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I, Litsa A Mortensen, hereby submit this original work as part of the requirements for the degree of Master of Arts in Anthropology.

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The Chronostratigraphy of Big Bone Lick and its Archaeological Implications

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The Chronostratigraphy of Big Bone Lick and its Archaeological Implications

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by

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Abstract

This study presents and evaluates data obtained from five 2x2m profiles at Big Bone Lick State Historic Site, Kentucky during summer fieldwork excavations of 2012. Through a multi-stage and multi-method approach this study provides a chronostratigraphic view of past geomorphic landscapes at the State Historic Site. The data are presented and evaluated to include sediment stratigraphy, archaeosediment stratigraphy, particle-size analysis, cultural artifacts, vertebrate paleontology, optically stimulated luminescence dates, and radiocarbon dates. The data are then correlated and integrated into geochronological, archaeological, and paleoenvironmental aspects. The current landscape, environmental information, historical information, and previous archaeological work at Big Bone State Historic Site are all taken into account. The ultimate goal of archaeology is to determine the interrelationships between past human cultures and the environment in which they lived. The environment is a dynamic factor in the analysis of archaeological content (Butzer 1982). Geoarchaeology aims to use geological information for archaeological use. The purpose of geoarchaeology is to reconstruct past environments and landscapes in which prehistoric people lived and apply the information to the archaeological record. By examining the chronostratigraphy of Big Bone Lick State Historic Site, Kentucky, this study aims to define what the environment was like at different periods of human habitation as well as how the environment and subsequently, human occupation, changed with climatic fluctuations since the Late Pleistocene.
Acknowledgements

First, I would like to thank my advisor, mentor, and first chair on my committee, Dr. Kenneth Barnett Tankersley for helping make this research possible. I would also like to thank Dr. Vern Scarborough for being on my committee as my second reader. Thanks to the Court Archaeological Research Fund (PI Kenneth Barnett Tankersley) and the University Research Council (PI Crowley, Co-PIs Kenneth Barnett Tankersley, Linda Plevyak, and Aaron Diefendorf), which funded this thesis. I would also like to thank the Boone County Parks Department, specifically Big Bone Lick State Historic Site’s Naturalist Todd Young for helping in the summer 2012 excavation process. A special thanks to Alyssa Atkinson for her tireless efforts to assist me in fieldwork excavations and lab work throughout the summer of 2012. Thanks go out to Blake Plowden, Alex Schroff, Jessica Hughes, Eduardo Armas, Tyler Swinney, Andras Nagy, and the countless public volunteers who helped me excavate at Big Bone Lick during the summer of 2012. I would also like to thank my family for always encouraging me through my graduate work.
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Chapter 1: Introduction

The environment is our earth’s surface distinguished by physical, chemical, and biological criteria. When examining the paleoenvironment of a given area for archaeological purposes, the reconstruction of both the paleoclimate and the geomorphic landscape are of primary importance. The reconstruction of the paleoclimate and the landscape from sedimentological and stratigraphic studies can be considerably enhanced by a combination of fauna and plant remain analysis (Hassan 1985). The interpretation of the prehistoric record in terms of past patterns of interactions and interrelationships between humans, other organisms, and their physical habitats is a key aspect of geoarchaeology (Rapp and Hill 2006).

The time and spatial scale under which archaeologists work is significantly less than those of geologists, given the period of time humans have been present versus geological history (Rapp and Gifford 1985). The time scale with which this thesis will be concerned starts when humans began to populate the New World during the very Late Pleistocene and into the Holocene. Since the Late Pleistocene, physical and cultural landscapes have evolved in response to a combination of natural and anthropogenic features. Therefore, the integration of anthropology and geology is required to understand this evolution of the landscape (Wells 2001).

The area chosen for this study is Big Bone Lick State Historic Site, Kentucky (Figure 1-6) located in Boone County within the Northern Bluