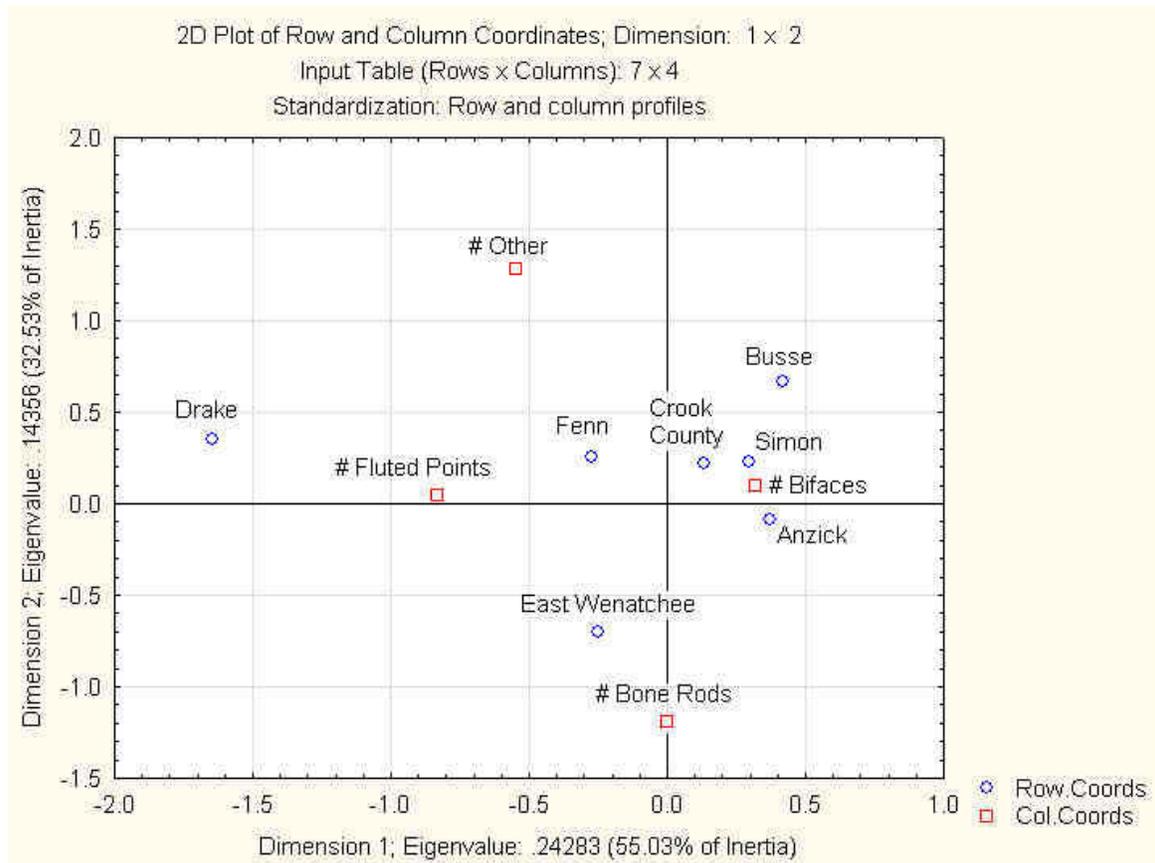


Figure 50: Correspondence analysis results displaying seven Clovis caches and their relation to four artifact types based on count data (blade and flake data are removed).

## GEOARCHAEOLOGY OF THE CACHE SITES

### Overview

The locations of the known cache sites in this study lie just to the east and to the west of the Rocky Mountains. The East Wenatchee, Anzick, and Simon sites are located in intermontane river basins. The theoretical location of the Fenn cache is also an intermontane basin. For East Wenatchee and Anzick, mountains border the prairies to the east and west. For Simon and Fenn, mountains run along the north and the south. Erye's (1968) vegetation map places Fenn in a sagebrush/chaparral zone, while the three other caches are located in prairies.

#### *East Wenatchee*

For the area surrounding the East Wenatchee site, the most notable geographic feature is the Channeled Scablands. This landform lies in between the Cascade and Rocky Mountains and consists of a basalt-dominated drainage basin that retains large flood ripples from the melting of the ice sheets at the end of the Pleistocene (Rosenfeld 1979). During the last glacial maximum (18,000 to 20,000 years ago), the Cordilleran Ice Sheet expanded into Washington, Idaho, and Montana in the form of several lobes. One of these lobes, the Purcell lobe, blocked the Clark Fork River, creating a natural dam to form Glacial Lake Missoula. By Clovis times, the lake had filled enough to spill over the Purcell Lobe's dam, and the ice was quickly swept away. Over a matter of weeks, all of Glacial Lake Missoula poured through eastern Washington and scoured the land, leaving

giant ripple marks in its wake (Booth et al. 2004:35-38). When J. Harlen Bretz proposed this scenario in the early twentieth century, most geologists refused to accept such an endorsement of catastrophism. However, evidence for such floods was found in numerous locations in eastern Washington, and the discovery of deposits left by Glacial Lake Missoula in Montana confirmed the existence of a source for the flooding (Booth et al. 2004:35-36).

An additional natural disaster affected the area of East Wenatchee just prior to the Clovis occupation at East Wenatchee. In studying the geology of the site, Mehringer and Foit (1990) note the presence of Glacier Peak tephra from about 11,250 radiocarbon years B.P. in the stratigraphy. Moreover, the researchers state that the tephra is apparent in a siliceous crust that appears on the undersides of the artifacts. The fact that the crust appears only on the bottom of the artifacts and not on top indicates that the cache was left just after the Glacier Peak eruption (Mehringer and Foit 1990).

The climatic conditions in the area indicate that the Cascade Mountains tend to create a rain shadow over the eastern portion of Washington state (Lahey 1979). According to Frenkel (1979), the modern vegetation in the region is dominated by big sagebrush (*Artemisia tridentate*).

### *Anzick*

According to Scott Jones' MA thesis (1997), the Anzick site lies within the Crazy Mountain Basin located between the Bridger Mountains to the west and the Crazy Mountains to the east. The Crazy Mountain Basin is underlain by the Livingston Formation, a sandstone bedrock structure from which the Anzick outcrop is derived

(Jones 1997). Lahren and Bonnicksen (1974) state that the sandstone outcrop is a collapsed rock shelter, and the Anzick cache was buried with human remains beneath this shelter. Bailey's (1976) ecoregions map places the Anzick site within the foothills prairie, a narrow band of *Agropyron*, *Festuca*, and *Stipa* grassland that runs along the eastern edge of the Rocky Mountains. To the west of this region is douglas fir and western spruce-fir forests, and to the east are *Bouteloua*, *Stipa*, and *Agropyron* grassland interspersed with eastern ponderosa forests (Bailey 1976).

### *Simon*

The immediate area surrounding the Simon cache site is the Big Camas prairie, an eastwardly elongated plain that follows Camas Creek. The Big Camas prairie is bordered on the north by the Soldier and Smoky Mountains and on the south by the Mount Bennett Hills (Butler 1963). This area has been accumulating fluvial deposits since the mid to late Pleistocene and is underlain by igneous bedrock at a depth of 150 to 300 meters. The Simon artifacts came from yellow alluvium a mile east of Deer Creek (Butler 1963). This region experiences warmer and drier winters than most of the northwestern United States due to the position of the Sierra Nevada range (Lahey 1979). Like the East Wenatchee site, the modern vegetation surrounding the Simon cache site is *Artemisia tridentate*. However, this area is closely bordered on the north by *Pinus ponderosa*, *Abies grandis*, and *Pseudotsuga menziesii* forests (Frenkel 1979). It is worth noting that the Big Camas Prairie is historically known as an important locality for gathering camas and was utilized by various Native American tribes until the latter part of the 19<sup>th</sup> century (Butler 1963).

### *Fenn*

Based on Frison's (1991) hypothesis that the Fenn cache is from the borders of Wyoming, Utah, and Colorado; the Green River Basin, particularly near Flaming Gorge Reservoir, is a reasonable hypothetical location for this cache. The Flaming Gorge is located on the eastern edge of the Great Basin and would have lied east of Lake Bonneville in Pleistocene times (Cressman 1977). The border of the Great Basin is a likely location for the Fenn cache site due to the fact that a crescent (typical of Western Stemmed technology in the Great Basin) is present along with the Clovis artifacts. The northern portion of the gorge is a sagebrush steppe, while the southern part runs into a juniper and pinyon forest (Bailey 1976). Houghton (1976) states that elevation changes in the Great Basin bring about dramatic changes in vegetation and precipitation. He notes that for every 60-meter rise, precipitation increases by as much as 3 centimeters and vegetation becomes more varied and forested (Houghton 1976: 24). Flaming Gorge cuts into one of these elevation rises. One of the goals of this research is to determine whether this area compares favorably to the contexts of the other cache sites.

## Large-Scale Geomorphological Events

### *Glacial Lake Missoula and the Scabland Floods*

Towards the end of the Pleistocene from 15,000 to 13,000 calendar years B.P., much of northern Idaho and Western Montana was covered in glacial ice and meltwater lakes (Figure 51). Glacial Lake Missoula, the most of prominent of these lakes in the region, grew to encompass an area of 7,510 square kilometers with a maximum depth of

610 meters and a water volume of 2,085 cubic kilometers, or half the volume of modern Lake Michigan (Alt 2001:9). In Idaho, the Purcell Lobe extended southward from the Cordilleran ice sheet along the Clark Fork River valley. The lobe dammed the river near its present-day mouth at Pend Oreille Lake (USGS 1982). The combination of the dammed Clark Fork River and the nearby Bitterroot Mountains enabled the massive volume of Lake Missoula to accumulate.

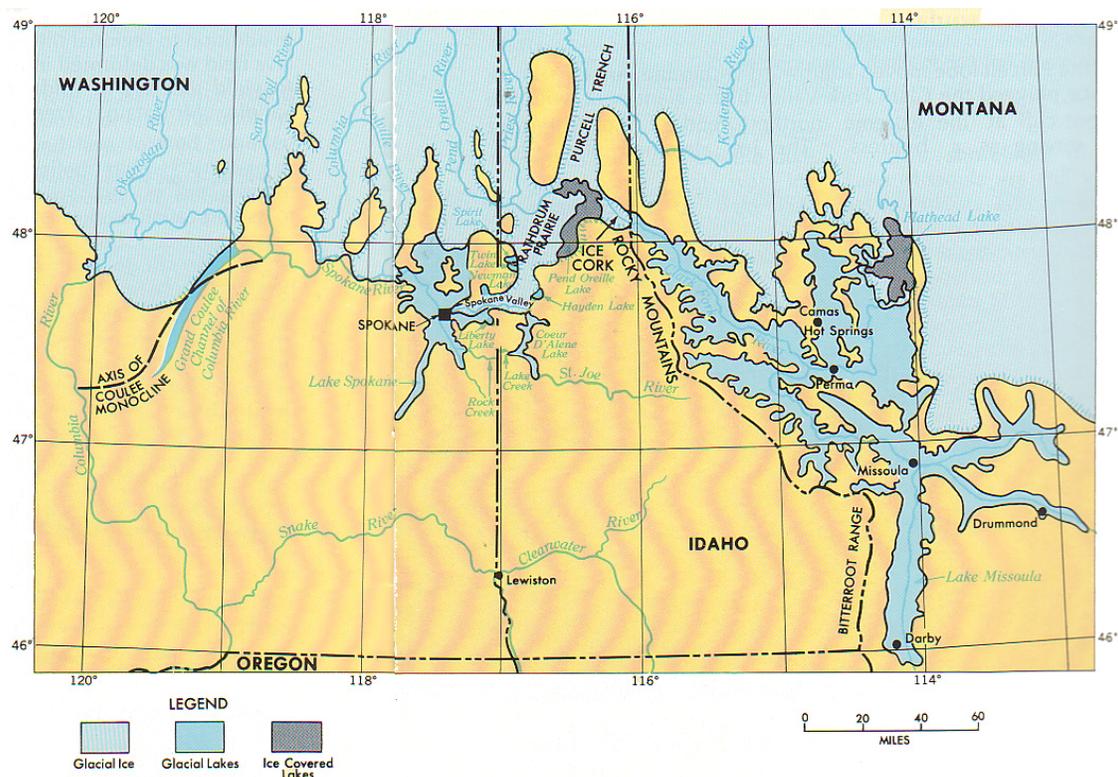


Figure 51: Map of eastern Washington, northern Idaho, and western Montana showing the positions of the continental ice sheets and the glacial lakes during the late Pleistocene (USGS 1982:8-9).

Additional river dams and glacial lakes formed in neighboring areas, as well. The Okanogan Lobe extended southward into the path of the Columbia River, diverting it into a channel along the Coulee Monocline. Between the Okanogan and Purcell Lobes, the Colville Lobe blocked the path of the Spokane River, forming Glacial Lake Spokane.

Additionally, the moraines and kame terraces that these lobes left behind form the boundaries of modern lakes such as Spirit Lake, Twin Lakes, Newman Lake, Hayden Lake, Coeur d'Alene Lake, and Liberty Lake (USGS 1982).

Glacial Lake Missoula could grow up to 90% of the height of the Purcell Lobe. Because the volume of ice is 10% less than water, the rising lake water eventually became high enough to float the lobe. The floating lobe then easily broke into icebergs and was swept away in the massive torrent of the draining lake. Afterwards, the Clark Fork River flowed freely until the Purcell Lobe extended southward again, causing the process to repeat itself (Alt 2001:25).

Like the remnants of glacial lakes found in Europe, Glacial Lake Missoula left behind sequences of varves in the stratigraphic record (Figure 52). Varves are a series of interbedded bands of sediments that accumulate according to a seasonal cycle. During the summer, meltwater brought silty glacial sediments, called "rock flour," into the lake. This sediment was rich in nutrients and could support organic life such as algae. However, the algae could not survive the winter climate, and the organic remains of the algae accumulate on the lake bed during these colder months. In Montana, the stratigraphic record for Glacial Lake Missoula shows 36 sequences of varves, each separated by fluvial silt deposits (Alt 2001:27). This record indicates that the lake formed and broke through the Purcell Lobe at least 36 times. Additional studies have found that up 100 Missoula floods have taken place (Booth et al. 2004:36). Also, the number of varve layers within each sequence decreased with every break. The earliest varve sequence has 58 paired bands of sediment, and the last sequence has only nine (Alt 2001:29). Therefore, the draining of Lake Missoula occurred after a shorter filling

period, and with less volume, over time. If the volume of the floods had been increasing with time, the stratigraphy would not have been preserved. This decrease in volume most likely represents deglaciation at the end of the Pleistocene, as the Purcell Lobe became smaller and more easily broken over time.



Figure 52: A roadcut along Highway 90, 20 miles west of Missoula, Montana. The pale bands are river silts; the dark bands sequences of glacial lake sediments with varves (D. W. Hyndman photo from Alt 2001:26).

The East Wenatchee site lies along the western edge of the Channeled Scablands in Washington state. This region bears the markings of multiple flood events caused by the sudden draining of Glacial Lake Missoula. The bedrock in this area is made up of columnar Miocene basalt which was covered by a thin veneer of loess prior to the floods (USGS 1982). The columnar structure of this basalt is particularly susceptible to flood erosion. Additionally, the drainage of Lake Missoula deposited large gravel beds across the Channeled Scablands, particularly during the lake's more powerful early floods (Alt

2001:91, 95-96). Mehringer and Foit (1990:495) state that the scabland floods left immense ripple marks across the landscape, with 100 m between crests.

Waitt and Atwater (1989) provide a description of the geomorphology of the East Wenatchee area while participating in a field trip across the Channeled Scablands. Based on several stops in and around the cache site (within 30 km), they construct a sequence of flood events for the end of the Pleistocene. They state that Lake Missoula is not the only source of floods in this portion of the scablands; later floods from Glacial Lake Columbia and another extinct lake farther north in Canada may have also impacted this area. Before the Okanogan Lobe of the Cordilleran Ice Sheet reached its maximum extent, flood waters from Lake Columbia swept through the Wenatchee area through Moses Coulee, about 20 km to the southeast of the cache. The late Pleistocene stratigraphy of Moses Coulee consists of: 1) four beds of basalt pebbles and granules that thicken southward and are interpreted as alluvial fans from Moses Coulee floods; 2) interbedded sand and silt that represents slackwater from more distant Grand Coulee floods; and 3) giant dunes of cobble gravels and boulders (1.5 m diameter) of Swakane gneiss from farther up the valley. In the vicinity of the cache, a greater number of large gneiss boulders are visible. 15 or more boulders are over 5 m in diameter, and one is 13 m. Due to the fact that the maximum extent of glaciation was 52 km up the valley, giant floods must have transported these boulders. The boulders can be found up to 40 m above the modern level of the Columbia River. Surrounding the East Wenatchee site, giant dunes cover the area and are capped by a mantle of loess. The crests of the dunes 160 m apart, and boulders in this area are up to 0.5 m in diameter. Waitt and Atwater (1989) describe this area as the “world’s most colossal point bar.” The nearby Malaga gravel dunes show

signs of later flood activity, as they are not covered by loess nor the Glacier Peak tephra of 11,250 B.P (Waite and Atwater 1989:44-48).

In sum, the area surrounding East Wenatchee was mostly peripheral to the Lake Missoula floods, but it did endure other floods from Glacial Lake Columbia, especially before and after the maximum extent of the Okanogan Lobe. In particular, the flood that immediately underlies the Glacier Peak tephra may have originated from the draining of Lake Columbia. Additionally, two subsequent floods brought created more dunes and brought additional boulders to the area. The source of these floods would have been a later glacial lake from a contemporaneous glacial margin in Canada (Waite and Atwater 1989:48).

#### *Late Pleistocene Volcanic Eruptions*

Glacier Peak is a dormant volcano in the northern Cascade mountain range, northeast of Seattle and southeast of Mount Baker. Glacier Peak was highly active during the late Pleistocene, and while it was originally thought to have erupted one to three consecutive times, subsequent investigations have revealed that the volcano underwent nine or more eruptions over a period of up to 1,500 years (Porter 1978:30, 37). Most of these tephra layers are only distinguishable within 50 km of Glacier Peak. However, three of the layers (G, M, and B, from oldest to youngest) extend beyond this range (Figure 53). Layer G is found eastward past Idaho and into the Rocky Mountains of Alberta and Montana. Layer B extends southeast through Idaho into the Montana and Wyoming Rocky Mountains. Finally, the full extent of Layer M is unknown, but it is found south of Glacier Peak, along the Cascade Range (Porter 1978:31-33).

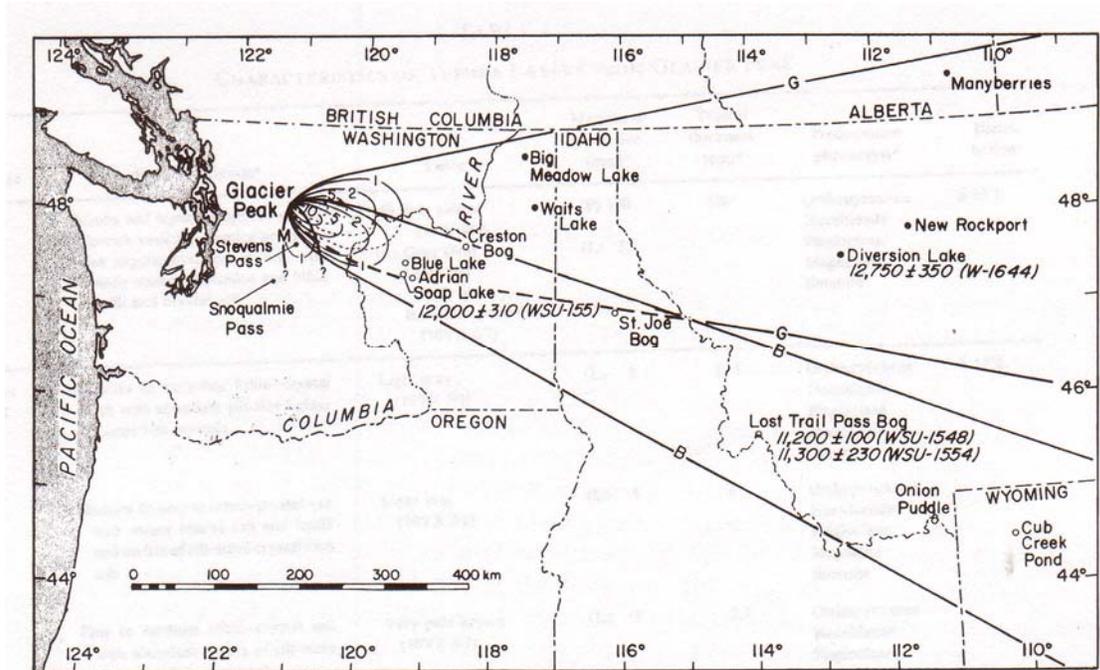


Figure 53: Inferred distribution of Glacier Peak tephra layers G, M, and B in northwestern United States and adjacent southwestern Canada. Remote localities of Layer G (solid circles) and Layer B (open circles) from Lemke et al. (1975), Smith et al. (1977), and Westgate et al. (1970). Grain-size isopleths in centimeters (Porter 1978:31).

Radiocarbon ages are associated with the most widespread tephra layers. The first accepted age of Layer G is  $12,750 \pm 350$  radiocarbon years B.P., based on mollusk shells found within the tephra in Montana's Diversion Lake (Porter 1978:37). However, subsequent studies of Layer G at Sheep Mountain Bog, Montana, indicate that its age may actually be closer to 11,200 B.P. (Mehring et al. 1984). At Lost Trail Pass Bog in the Bitterroot Mountains of Montana, Mehring et al. (1977:351-352) approximate the age of the Layer B tephra as 11,250 B.P., an average of two ages on organic sediment with values of  $11,200 \pm 100$  below the tephra and  $11,300 \pm 230$  above it. However, it is worth noting that this age encompasses two separate Glacier Peak eruptions that occurred within a short span of time, probably less than 25 years of each other (Mehring et al.

1977:366). Porter (1978:37) considers both of these consecutive eruptions to represent Layer B.

Based on these radiocarbon ages and geographic distributions, Layer B appears to be the most likely Glacier Peak tephra to underlie the Clovis artifacts at East Wenatchee. However, Mehringer and Foit (1990:500) state that the glass chemistry of tephra samples adhering to the bottoms of the artifacts is more similar to Layer G. This tephra layer was originally thought to be 1,500 years older than Layer B, pre-dating any accepted radiocarbon age for Clovis technology (Porter 1978:37). However, Mehringer et al. (1984) claim that all the Glacier Peak eruptions most likely occurred within decades of each other and that statistical uncertainty can explain the discrepancies in the radiocarbon ages. Additionally, Foit et al. (1993) demonstrate that Layers B and G have nearly indistinguishable chemical signatures, so the true identity of the Glacier Peak tephra at East Wenatchee may still be unknown.

The thickness of Layers B and G decrease rapidly with increasing distance from Glacier Peak (Figures 54 and 55). Projections based on Porter (1978:33, 36) estimate that the thickness of an intact Layer B at East Wenatchee would be less than 10 cm. An intact Layer G at East Wenatchee would be less than 5 cm. Maximum particle thickness also decreases over distance so that the largest Layer B and G particles at East Wenatchee would be less than 2 cm in diameter (Porter 1978: 34).

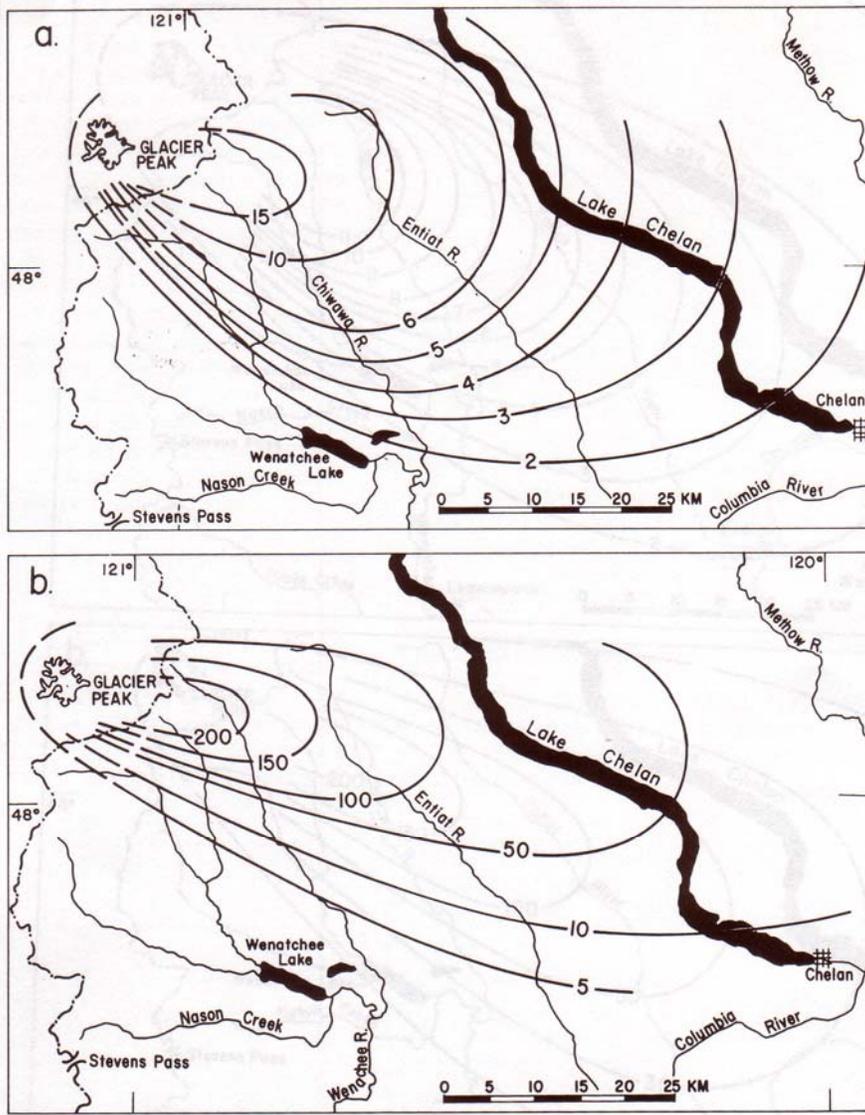


Figure 54: (a) Maximum particle size of tephra Layer G. Isopleths in centimeters. (b) Maximum thickness of tephra Layer G. Isopachs in centimeters (Porter 1978:34).

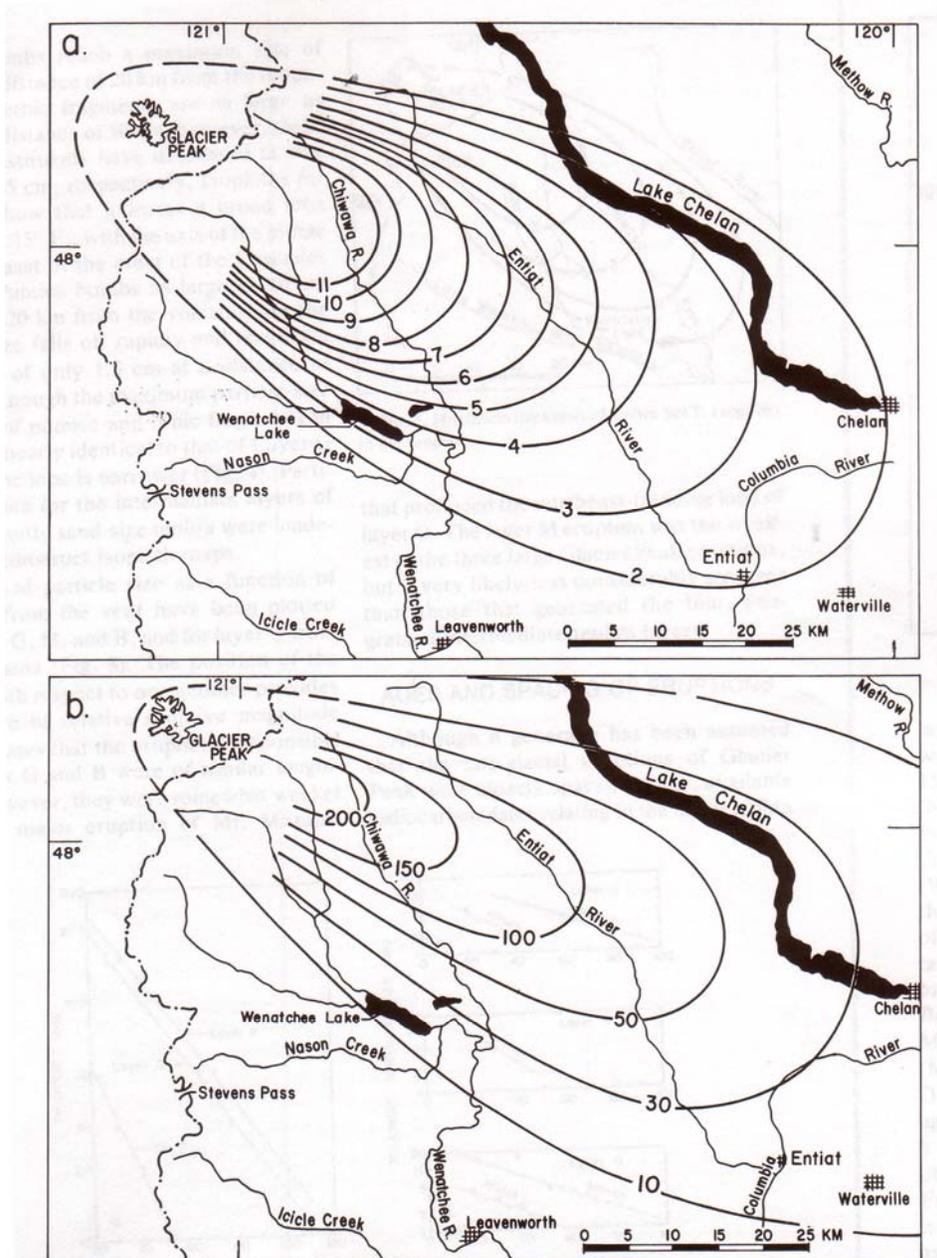


Figure 55: (a) Maximum particle size of tephra Layer B. Isopleths in centimeters. (b) Maximum thickness of tephra Layer B. Isopachs in centimeters (Porter 1978:35).

Eruptions at Mount St. Helens appear to be contemporaneous to the Glacier Peak eruptions. According to Sarna-Wojcicki et al. (1983), Mount St. Helens' Layer S erupted between 13,000 and 12,000 B.P. In eastern Washington, Layer S tephra is found interbedded with the last Channeled Scablands flood deposits from the draining of Lake

Missoula. Next, Layer J erupted between  $11,700 \pm 400$  and  $8,300 \pm 300$  B.P. Its extent is not well known, but it is present at Lind Coulee and was therefore most likely deposited in the East Wenatchee area as well (Sarna-Wojcicki et al. 1983:65-66).

Finally, the Mazama tephra, although deposited much later than the Clovis period, is an important marker bed for stratigraphic studies across the northwestern United States (Figure 56). Mount Mazama, presently occupied by Crater Lake in Oregon, erupted approximately 7,000 to 6,700 years ago. The volcano erupted as many as six times within 3 to 200 years, and four of these deposits extend far beyond the crater. The Mazama tephra, termed Layer O, has been noted in Oregon, Washington, northern California, Idaho, western Montana, western Wyoming, and northern Utah (Sarna-Wojcicki et al. 1983:68-69). Because of its wide distribution, Layer O potentially extends to all four of the Clovis cache sites in this study.

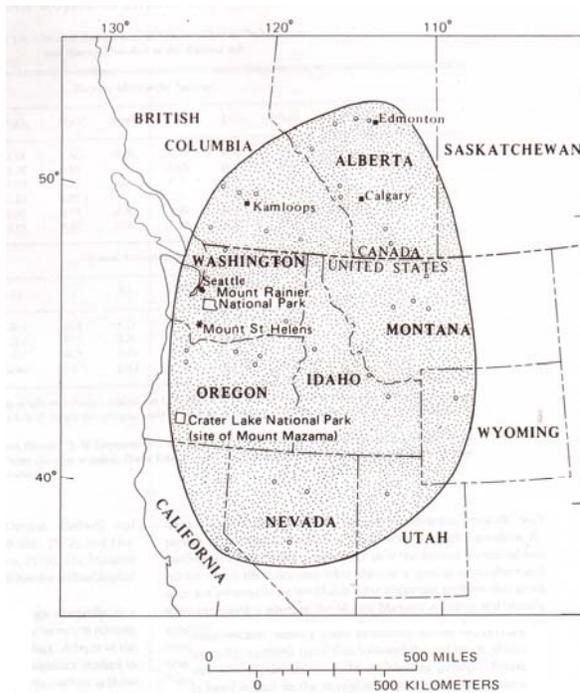


Figure 56: Minimum extent of Mazama ash (patterned) in the western United States and Canada. Circles mark sites where ash layer has been identified (Sarna-Wojcicki et al. 1983:69 after Mullineaux 1974:Figure 12).

*Pluvial Lakes and the Snake River Floods in Idaho*

After the last glacial maximum, Lake Bonneville was located to the south of the Simon cache and to the west of the probable location of the Fenn cache (Figure 57). The largest of the pluvial lakes, Bonneville's maximum extent covered most of western Utah and extended slightly into southeast Idaho. It covered an area of 51,640 km<sup>2</sup>, had a maximum depth of 335 m, and a water volume of 7,500 km<sup>3</sup>. The lake also contained about 20 small islands (Smith and Street-Perrott 1983:194).

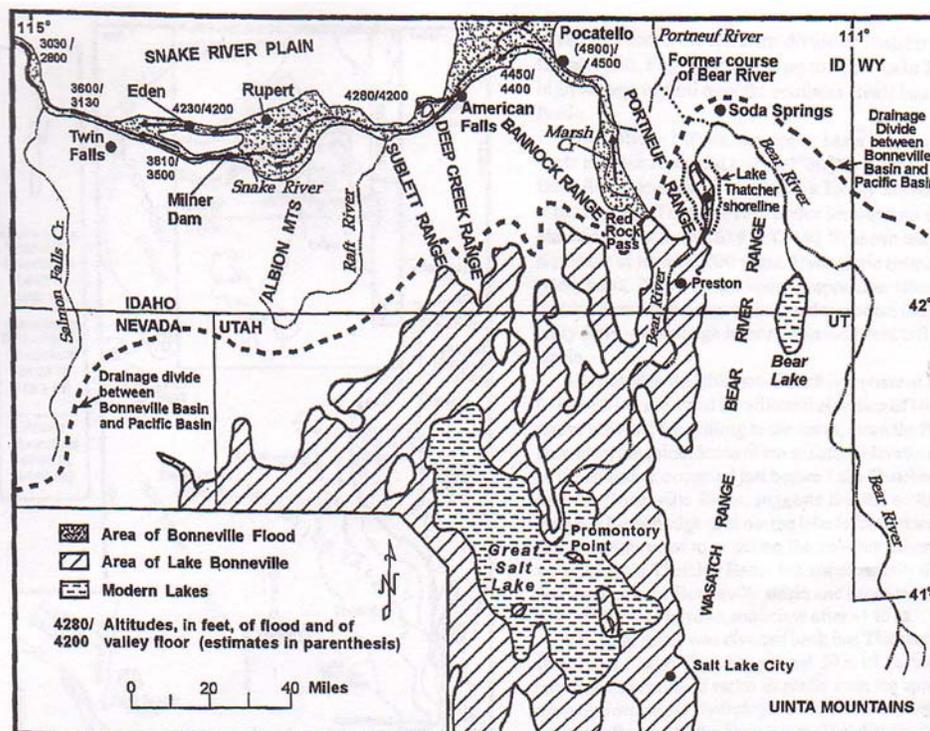


Figure 57: Map of Lake Bonneville and the path of its flood (Link et al. 1999:252).

The geological history of Lake Bonneville is complex because radiometric procedures have often produced conflicting ages. Morrison (1965) wrote a well known study of the Great Basin's Quaternary geology, proposing that the late Pleistocene Lake

Bonneville formation is bracketed by two paleosols: the underlying Promontory soil and the overlying Graniteville soil (Figure 58). His data are based on studies of eastern Jordan Valley, southern Promontory Point, and the Oak City-Delta areas in Utah. Throughout this formation, Lake Bonneville had two members (White Marl and the Upper Member) where it reached a maximum shoreline level. The two members are separated by a period in which Lake Bonneville appeared to evaporate completely before refilling. The Upper Member reached a slightly higher water level than the White Marl member, and Lake Bonneville overflowed its bank at Red Rock Pass in southeastern Idaho. This overflow was the second of such events in the Pleistocene; the earlier overflow occurred during a maximum water level at least 40,000 years ago. Each time, the overflows caused catastrophic floods along the Snake River through Idaho and Oregon (Morrison 1965:273-275). Morrison's (1965:276) estimation states that the maximum extent of the Upper Member and the overflow at Red Rock Pass occurred between 15,000 and 12,000 calendar years ago.

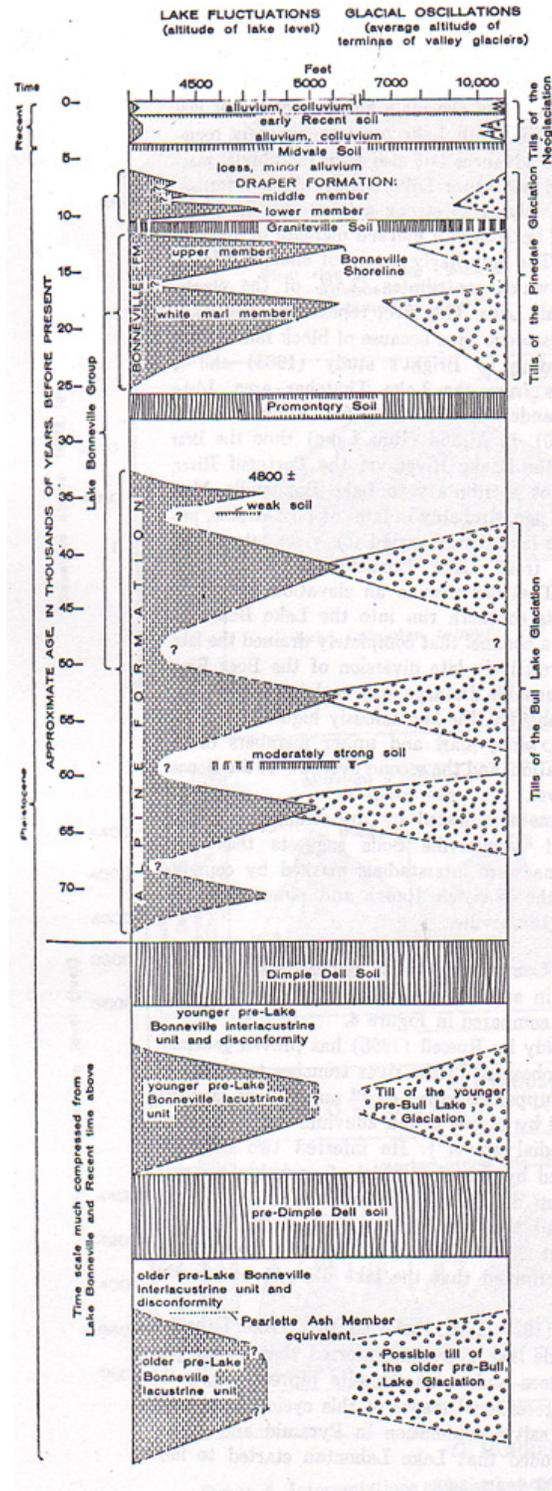


Figure 58: Fluctuations of Lake Bonneville and of Wasatch Mountain glaciers inferred from lacustrine and glacial successions, mainly in the Little Cottonwood Canyon-Eastern Jordan Valley areas, Utah (Morrison 1965:275).

According to Link et al. (1999), a combination of a mesic Pleistocene climate and occasional inflow of water from the Bear River (whose flow was often diverted by volcanic activity) enabled the maximum filling of Lake Bonneville. Bear River became permanently diverted into Lake Bonneville around 60,000 to 40,000 years ago. During this time, Red Rock Pass was filled with Cambrian limestone overlain with Tertiary sediments and alluvial fans from the Bannock and Portneuf mountain ranges. Lake Bonneville filled from 30,000 to 15,000 calendar years ago, and water leaked through the permeable gravels and karst limestone of the pass. At about 15,000 years ago, the lake level was high enough to spill over the pass, but the spill was not catastrophic. However, the alluvial dam eventually failed at the Zenda Threshold at 14,500 years ago, and the lake waters spread at the American Falls area. The flow primarily followed the Snake River, but it also diverged northwest along Lake Channel before rejoining the Snake River at Massacre Rocks (Link et al. 1999).

Currey's (1990) comprehensive study of pluvial lake geomorphology agrees with the scenario presented by Link et al. According to Currey, Lake Bonneville underwent a succession of three stages between 21,000 and 13,000 calendar years ago. The first stage lasted from 21,000 to 15,300 years B. P. and consisted of closed-basin transgression. From 15,000 to 14,500 B. P., Lake Bonneville was a threshold-controlled open basin until the catastrophic flood destroyed the threshold at Red Rock Pass. The final stage was made up of closed basin regression resulting in the formation of the Great Salt Lake. This stage lasted from 14,200 to 13,000 calendar years B. P. (Currey 1990:198-201).

The existence of pluvial lakes in Idaho itself is speculative, although geologists know of a large lake (Lake Idaho) that existed along the Snake River valley in the

western portion of the state during the Pliocene (Swirydczuk et al. 1982). The deposits left by Lake Idaho comprise what is known as the Glens Ferry Formation in the geological record. The Glens Ferry formation is made up mostly of lacustrine facies, with a lesser extent of fluvial and floodplain facies also present. These deposits extend westward from the town of Hagerman in Gooding County, Idaho into western Oregon. At the type site, the Glens Ferry deposits are at least 600 meters thick (Swirydczuk et al. 1982:545). It is possible that Lake Idaho extended into the Big Camas Prairie based on the fact that Gooding County, located immediately to the south, contains the Glens Ferry Formation. However, the Formation's age ranges from the late Pliocene to the early Pleistocene and was replaced by subsequent gravel deposits and by the Bruneau Formation well before humans could have occupied Idaho (Kimmel 1982:560).

According to Kohntopp (2001:24), the Big Camas Prairie contains deposits of a pluvial lakebed. However, no known published resources detail the existence of this pluvial lake. It is possible that the small valley did contain a pluvial lake based on the fact that the Soldier and Smoky mountains just to the north have glacial deposits (Figure 59). It may also be possible that the Big Camas Prairie was flooded during the existence of Lake Idaho and/or during the draining of Lake Bonneville. However, both of these events occurred prior to the Clovis period and would not have directly affected the people who left behind the Simon cache.

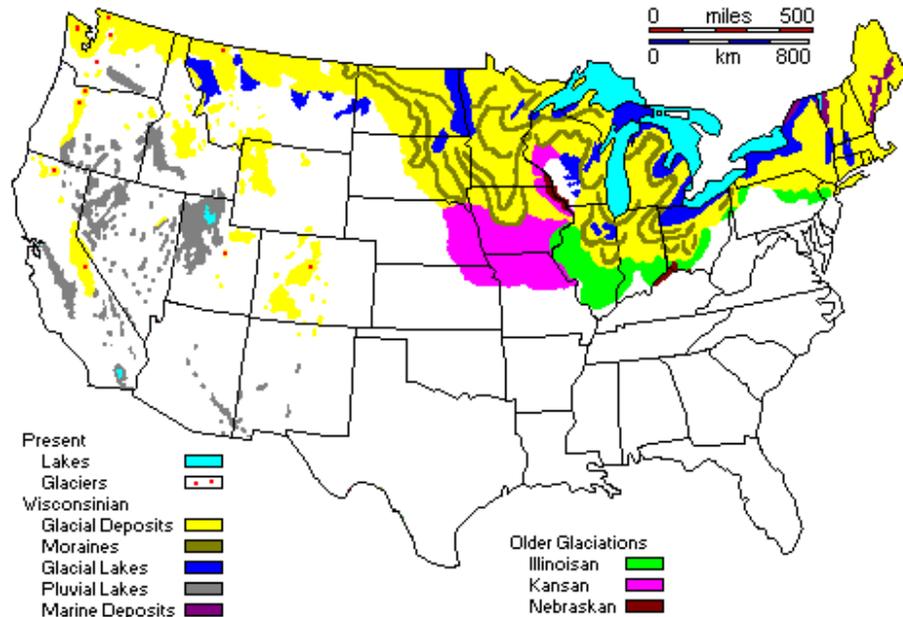


Figure 59: Glacial deposits and landforms in the continental United States (Dutch 1999).

### *Pleistocene Geomorphology of Wilsall, Montana and the Surrounding Mountains*

The Anzick site near Wilsall, Montana lies on the Shields River floodplain and is bordered by two mountain ranges: the Bridger Mountains to the west and the Crazy Mountains to the east. Lahren and Bonnicksen (1971) state that both of these mountain ranges were glaciated during the late Pleistocene. However, the Wisconsin glaciers only extended to the edge of the Shields River floodplain. Previous glacial advances did go farther into the floodplain, but they did not cover the entire area, as was the case with the Yellowstone Valley to the south (Lahren and Bonnicksen 1971).

The floodplain itself is made up of sandstone from the Livingston Formation. This formation outcrops occasionally in the floodplain, particularly along Battle Ridge, which follows the Shields River near the Anzick site northeast into Wilsall (Jones 1997:32). Livingston sandstone also comprises the cliff that runs along Flathead Creek at the location of the Anzick site. Jones (1997:39-40) theorizes that the Flathead Creek

channel has filled since the end of the Pleistocene due to the influx of a spring system. He proposes that the channel was lower during the Clovis period and that the Anzick site was located in a rockshelter or ledge along the sandstone cliff, rather than at the base of the cliff as it appeared in 1968. The cliff itself also weathered during this span of time, and the resulting colluvium eroded the rockshelter and buried the Anzick site.

### *The Green River Basin and Southwest Wyoming*

The proposed location for the Fenn cache is the Green River Basin. This area is a plain that is bordered by the Wyoming Range to the west, the Wind River Mountains to the north, the Rock Springs Uplift to the east, and the Uinta Mountains to the south. The basin is characterized as an elevated, cool desert environment, with a geomorphology made up of flood terraces that have formed since the end of the Pleistocene. As glaciers from the Wind River and Uinta Mountains melted, glacial outwash flowed into the Green River Valley. As river volume decreased following the retreat of the glaciers, increasingly lower terraces were eroded into the Green River Basin. The uppermost terraces now consist of patches of elevated alluvial quartzite gravels along a relatively flat bench. Various small drainages flow from the upper bench into the Hams Fork and Blacks Fork Rivers, which in turn join the Green River. The bedrock in this area is made up of Eocene marl, sandstone, and shale from the Bridger Formation. Aeolian deposits also occur in patches along sheltered areas on the downwind side of the bench crests, and larger dune formations (such as dome and longitudinal dunes) occur across the basin floor. The dune deposits are made up of aeolian sands and alluvial silts (Thompson and Pastor 1995:2-4).

### *Discussion and Conclusion*

The advance of glaciers followed by the buildup and subsequent flooding of large lakes at the end of the Pleistocene may be linked to the eruptions of volcanoes in the northwestern United States during the Ice Age. According to Bray (1976), ash from volcanoes could hypothetically reduce solar exposure during the summer. In turn, winter snows would not melt as thoroughly as normally, and the resulting climate change could have a deleterious impact on life in the region.

The eruptions of Glacier Peak may have had a profound impact on Paleoindian subsistence and survival. The ash from the Glacier Peak eruptions would have reduced growing seasons and caused stress for the entire ecosystem (Davis 1995). The cache at East Wenatchee may have represented an offering to stave off the effects of food shortage following the eruptions. In more general terms, ceremonial Clovis caches (ones that contain completed tools and red ochre) may have been offered during times of tragedy. The Anzick cache is the most dramatic example as it is associated with the burial of a child.

### Site-Specific Geoarchaeological Interpretations

The contexts of each of the four Clovis caches have different degrees of preservation, with East Wenatchee being the most well-preserved and Fenn being the least. As such, the completeness of the geoarchaeological record differs by site. Each cache offers its own contextual problems and presents unique geoarchaeological questions.

*East Wenatchee*

This cache has the most complete geoarchaeological record by far, but its completeness has not prevented the development of a heated debate among the archaeologists involved in the excavations. The debate centers on whether Paleoindians purposely buried the East Wenatchee artifacts in pits or left them on the Clovis-age surface. Modern excavation and analytical techniques could easily solve such a problem, but the 15-year moratorium imposed on the site in 1992 prevents further investigations until at least 2007 (Hall 1992).

The East Wenatchee cache is located at R&R Orchards in the town of East Wenatchee, Washington. The apple orchard lies in the trough of a 100 m-long current ripple that runs along a giant point bar caused by the catastrophic flooding of the Columbia River (Figure 60, Mehringer and Foit 1990:495). The origin of the flood may have been the draining of Lake Missoula or the later draining of Lake Columbia (Waite and Atwater 1989:48). Previous, larger floods left higher ripples along canyon walls to the north of the site (Mehringer and Foit 1990:495). The cache site now stands 180 m above the modern-day Columbia River (Alt 2001, Mehringer 1989:2).

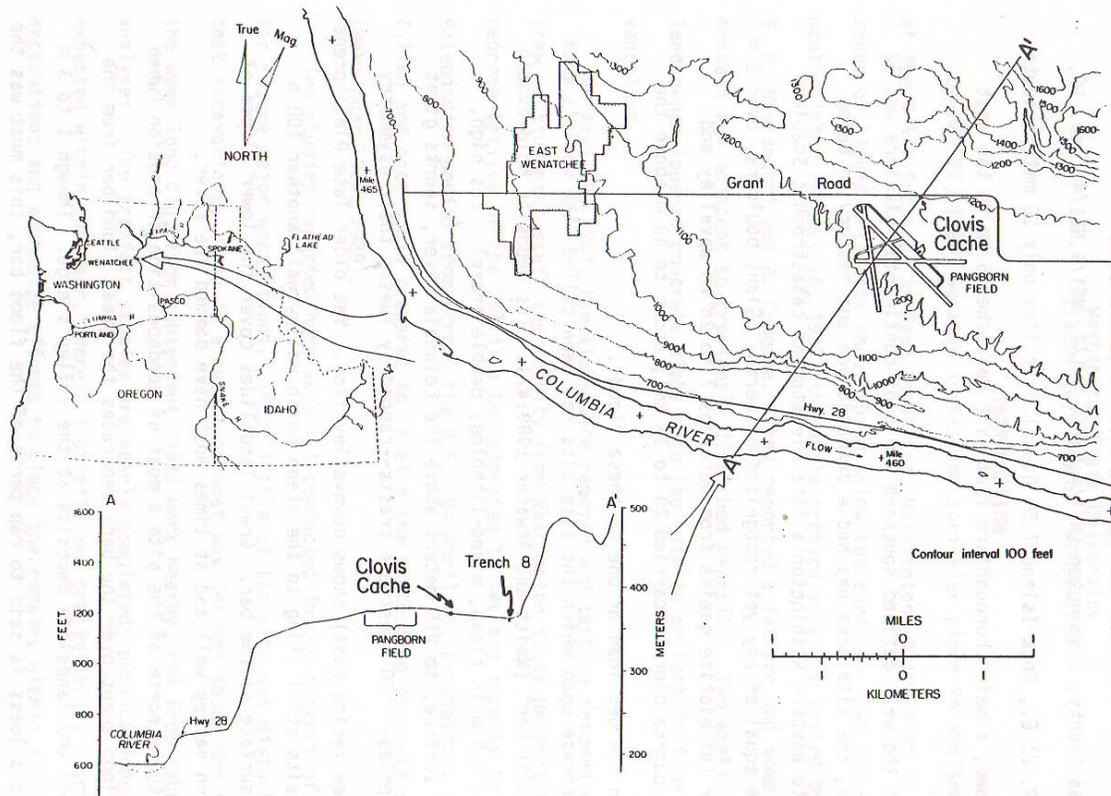


Figure 60: The study area with topographic cross section from the Columbia River over the terrace through the Clovis cache and the moat (Trench 8), to the canyon cliffs (A A'; 10X vertical exaggeration) (Mehringer 1989:3).

In 1988, Mehringer and a team of excavators dug stratigraphic test pits 16 m east and 9 m west of the cache site. They encountered the point bar sediments at depths of 80 cm and 68 cm, respectively. The excavators could not identify the point bar sediment visually; it was instead a change of texture that they could feel with their trowels. However, the point bar sediment did contain occasional basalt “drop stone” cobbles left by the floods. The sediment that overlies the point bar deposits is a layer of loess that has been deposited during the late Pleistocene and Holocene. Mehringer named the contact between these to layers Contact A (Mehringer 1989:4-6). In order to gain an accurate understanding of the sediments overlying the cache, Mehringer (1989:31-34) took vertical and horizontal sediment samples from the west wall of Excavation Unit 9,

horizontal samples from the south wall of Unit 9, and vertical samples from the west wall of Unit 7 (Figure 61).

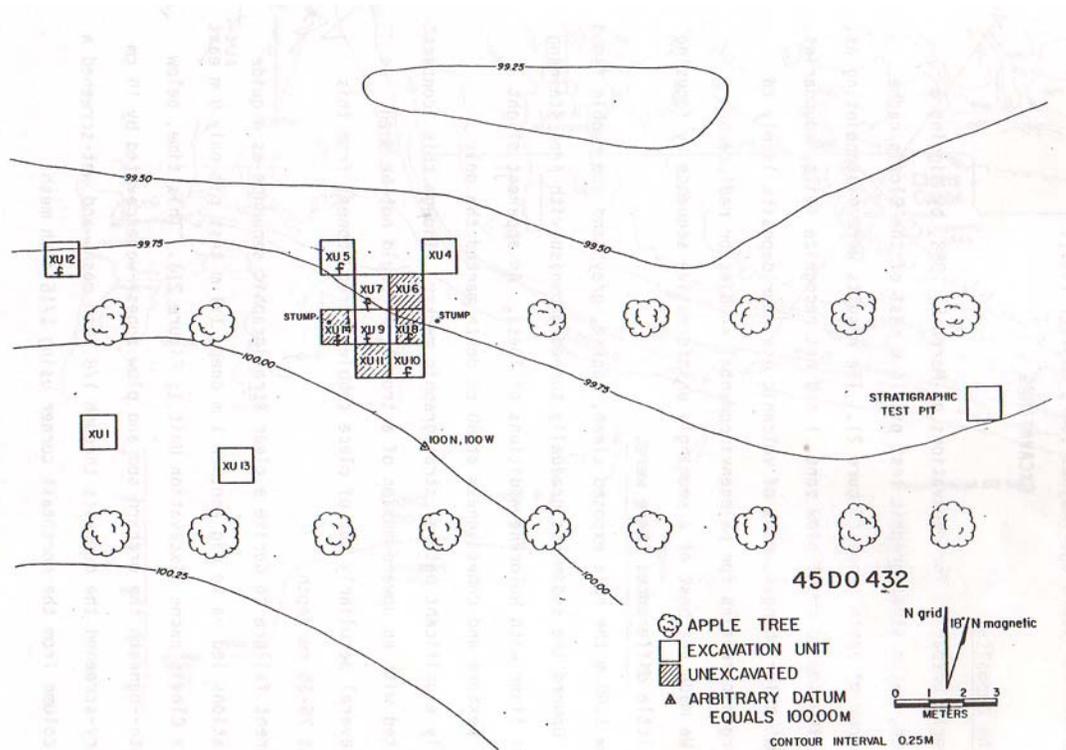


Figure 61: Layout of excavation units in the R&R Orchards just south of Grant Road (Mehring 1989:5).

Mehring (1989:6) noted that the loess layer has a slightly grayer color than the point bar sediment below Contact A, causing him to suspect the presence of tephra. In the course of the excavation, Mehring also observed the presence of pumice fragments within the grayer deposits. To gain a better understanding of the area's stratigraphy and tephrochronology, excavators dug 23 backhoe trenches across a valley 500 m to the north of the cache site. This valley lies between the cache and a canyon wall, with a moat running along the wall that fills with meltwater in the spring (Figure 62). The results of the backhoe trenching revealed seven layers, with the lowest consisting of coarse, loose

flood deposits. These gray sands and gravels represent the Pleistocene flood surface and generally fine upward, although some lag gravels appear towards the top. The next layer is made up of weakly laminated layers of brown sand and silt that have a prismatic ped structure. This layer occurs only in the deep moat deposits. The next layer, appearing everywhere except in the deepest moat deposits, is Contact A. The layer is similar to its corresponding moat deposits in that it contains brown coarse sand, however, it does not exhibit any signs of soil development. Overlying the coarse sand is the Glacier Peak tephra, which appears in the moat as lenses of mostly mixed white pumice with grains ranging from sand to silt in size. Above the Glacier Peak tephra lies the Pre-Mazama soil, the only Holocene soil that appears in Mehringer's analysis. The soil is very distinct in the moat area and features characteristics of a natric horizon. The soil becomes increasingly less distinct as one moves southward away from the moat and towards the cache. However, the soil can still be identified based as slightly reddish layer just under the Mazama tephra in Backhoe Trench 23, just across Grant Road from the cache site. The next layer is the Mazama tephra, which is mixed with loess deposits but is identifiable based on its light color. Because of its mixed deposition, the Mazama tephra has indistinct boundaries. Finally, the surface layer of Mehringer's study is the plow zone, the disturbed modern sediment that typically extends 20 to 30 cm into the ground except in areas of erosion (Mehringer 1989:18-28). It is also notable that Mehringer makes a point of stating that he could detect no Clovis-age living surface nor any sign of human disturbance of the sediment overlying the cache. He therefore proposes that the Paleoindians left the cache on the surface or buried it shallowly (Mehringer 1989:34, 40).

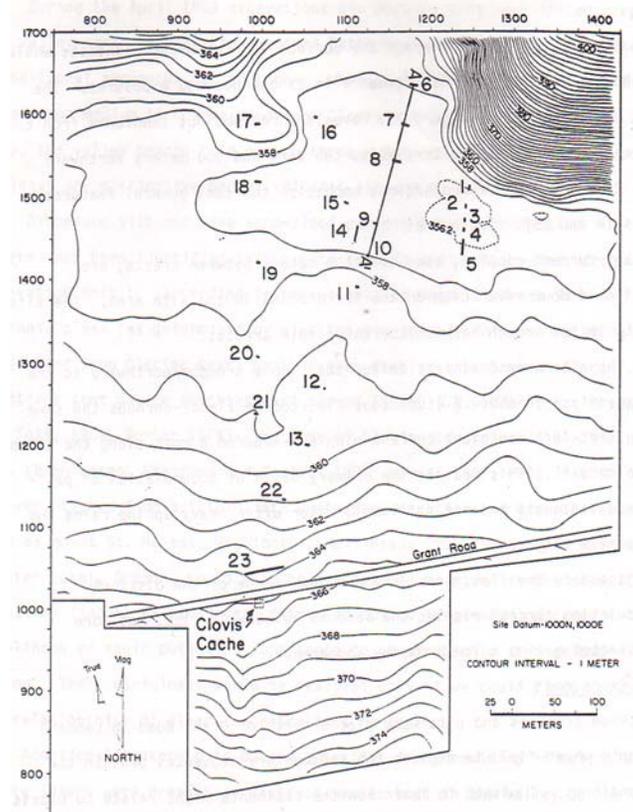


Figure 62: Base map produced using a computer program with data collected on the SDR-22 Electronic Field Notebook of a Lietz, Set 2 Total Station EDM (Mehringer 1989:19).

Although the sediment overlying the East Wenatchee cache itself is relatively uniform and therefore not useful for stratigraphy, the homogeneity of the sediment and dense concentrations of large artifacts enables accurate readings from ground penetrating radar. The radar readings confirmed the presence of Clovis artifacts in Excavation Units 7 and 9. The radar also picked up denser concentrations adjacent to these units, but Mehringer was not prepared to excavate such a large feature. Additional test units (12 and 13) farther from the cache revealed rodent burrows in Unit 12 and modern trash in Unit 13 as the sources of radar anomalies (Mehringer 1989:8-10).

The key to obtaining an age for the cache depended on careful sedimentological analyses rather than radiometric methods (Figure 63). Many of the artifacts from the

cache exhibit a siliceous crust on their ventral surfaces. Additionally, the five artifacts that Mehringer's excavation removed in 1988 also had the crust present. One of the most notable aspects of the crust is the fact that it is not present on portions of artifacts that overlie other artifacts. This fact, when combined with the knowledge that the crust only appears on the artifacts' undersides, indicates that the sediment below the cache has different properties than the sediment above it. One biface (WSHS Number 1992.24.21) that excavators removed during the 1988 excavation retained one centimeter of its surrounding sediment. This sediment revealed that the biface had a crust that was rich in pumice. Mehringer and Foit's (1990) electron microprobe analyses showed that the pumice from the crust on the artifacts matches pumice from the underlying sediment and from Trench 8 in the moat. All these samples appear to match chemically to the Glacier Peak, Layer G tephra. Additionally, very little Glacier Peak tephra is present in the sediment overlying the artifacts. The solubility of the volcanic glass beneath the cache caused the crust to form and the sediment to adhere to the artifacts (Mehringer and Foit 1990:497-500). As previously stated, Glacier Peak's Layer G tephra was originally thought to be approximately  $12,750 \pm 350$  radiocarbon years old, but later studies revealed that two major Glacier Peak eruptions (B and G) more likely occurred within a span of decades around 11,250 radiocarbon years ago and are extremely similar in composition (Porter 1978, Mehringer et al. 1984, Foit et al. 1993).

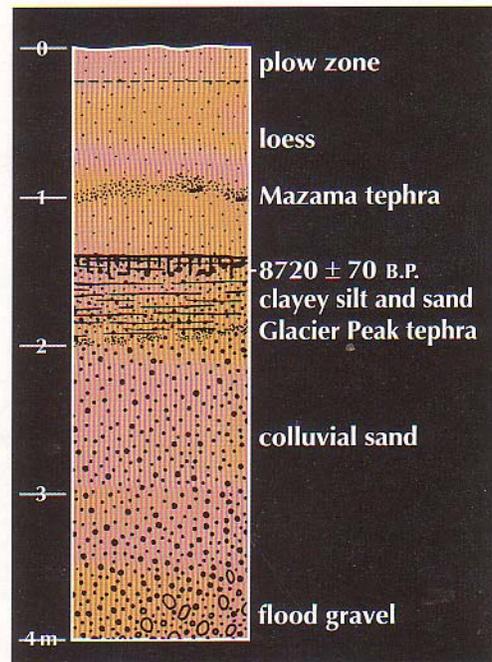


Figure 63: Schematic section of a 4-m-deep backhoe pit shows stratigraphic relationships of Mazama and Glacier Peak tephras in the post-flood sediments of the terrace moat 500 m north of the Clovis site (Mehringer and Foit 1990).

R. M. Gramly continued the excavations at the East Wenatchee in 1990, but he and his team of volunteers reached a different conclusion regarding the features than Mehringer and his team. Contrary to Mehringer's (1989:34, 40) assertion that no pit features are visible at the cache site, Gramly (1993:6) claims that most of the artifacts lay in a shallow pit of 1.1 by 1.5 m. He bases this conclusion on observations of slightly darker, looser sediment above the unexcavated artifacts. Gramly also claims that a second, deeper pit exists to the east of the main pit feature. The excavators encountered this second feature in a trench (N101E102 to N105E102 from the SE corner) two meters east of the cache excavation. The excavators uncovered a sidescraper and a blade from the bottom of this feature, at a depth of 93 cm. Throughout the fill overlying these artifacts were small flakes of agate and obsidian. Interestingly, the two artifacts from this

feature were 20 cm deeper than those from the main cache just two meters to the east (Gramly 1993:6). As proof for the existence of the second pit feature, Gramly (1993:24) creates a plot of soil sample fractions for the east and west walls of the trench (Figure 64). The graph appears to indicate disturbances in the sediment from 103N to 104N on the west wall and from 103.8N to at least 105N on the east wall. However, the y-axis and strata are not clearly labeled, making interpretations of the results difficult if not impossible.

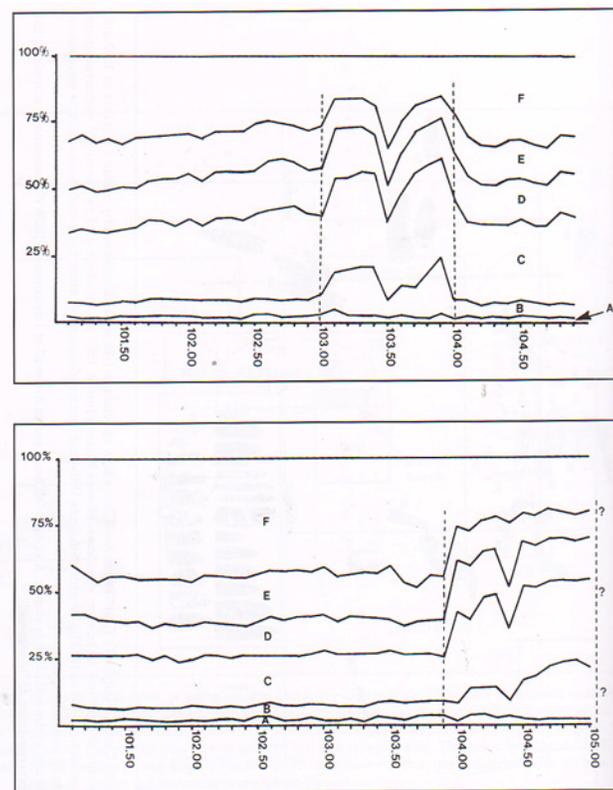


Figure 64: Sieved soil sample fractions for samples at 10 cm intervals along the west wall (top graph) and east wall (bottom graph) of L-shaped trench, East Wenatchee Clovis site, 1990 excavations. The samples were taken at the 65 cm level below surface. Boundaries of Feature 2 are presumed to exist at abrupt changes in slope (dashed line) at points N103.00 and N104.00 (west wall) and N103.80 (east wall) (Gramly 1993:24).

Robert Mierendorf (1997), the Washington State archaeologist who was the first professional to investigate the East Wenatchee site, criticizes Gramly's pit hypothesis. He points out that Mehringer's (1989) more careful stratigraphic analysis failed to locate any burial pits, despite the fact that Mehringer took numerous horizontal and vertical soil samples at close intervals. On the other hand, Mierendorf (who was present during Gramly's 1990 excavation) states that Gramly did not shave the walls or record their profiles prior to his excavation. Therefore, vertical evidence of pit fill overlying the artifacts has been lost. As alternative explanations for Gramly's two pits, Mierendorf offers two hypotheses. The first hypothesis is that the first pit, which contains the majority of the cache artifacts, is actually Contact A (Mierendorf 1997:59). Mehringer's description of the texture change in the sediment at the contact is strikingly similar to Gramly's identification of the pit boundary. For Gramly's second pit feature, Mierendorf (1997:59) provides an explanation that it may have been the remnant of a hole that was dug for a tree in the apple orchard.

Although the debate concerning pit features at the East Wenatchee site cannot be resolved fully until the moratorium on excavation is finished, it is likely that both studies have made valid points. Mehringer's (1989) report did not rule out the possibility of shallow pit features, although he did not detect any disturbance in the overlying sediment. Mierendorf (1997:59) interprets Contact A to be a possible deflation surface, wherein much of the evidence of overlying pit fill may have eroded away. Furthermore, Gramly (1998) claims that Mierendorf's test pit from the original 1987 excavation was situated entirely within the cache pit, and therefore no pit boundary could be detected at that time.

*Anzick*

The context of the Anzick site is not nearly as specific as East Wenatchee, but there is some evidence to provide archaeologists with an idea of the cache's original provenience. The construction workers who discovered the cache destroyed the top overhang of the sandstone outcrop with dynamite in order to use the sandstone for fill material. Further down slope, the workers encountered finer-grained sediments containing the cache. They removed the artifacts and only stopped digging when they encountered a human skull underlying the Clovis assemblage. Dr. Dee Taylor, the first archaeologist to investigate the site, described his attempt to understand the cache's context as "an exercise in frustration." (Taylor 1969).

Despite Taylor's frustration, the context of the Anzick site is still more observable than that of many caches. In May 1971, Larry Lahren and Robson Bonnichsen investigated the stratigraphy of the Anzick site. Lahren and Bonnichsen excavated seven stratigraphic profiles, as shown in Figure 65: two to the west and down slope of the cache find, one on the location of the burial, one south of the cache on top of the sandstone outcrop, two along the slope of the outcrop to the east of the cache, and one to the east in the meadow down slope from the outcrop (Lahren and Bonnichsen ca 1980s).

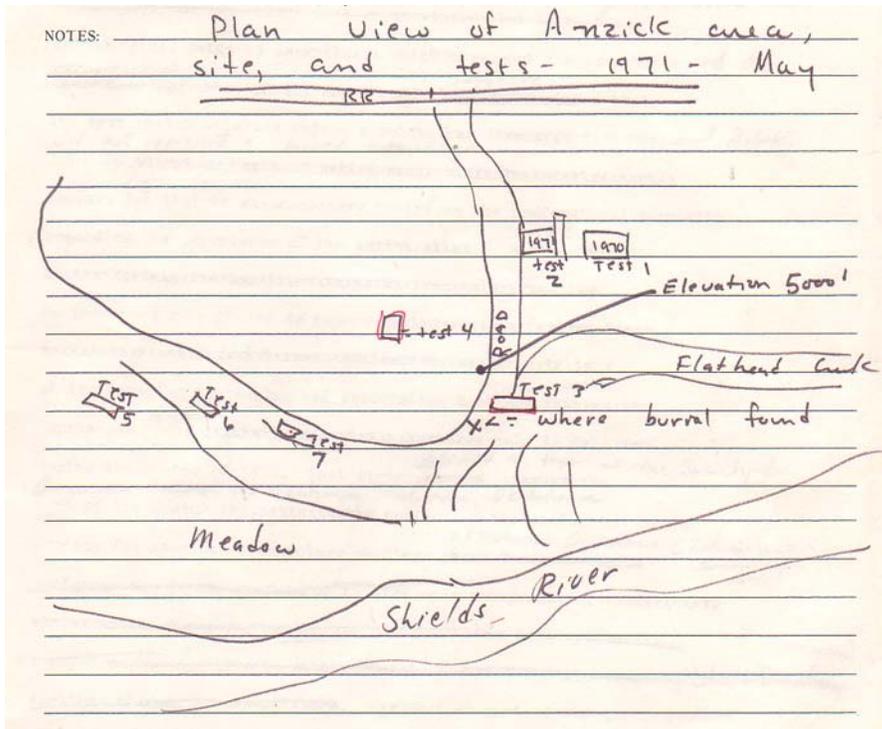


Figure 65: Plan view sketch of the Anzick site and test units. The map is oriented to the south (Lahren and Bonnicksen ca 1980s).

According to Lahren and Bonnicksen (ca 1970s), the geomorphology of the Anzick site is as follows:

1. Channel filling by the Shields River and Flathead Creek along, but not in, the burial site.
2. Rock (sandstone) weathering in the burial area and subsequent talus deposition.
3. The meadow area on the north side of the burial site seems to be the product of recent deposition over a spring system flowing from the west into the present channel of Flathead Creek.
4. It seems probable that during Clovis times the meadow area was considerably lower and that the burial may have been in a ledge or small rockshelter position, rather than in a basal slope position as it appears today.

Two sources of contention in the site's geoarchaeology are the nature of the association between the cache artifacts and the human remains and Taylor's (1969) theory that the sandstone outcrop was also used prehistorically as a bison jump. The

concern over the burial lies in the fact that not all the bones have radiocarbon ages that match with the Clovis period. Lahren (1999), however, offers his own interpretation to address this issue. While the Anzick site was originally believed to be a burial of two Clovis-age juveniles, Lahren's interpretation states that only one of the individuals is as old as the cache. Individual 1 consists of weathered and bleached cranial fragments that were found about 10 to 12 feet away from the cache, and Individual 2 represents the red ochre-stained remains that the construction workers found lying beneath the cache artifacts. AMS ages on Individual 1 averaged to  $8,610 \pm 90$  years B. P., and seven ages on Individual 2 have an average of  $10,680 \pm 50$  years B. P. Based on this evidence, Lahren suggests that only Individual 2 is part of the Anzick Clovis assemblage, while Individual 1 represents later cultural activity.

Lahren and Bonnicksen (ca 1980s) criticize Talyor's (1969) assertion that the Anzick site was also used as a bison jump. Bison jumps are sites that occur at the bases of cliffs or other sharp dropoffs where hunters can herd bison and drive them off the edge, creating a massive kill site. Well known bison jumps, such as the Bonfire site in Texas, contain the remains of hundreds of bison (Dibble and Lorrain 1968). On the other hand, the Anzick site does have bison remains, but they occur much more sparingly and are disarticulated. There is no clear evidence of human activity associated with the bison bones, and it is equally possible that carnivores or scavengers left the bones at the site (Lahren and Bonnicksen ca 1980s).

*Simon*

The original location of this cache lies along a plowed field about one mile to the east of Deer Creek in the Big Camas Prairie, Camas County, Idaho (Butler 1963:23). The site is about 50 km north of the Snake River (Woods and Titmus 1985:3). William Simon uncovered the artifacts in yellow alluvium while scraping the ground for a roadway (Butler 1963:22). The alluvium is the result of deposition that has been accumulating in the Big Camas prairie since the middle or late Pleistocene and consists of water-laden sediment that is 30% sand and 70% sandy clay in the upper 250 feet. The sediment also contains pebbles up to  $\frac{3}{4}$  of an inch in diameter (Piper 1926).

This portion of the Big Camas Prairie contains numerous small creeks and tributaries that join Camas Creek, which travels through the center of the prairie from west to east. Just to the west of the cache site is a field that has surface deposition of moist black clay. This clay represents evidence of a paleochannel lying adjacent to the cache. The tributaries of Camas Creek, including Deer Creek, are meandering streams, and this paleochannel most likely represents a former channel of Deer Creek (Butler 1963:23). Butler states that the Simon cache pre-dates the paleochannel, as it was found in the underlying yellow alluvium instead of the black clay. Because the roadway construction removed the overlying sediment, it is impossible to determine whether the black clay was present directly above the cache, however. Moreover, Butler (1963:23) states that the cache was buried about 12 to 18 inches deep on a rise in the yellow alluvium. The cache site was no more than 18 feet in diameter and was situated along the western slope of this rise. It is possible that this raised surface was not part of the paleochannel immediately to the west.

One curious aspect of the Simon site is a portion of red stained sediment that occurs in the center of the 18-foot wide area designated as the find spot. Butler (1963:23) states that this stained area represents an area of burned sediment, but he admits that no faunal remains nor charcoal were associated with the artifacts. Butler does state that one biface exhibits pot-lid scars on both sides, indicating that the artifact had been exposed to fire. This evidence, however, is too scant to ascertain that the red stain in the ground is the result of fire. It seems equally, if not more likely that the red staining is due to the presence of red ochre.

Kohntopp (2001:69) proposes that the Big Camas Prairie is the location of a pluvial lake that did not dry until 10,000 years B. P. Therefore, the Simon cache could be a watery offering, similar to river offerings found in prehistoric Europe. However, this theory is most likely erroneous due to the fact that no published research indicates the presence of a pluvial lake so far north of the Great Basin. Moreover, the sediment of the Big Camas Prairie is alluvial, and published references make no mention of lacustrine deposits, such as extensive clay deposition, varves, laminae, or evaoporites. Moreover, the presence of red ochre/burnt ground at the site of the cache argues against the possibility of a watery offering. The pluvial lake hypothesis would have to explain how the red staining could appear if the entire area was under water during the Clovis period.

### *Fenn*

Archaeologists know of two different stories concerning the original context of the Fenn cache. One story is that the cache was uncovered in a plowed field, while the other states that the artifacts were found in a skin bag in a dry cave (Frison and Bradley

1999:22). Frison and Bradley believe that the cave hypothesis is more likely because the artifacts show no evidence of plow damage. Moreover, the modern-day people consider the region of the Wyoming Basin, of which the Green River Basin is a part, to be largely inhospitable and not suitable for farming (Sharrock 1966:1). However, the notion that a bag could remain intact even in a cave since the terminal Pleistocene seems to be far-fetched.

Because the location of the actual Fenn site is unknown, the Pine Spring site (48SW101) may act as an approximation for the conditions and landscape that Paleoindians encountered in the region (Figure 66). The Pine Spring site is located about ten miles west of the Flaming Gorge reservoir along the northern slope of Black Mountain in Sweetwater County, Wyoming. A spring outlet provided a source of water for the inhabitants of the site and is located immediately to the west of Excavation Trenches 4 and 6. Moreover, a chert outcrop is present to the northwest, slightly down slope from the site. This outcrop is made up of limestone interspersed with nodules of black and tan banded “tiger” chert of the Green River Formation (Sharrock 1966:12-17). The area is largely devoid of vegetation, except near the spring itself. The landscape adjacent to the spring consists of two parallel ridges that support localized plants. This vegetation has persisted long enough for soils to develop along the spring, although there is almost no soil development elsewhere in the area. The vegetation that depends on the spring changes as one moves down slope, starting with mahogany at the springhead, then juniper, then alternating aspen and cottonwood, and finally blue spruce at the northernmost portion of the site (Sharrock 1966:12-15). The soils near the spring are formed from bentonitic calcareous clay and from landslide deposits that overlie clay and

shale from the Bridger Formation. The soil that formed on the clay has an A1 horizon that extends from the surface to a depth of 15 inches, an A-C horizon from 15 to 18 inches, and a Cca horizon from 18 to 41 inches. The soil that formed on the landslide deposit has an A horizon that extends to 13.5 inches, and the B horizon extends down to 48 inches. Both soils have calcium carbonate present throughout their profiles, indicating the presence of water. The spring and the soil formation most likely became active at the end of the Pleistocene (Eardley 1966:197-200).

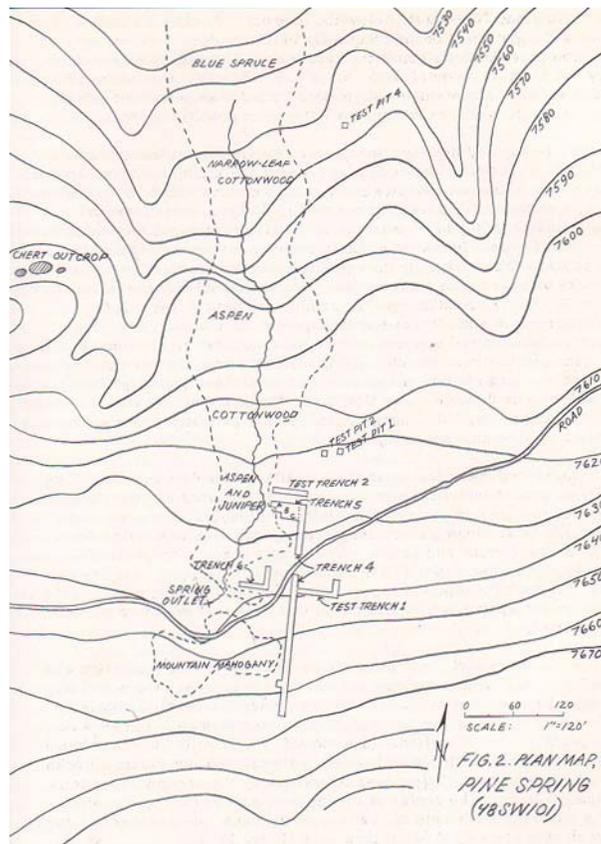


Figure 66: Map of the Pine Spring site with excavation trenches (Sharrock 1966:13).

The 1966 excavations at Pine Spring site identified three cultural occupation levels (Figure 67). The lowest and earliest identifiable occupation occurs in the C

horizon of the soil. The development of the C horizon after the deposition of cultural material has removed any trace of burned ground or ash lenses, and no features were noted. Occupation 2 occurs in the B horizon and has some evidence of fire discoloration and charcoal flecks. Additionally, there are fire-lined hearth features in Occupation 2. Finally, Occupation 3 appears in the A horizon and on the surface, along with modern trash. Ceramics appear in this level, but features are not present due to rodent burrowing. Occupation 1 is believed to represent the Plano paleoindian complex based on projectile point typology and radiocarbon ages of  $9,745 \pm 195$  B. P. and  $11,880 \pm 410$  B. P., although the latter date is most likely erroneous. Occupation 2 is generally considered Archaic, with a radiocarbon age of  $3,685 \pm 80$  B. P., but Plano points appear in this level as well. Occupation 3 is not as well-identified, but it is obviously later based on Fremont ceramics and a prevalence of groundstone technology. The three occupations all appear to represent quarrying and camping activities, with some food processing as evidenced by the presence of bison and camel bones in the earliest occupation and cooking stones and groundstones in the later levels (Sharrock 1966:20-29).

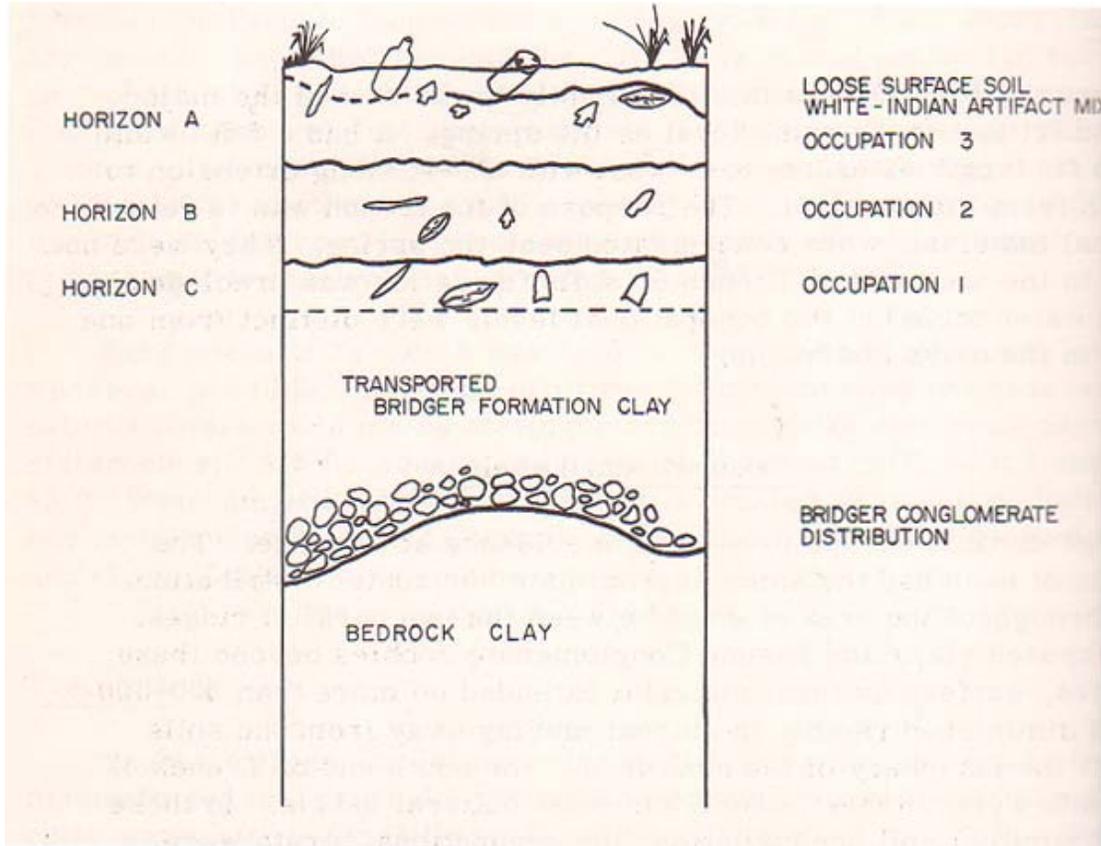


Figure 67: Sketch of a typical section, Pine Spring site (Sharrock 1966:20).

During the summers of 1998 and 2000, archaeologists lead by Robert L. Kelly (2000) re-investigated the Pine Spring site. The purpose of the further excavations was to answer some lingering questions left by Sharrock's original analysis. First, the excavations provided additional lithic analysis, including usewear analysis and the recovering of pressure flake debitage that was not present in the original collection. Second, Kelly's research examined the faunal remains for signs of human use. Third, Kelly focuses on the camel and bison remains to determine whether they are associated with human artifacts. Finally, the 1998 and 2000 excavations intended to clear the ambiguity surrounding the stratigraphy of the site. My analysis focuses on this latter goal (Figures 68 and 69).

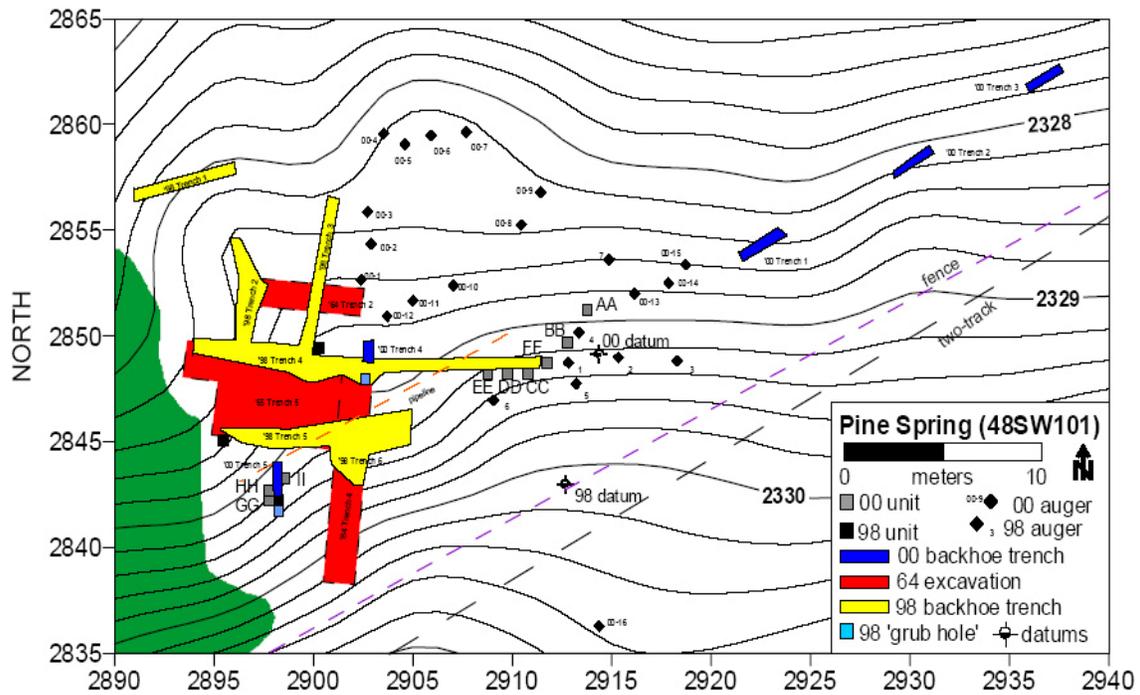


Figure 68: Map of the main excavation area (Kelly 2000:12).

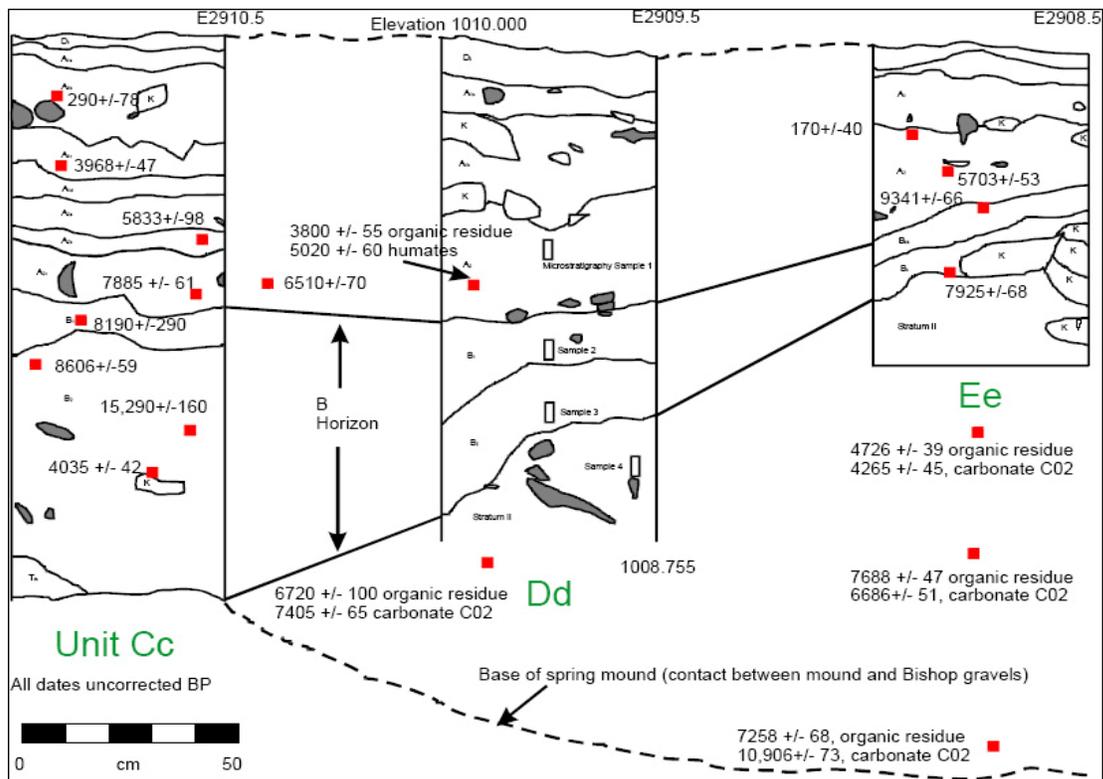


Figure 69: Units excavated along 1998 Trench 4 with radiocarbon dates (Kelly 2000:16).

The 1998 and 2000 excavations were unfortunately unable to replicate Sharrock's stratigraphic findings in terms of Occupation levels, but Kelly (2000) agrees that soil is more developed to the east of the spring than to the west. The later excavations did uncover more late Paleoindian artifacts, but their findings of mixed deposits were more widespread than Sharrock had indicated. Kelly states it is possible that the site has been deflated by wind activity, and it is also likely that long periods of stability and soil formation have compressed the stratigraphic time periods. The site has also been plagued with looting and bioturbation, complicating the archaeologists' attempts to uncover intact stratigraphy. Kelly (2000:46-47) noted that the largest cobbles of colluvial rock appear in the lowest levels of the site, while only the smallest of debitage and bone fragments appear in these levels. Therefore, the cultural materials were probably deposited over the colluvium and worked their way down through bioturbation, clay swelling, and freeze-thaw cycles.

If the Pine Spring site is an accurate depiction of Paleoindian sites in the Green River Basin, then one can project some hypotheses as to the context of the Fenn cache. At Pine Spring, the Paleoindian artifacts were shallowly buried, mostly less than 1 m. Outcrops of tiger chert, resembling the Green River Formation chert that Frison and Bradley (1999) describe in the Fenn collection, are common in the area. The cache would also have been located near a water source, as the other three caches in this study have been located along or near creeks or rivers. Therefore, a location near a spring would have been a distinct possibility for the Fenn cache. Unfortunately, had archaeologists actually uncovered the Fenn cache, the bioturbation, clay swells, and

freeze-thaws that can occur in the area would probably have disturbed the cache's original context.

### *Soil Acidity and the Preservation of Organic Artifacts*

The presence of bone rods at East Wenatchee and Anzick sets these two cache sites apart from Simon and Fenn. However, because the rods are made from organic materials, it is possible that the artifacts simply did not preserve into the present. If bone rods were originally present in all four of these caches, then the level of acidity in the soil at each site could account for their presence or absence today.

For the East Wenatchee site, the soil surrounding the area is characterized as Pogue fine sandy loam and has a pH range of 6.1 to 7.8 (USDA 1981a). Moreover, Gramly (1990) states that the sediment surrounding the cache has a pH of 6.5, but it may have become acidic in recent years due to the planting of the apple orchard. The surface soil surrounding the Anzick site has a pH of 7.6 to 7.8, which probably contributes to the preservation of both the bone rods and the human remains (Park County, MO NRCS personal communication). The Simon site lies within either the Brinegar loam, which has a pH range of 6.1 to 7.3 and may represent the paleochannel sediment, or the Rands loam representing the yellow alluvium with a pH of 6.1 to 6.5 near the surface (USDA 1981b). If the Simon cache actually came from the Rands loam, then the soil's high acidity could have erased any traces of organic materials associated with the cache. However, the area of the Pine Spring site has a pH of 7.5 to 9 (Jeff Louis personal communication). If the Pine Spring site is an accurate approximation for the location of the Fenn cache, then soil acidity cannot explain the absence of bone tools from the collection.

In sum, it is possible that the pH of the soil at a cache site may contribute to the presence or absence of bone rods, but it is not necessarily the deciding factor. Based on the extremely basic soil that is present in the Pine Spring site, it is likely that the Fenn cache never contained bone tools at all. As such, bone rods do not always accompany the stone tools found in Clovis caches, and their presence or absence may indicate different purposes for the caches.

## CONCLUSIONS

The four Clovis caches presented in this study relate to each other in a number of ways, but no two are exactly the same. It presents a difficult dilemma for anyone who seeks to define technological differences within a single complex. However, the results of this study can provide some new directions for research.

The statistical analyses first show that the artifact assemblages are largely not normally distributed, but the subsequent methods used in this study do not depend on normal distribution. The factor analysis reveals that all variables could be condensed into components of size and shape and that these components can be applied to all artifact types. Extensive cluster analyses reveals that, within each site, fluted points have two to four size and shape clusters, bifaces have four to six clusters, and bone rods generally have two or three clusters per assemblage. Analyses of the size and shape data from all the cache sites reveals that fluted points form three clusters according to size but not shape, bifaces do not form discernable clusters (although Anzick and Simon have greater variances than East Wenatchee and Fenn), and bone rods cluster almost entirely according to their site of origin. Comparing the results of the size and shape analysis on the East Wenatchee artifacts to their *in situ* locations at the site reveals that only the fluted points may have been grouped according to size and shape. However, one cannot rule out that the fluted points may have been randomly placed, or the bifaces and bone rods may have been disturbed from their original positions.

Additionally, the correspondence analyses portray some overlooked aspects of the cache assemblages. The first analysis shows the overwhelming number of flakes that are

present at East Wenatchee compared to the other three caches. After adding five additional caches for the second analysis, the caches split into groups characterized by their abundance of blades, flakes, or fluted points and bifaces. After eliminating the blade and flake categories for the third analysis, two of the four original caches remain biface-dominated, but East Wenatchee is closer to the bone rod category, and Fenn is closest to the fluted point category. Adding three extra caches for the fourth analysis does not substantially change these results.

The geoarchaeology of the cache sites provides some comparative insight to the caches' contexts. Paleoindians left the East Wenatchee cache on a giant point bar along the bloated Columbia River at the end of the Pleistocene. It is possible that the Channeled Scablands immediately to the east of the site were flooded at this time, either from the draining of Lake Missoula or the emptying of Lake Columbia. Additionally, the cache was deposited immediately following an eruption of Glacier Peak. Undoubtedly, this period was a time of profound geological changes in eastern Washington State. It is possible that Paleoindians left the East Wenatchee cache as a ritual offering to stave off these disasters, although the evidence of red ochre that is often associated with ritual offerings is enigmatically scant. Moreover, the presence of small flakes at the site may indicate that more mundane activities also occurred.

Examining the geoarchaeological literature that is available for the Anzick site reveals that the cache may represent the burial assemblage of one individual, not two as was previously assumed. The second burial consists of weathered cranium fragments that were found ten to twelve feet away from the cache assemblage. Unlike the artifact

assemblage and the first burial, the second burial is not covered in red ochre and has a radiocarbon age that is 2,000 years younger than the Clovis period (Lahren 1999).

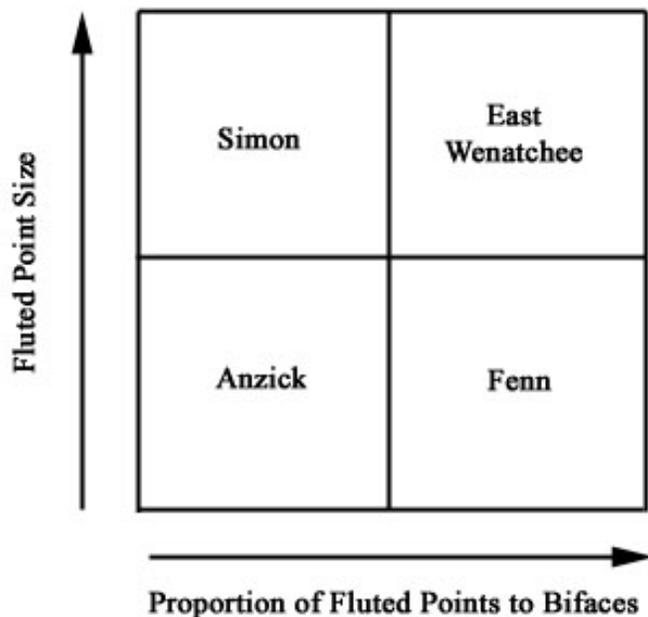
Kohntopp (2001:69) proposes the possibility that the Simon cache was an offering that was thrown into a pluvial lake. However, the geological evidence found in this study does not support this hypothesis. No known studies on the geology of Idaho show that pluvial lakes have existed in the area since the late Pliocene, and the draining of Lake Bonneville through the Snake River does not seem to extend into the Big Camas Prairie. While it might be reasonable to infer that there would have been more water in the Big Camas Prairie as mountain glaciers melted at the end of the Pleistocene, the geological evidence shows extensive fluvial deposits and paleochannels, rather than an accumulation of lacustrine sediment. Moreover, the presence of a red-stained surface at the find spot indicates either that the artifacts were covered with red ochre, or that the ground around them was burned. Either way, such evidence would not likely be present in a watery offering.

Being from an unknown location, understanding the context of the Fenn cache requires research on an analogous site. The Pine Spring site is a Paleoindian site in southwestern Wyoming that serves this purpose well. The site contains shallowly buried Paleoindian components, a nearby source of Green River chert, and it is adjacent to a spring. Another well known Paleoindian site in this area, the Finley site, is also shallowly buried and located near a spring (Frison 1978:183-185). Therefore, if the Fenn cache was located in an open air site in the same area, it may have been shallowly buried and located near a similar water source.

One of the mysteries surrounding Clovis caches is the presence of bone rods. This research tested the hypothesis that bone rods may have been present at each cache but only survived in the caches that have low soil acidity. The data do not support this hypothesis, as East Wenatchee has fairly acidic soil and bone rods present, while the area around the Pine Spring site has extremely basic soil, but bone rods are not present in the Fenn cache.

Comparing the Clovis caches against each other is a complicated process, as no two caches are universally similar to each other. By looking strictly at the fluted points and bifaces, the two artifact types that are present in each of the four caches, the following pattern emerges (Table 36):

Table 36: Increasing fluted point size compared in increasing proportions of fluted points to bifaces in each cache assemblage.



Judging entirely from these criteria, one might logically assume that caches with a high number of bifaces would be utilitarian, and caches with many large fluted points would be ritual. However, the Anzick cache has many times more bifaces than fluted points, and most of the points from Anzick are relatively small. Still, the Anzick cache is the only assemblage associated with a known burial, so it is obviously ceremonial. One cannot, however, rule out the possibility that all the caches are in some way ceremonial. Different cache contents may indicate different ritualistic behaviors, different seasons, or even different cultures. It is also possible that a mortuary assemblage contains the toolkit of the individual that is buried, and hence a whole reduction sequence from large biface to finished point could be present. Other caches may represent more regular, planned offerings in which completed tools are more common.

Examining the caches from a regional perspective brings forth some additional patterns in Clovis caching behavior (Figure 70). Based data available from nine caches in the western United States, various regional patterns emerge. The northernmost caches contain bone rods, the westernmost caches have large fluted points, caches in the Rocky Mountains and northern Great Plains emphasize bifacial technology, and caches in the south emphasize blades. These regional patterns may be only tentative, however, and new data from additional Clovis caches will undoubtedly modify these results.

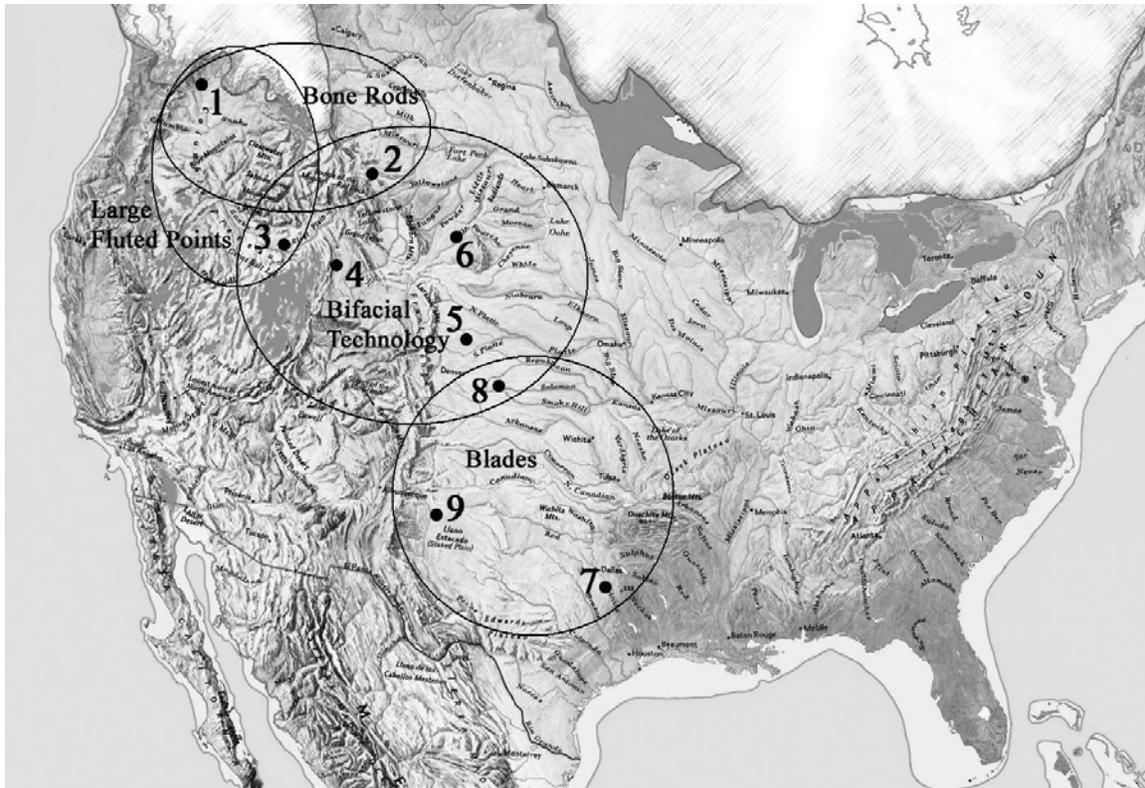


Figure 70: Locations of Clovis caches in the United States with circles enclosing the regional patterns. 1=East Wenatchee, 2=Anzick, 3=Simon, 4=Fenn, 5=Drake, 6=Crook County, 7=Keven Davis, 8=Busse, 9=Green.

## REFERENCES CITED

- Alt, D. D.  
2001 *Glacial Lake Missoula and Its Humongous Floods*. Mountain Press Publishing, Missoula, Montana.
- Bailey, R. G.  
1976 *Ecoregions of the United States*. U. S. Department of Agriculture, Washington, D.C. [map]
- Baxter, M. J.  
1994 *Exploratory Multivariate Analysis in Archaeology*. Edinburgh University Press, Edinburgh, Scotland.
- Bonnichsen, R., S. Barnes, K. Goodrich, W. DuPlessis, T. Stryffeler, M. Weitzel, and D. White.  
1995 Data Base and Systematics for the East Wenatchee Clovis Site, East Wenatchee Washington (45-WH-482). Manuscript on file, Center for the Study of the First Americans, Texas A&M University, College Station.
- Booth, D. B., K. G. Troost, J. J. Clague, and R. B. Waitt  
2004 The Cordilleran Ice Sheet. In *The Quaternary Period in the United States*, edited by A. R. Gillespie, S. C. Porter, and B. F. Atwater, pp. 17-43. Elsevier, Amsterdam.
- Bray, J. R.  
1976 Volcanic Triggering of Glaciation. *Nature* 260:414-415.
- Brooker, J.  
2000 East Wenatchee Clovis Point Arrowhead Find. Electronic document, [http://www.suite101.com/article.cfm/washington\\_state/40822](http://www.suite101.com/article.cfm/washington_state/40822), accessed September 7, 2005.
- Butler, B. R.  
1963 An Early Man Site at Big Camas Prairie, South-Central Idaho. *Tebiwa* 6:22-34.
- Butler, B. R. and R. J. Fitzwater  
1965 A Further Note on the Clovis Site at Big Camas Prairie. *Tebiwa* 8(1):38-40.
- Canby, T. Y.  
1979 The Search for the First Americans. *National Geographic* 156(3):330-363.
- Collins, M. B.  
1999 *Clovis Blade Technology*. University of Texas Press, Austin.

Collins, M. B. and T. R. Hester

2001 Clovis Occupation in Central Texas. Electronic document, <http://www.utexas.edu/research/tarl/research/Gault/desc/desc.htm>, accessed September 9, 2005.

2004 Interpreting the Clovis Artifacts from the Gault Site. Electronic document, <http://www.utexas.edu/research/tarl/research/Gault/artifacts/artifacts.htm>, accessed September 9, 2005.

Cressman, L. S.

1977 *Prehistory of the Far West*. University of Utah Press, Salt Lake City.

CSFA (Center for the Study of the First Americans)

ca. 1974 Anzick Site 24PA506 Data and Information. Manuscript on file, Center for the Study of the First Americans, Texas A&M University, College Station.

Currey, D. R.

1990 Quaternary Palaeolakes in the Evolution of Semidesert Basins, with Special Emphasis on Lake Bonneville and the Great Basin, U.S.A. *Palaeogeography, Palaeoclimatology, Palaeoecology* 76:198-214.

Davis, L. G.

1995 Late-Pleistocene Volcanic Activity in the Pacific Northwest: Cultural and Environmental Considerations. *Current Research in the Pleistocene* 12:113-114.

Dibble, D. S. and D. Lorrain

1968 *Bonfire Shelter: A Stratified Bison Kill Site, Val Verde County, Texas*. Texas Memorial Museum Miscellaneous Papers No. 1, Austin.

Dutch, S.

1999 Pleistocene Glaciers and Geography. Electronic document, <http://www.uwgb.edu/dutchs/EarthSC202Notes/GLACgeog.htm>, accessed August 19, 2005.

Eardley A. J.

1966 Appendix 1. In Prehistoric Occupation Patterns in Southwest Wyoming and Cultural Relationships with the Great Basin and Plains Cultural Areas, by F. W. Sharrock, pp.195-207. *University of Utah Anthropological Papers* 77. University of Utah Press, Salt Lake City.

Ferring, C. R.

1989 The Aubrey Clovis Site: A Paleoindian Locality in the Upper Trinity River Basin, Texas. *Current Research in the Pleistocene* 6:9-11.

- Foit, F. F., Jr., P. J. Mehringer, Jr., and J. C. Sheppard  
 1993 Age, Distribution, and Stratigraphy of Glacier Peak Tephra in Eastern Washington and Western Montana, United States. *Canadian Journal of Earth Sciences* 30(3):535-552.
- Frenkel, R. E.  
 1979 Vegetation. In *Atlas of the Pacific Northwest*, edited by R. M. Highsmith, Jr. and A. J. Kimerling, pp. 55-60. Oregon State University Press, Corvallis.
- Frison, G. C.  
 1978 *Prehistoric Hunters of the High Plains*. 1<sup>st</sup> ed. Academic Press, Inc., San Diego.  
 1991 *Prehistoric Hunters of the High Plains*. 2<sup>nd</sup> ed. Academic Press, Inc., San Diego.
- Frison, G. C. and B. Bradley  
 1999 *The Fenn Cache: Clovis Weapons and Tools*. One Horse Land & Cattle Company, Santa Fe, New Mexico.
- Gramly, R. M.  
 1990 *Clovis Dig 2 vol. 6*. Produced and directed by J. Gahringer, 2 hours. Center for the Study of the First Americans, Texas A&M University, College Station. [videocassette]  
 1993 *The Richey Clovis Cache*, 1<sup>st</sup> ed. Persimmon Press, Buffalo, New York.  
 1998 Pit Features at the East Wenatchee Clovis Site and Elsewhere. *Current Research in the Pleistocene* 15:14-16.  
 2004 *The Richey Clovis Cache*, 2<sup>nd</sup> ed. Partners' Press, Kenmore, New York.
- Green, F. E.  
 1963 The Clovis Blades: An Important Addition to the Llano Complex. *American Antiquity* 29(2):145-165.
- Hall, D. A. (editor)  
 1992 Welcome Clovis Cache Accord Avoids One Troublesome Issue. *Mammoth Trumpet* 8(1):3.
- Hannus, L. A.  
 1989 Flaked Mammoth Bone from the Lange/Ferguson Site, White River Badlands Area, South Dakota. In *Bone Modification*, edited by R. Bonnicksen and M. H. Sorg, pp. 395-412. Center for the Study of the First Americans, Institute for Quaternary Studies, University of Maine, Orono.
- Haynes, C. V. and E. T. Hemmings  
 1968 Mammoth-Bone Shaft Wrench from Murray Springs, Arizona. *Science* 159(3811):186-187.

- Haynes, C. V., Jr., M. McFaul, R. H. Brunswig, and K. D. Hopkins  
1998 Kersey-Kerner Terrace Investigations at the Dent and Bernhardt Sites, Colorado. *Geoarchaeology* 13(2):201-208.
- Haynes, G.  
2002 *The Early Settlement of North America: The Clovis Era*. Cambridge University Press, New York.
- Hester, J. J.  
1972 *Blackwater Locality No. 1: A Stratified, Early Man Site in Eastern New Mexico*. Fort Burgwin Research Center (Southern Methodist University) Publication No. 8, Ranchos de Taos, New Mexico.
- Hofman, J. L.  
1995 The Busse Cache: A Clovis-Age Find in Northwestern Kansas. *Current Research in the Pleistocene* 12:17-19.
- Houghton, S. G.  
1976 *Trace of Desert Waters: The Great Basin Story*. Arthur H. Clark Company, Glendale, California.
- Jones, J. S.  
1997 *The Anzick Site: Analysis of a Clovis Burial Assemblage*. MA thesis, Department of Anthropology, Oregon State University.
- Kachigan, S. K.  
1991 *Multivariate Statistical Analysis: A Conceptual Introduction*, 2<sup>nd</sup> ed. Radius Press, New York.
- Kelly, R. L.  
2000 *Early Holocene Prehistory of the Intermontane West: Reinvestigation of the Pine Spring Site, Southwest Wyoming*. NSF 99-73272 Final Report, National Science Foundation, Washington, D.C.
- Kendall, D. G.  
1970 A Mathematical Approach to Seriation. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences*. 269(1193):125-134.
- Kimmel, P. G.  
1982 Stratigraphy, Age, and Tectonic Setting of the Miocene-Pliocene Lacustrine Sediments of the Western Snake River Plain, Oregon and Idaho. In *Cenozoic Geology of Idaho*, edited by B. Bonnicksen and R. M. Breckenridge, pp. 559-578. Idaho Geological Survey, University of Idaho, Moscow, Idaho.

Kohntopp, S.

2001 *A Summary of Four Lithic Caches on the South Central Snake River Plain of Idaho: Their Possible Purposes and Relationships*. MA thesis, School of Archaeological Studies, University of Leicester.

Kornfeld, M., K. Akoshima, G. C. Frison

1990 Stone Tool Caching on the North American Plains: Implications of the McKean Site Tool Kit. *Journal of Field Archaeology* 17(3):301-309.

Lafferty, R. H. III

1994 Prehistoric Exchange in the Lower Mississippi Valley. In *Prehistoric Exchange Systems in North America*, edited by T. G. Baugh and J. E. Ericson, pp. 177-213. Plenum Press, New York.

Lahey, J. F.

1979 Climate. In *Atlas of the Pacific Northwest*, edited by R. M. Highsmith, Jr. and A. J. Kimerling, pp. 43-54. Oregon State University Press, Corvallis.

Lahren, L.

ca 1990 The History of the Anzick Site: An 11,000 Year Old Mammoth Hunter Site in Park County, Montana. Manuscript on file, Center for the Study of the First Americans, Texas A&M University, College Station, Texas.

1999 Human Skeletal Remains from the Anzick Site (24PA506). Manuscript on file, Center for the Study of the First Americans, Texas A&M University, College Station, Texas.

Lahren, L. and R. Bonnicksen

ca 1970s The Anzick or Wilsall Site: A Clovis Complex Burial in the Shields River Valley of Southwestern Montana. Manuscript on file, Center for the Study of the First Americans, Texas A&M University, College Station, Texas.

1971 The Anzick Site: A Llano Complex Burial in Southwestern Montana. Paper presented at the Society for American Archaeology Annual Meeting, Norman, Oklahoma.

1974 Bone Foreshafts from a Clovis Burial in Southwestern Montana. *Science* 186(4159):147-150.

ca 1980s History of Discovery. Manuscript on file, Center for the Study of the First Americans, Texas A&M University, College Station, Texas.

Lemke, R. W., M. R. Mudge, R. E. Wilcox, and H. A. Powers

1975 Geologic Setting of the Glacier Peak and Mazama Ash-Bed Markers in West-Central Montana. *U. S. Geological Society Bulletin* 1395-H.

- Link, P. K., D. S. Kaufman, and G. D. Thackray  
1999 Field Guide to Pleistocene Lakes Thatcher and Bonneville and the Bonneville Flood, Southeastern Idaho. In *Guidebook to the Geology of Eastern Idaho*, edited by S. S. Hughes and G. D. Thackray, pp. 251-266. Idaho Museum of Natural History, Pocatello, Idaho.
- Mehringer, P. J., Jr.  
1989 *Age of the Clovis Cache at East Wenatchee, Washington*. A Report to the Washington State Historic Preservation Office, Washington State University, Pullman, Washington.
- Mehringer, P. J., Jr., S. F. Arno, and K. L. Petersen  
1977 Postglacial History of Lost Trail Pass Bog, Bitterroot Mountains, Montana. *Arctic and Alpine Research* 9:345-368.
- Mehringer, P. J., Jr. and F. F. Foit, Jr.  
1990 Volcanic Ash Dating of the Clovis Cache at East Wenatchee, Washington. *National Geographic Research* 6(4): 495-503.
- Mehringer, P. J., Jr., J. C. Sheppard, and F. F. Foit  
1984 The Age of Glacier Peak Tephra in West-Central Montana. *Quaternary Research* 21:36-41.
- Mierendorf, R. R.  
1997 Comments on the East Wenatchee Clovis Site (45DO482), Washington State, as Reported on by Richard M. Gramly. *Current Research in the Pleistocene* 14:57-60.
- Miller, K. A.  
1993 *A Study of Prehistoric Biface Caches from Texas*. MA Thesis, Department of Anthropology, University of Texas, Austin.
- Morrison, R. B.  
1965 Quaternary Geology of the Great Basin. In *Quaternary Geology of the United States*, edited by H. E. Wright and D. G. Frey, pp. 265-285. Princeton University Press, Princeton, New Jersey.
- Piper, A. M.  
1926 Ground Water for Irrigation on Camas Prairie, Camas and Elmore Counties, Idaho. *Idaho Bureau of Mines and Geology Pamphlet* 15.
- Porter, S. C.  
1978 Glacier Peak Tephra in the North Cascade Range, Washington: Stratigraphy, Distribution, and Relationship to Late-Glacial Events. *Quaternary Research* 10:30-41.

- Rathje, W. L. and M. B. Schiffer  
1982 *Archaeology*. Harcourt Brace Jovanovich, New York.
- Rea, D.  
1990 Demonstrating for the Dead: Dig Stirs Emotion on Both Sides. *The Wenatchee World*, 25 October. Wenatchee, Washington.
- Roper, D. C.  
1991 A Comparison of Contexts of Red Ochre Use in Paleoindian and Upper Paleolithic Sites. *North American Archaeologist* 12(4):289-301.  
1996 Variability in the Use of Ochre During the Paleoindian Period. *Current Research in the Pleistocene* 13:40-42.
- Rosenfeld, C. L.  
1979 Landforms. In *Atlas of the Pacific Northwest*, edited by R. M. Highsmith, Jr. and A. J. Kimerling, pp. 35-42. Oregon State University Press, Corvallis.
- Sarna-Wojcicki, A. M., D. E. Champion, and J. O. Davis  
1983 Holocene Volcanism in the Conterminous United States and the Role of Silicic Volcanic Ash Layers in Correlation of Latest-Pleistocene and Holocene Deposits. In *Late-Quaternary Environments of the United States, Volume 2: The Holocene*, edited by H. E. Wright, pp. 52-77. University of Minnesota Press, Minneapolis.
- Sharrock, F. W.  
1966 Prehistoric Occupation Patterns in Southwest Wyoming and Cultural Relationships with the Great Basin and Plains Cultural Areas. *University of Utah Anthropological Papers* 77. University of Utah Press, Salt Lake City.
- Shenman, S.  
1997 *Quantifying Archaeology*, 2<sup>nd</sup> ed. University of Iowa Press, Iowa City.
- Smith, G. L. and F. A. Street-Perrott  
1983 Pluvial Lakes of the Western United States. In *Late-Quaternary Environments of the United States, Volume 1: The Late Pleistocene*, edited by H. E. Wright, Jr. and S. C. Porter, pp. 190-212. University of Minnesota Press, Minneapolis.
- Smith, H. W., R. Okazaki, and C. R. Knowles  
1977 Electron Microprobe Data for Tephra Attributed to Glacier Peak, Washington. *Quaternary Research* 7:197-206.
- Stanford, D. J. and M. A. Jodry  
1988 The Drake Clovis Cache. *Current Research in the Pleistocene* 5:21-22.

Statsoft

- 2003 Correspondence Analysis. Electronic document,  
<http://www.statsoft.com/textbook/stcoran.html>, accessed September 27, 2005.

Swirydczuk, K., G. P. Larson, and G. R. Smith

- 1982 Volcanic Ash Beds as Stratigraphic Markers in the Glens Ferry and Chalk Hills Formations from Adrian, Oregon, to Bruneau, Idaho. In *Cenozoic Geology of Idaho*, edited by B. Bonnicksen and R. M. Breckenridge, pp. 543-558. Idaho Geological Survey, University of Idaho, Moscow, Idaho.

Tankersley, K. B.

- 2002 *In Search of Ice Age Americans*. Gibbs Smith, Salt Lake City.

Taylor, D. C.

- 1969 The Wilsall Site: An Exercise in Frustration. *Proceedings of the Montana Academy of Science* 29.

Thoms, A. V.

- 2005 Personal communication. Department of Anthropology, Texas A&M University, College Station, Texas.

Thompson, K. W. and J. V. Pastor

- 1995 *People of the Sage: 10,000 Years of Occupation in Southwest Wyoming*. Cultural Resources Report No. 67, Archaeological Services, Western Wyoming Community College.

Titmus, G. L. and J. C. Woods

- 1991 A Closer Look at Margin "Grinding" on Folsom and Clovis Points. *Journal of California and Great Basin Archaeology* 13(2):194-203.

USDA (United States Department of Agriculture)

- 1981a *Soil Survey of Douglas County, Washington*. Washington State University, Pullman, Washington.  
 1981b *Soil Survey of Camas County Area, Idaho*. University of Idaho, Moscow, Idaho.

USGS (United States Geological Survey)

- 1982 *The Channeled Scablands: The Geologic Story of the Spokane Flood*. U.S. Government Printing Office.

Waite, R. B. and B. F. Atwater

- 1989 Stratigraphic and Geomorphic Evidence for Dozens of Last-Glacial Floods. In *Glacial Lake Missoula and the Channeled Scablands*, edited by R. M. Breckenridge, pp. 37-50. 28<sup>th</sup> International Geological Congress Fieldtrip Guidebook T310. American Geophysical Union, Washington, D. C.

Westgate, J. A., D. G. W. Smith, and M. Tomlinson

1970 Late Quaternary Tephra Layers in Southwestern Canada. In *Early Man and Environments in Northwest North America*, edited by R. A. Smith and J. W. Smith, pp. 13-34. Students Press, University of Calgary.

Wheat, D.

1990 Director Vows Dig Will Go On. *The Wenatchee World*, 15 October. Wenatchee, Washington.

1991 Society Rethinking Clovis Offer. *The Wenatchee World*, 6 May. Wenatchee, Washington.

1992a Clovis Cache Buyout Talks Off. *The Wenatchee World*, March. Wenatchee, Washington.

1992b Historical Society Buys Clovis Rights: Agreement Includes 15-Year Moratorium on Digging. *The Wenatchee World*, 7 July. Wenatchee, Washington.

Wiseman, R. N., D. Griffiths, J. V. Sciscienti

1994 The Loco Hills Biface Core Cache from Southeastern New Mexico. *Plains Anthropologist* 39(147):63-72.

Woods, J. C. and G. L. Titmus

1985 A Review of the Simon Clovis Collection. *Idaho Archaeologist* 8(1):3-8.

## APPENDIX

The Microsoft Excel file that accompanies this thesis contains all the artifact measurement data, ratio variables, transformations, and factor analysis scores used in this research. The first tab, entitled Data, consists of all the measurements. Each row represents an artifact, and each column represents a variable. The red cells indicate values where an artifact measurement should be present but is missing or unobtainable. The second tab, entitled Codes, contains definitions for each value used in the nominal variables (site, artifact type, and raw material).

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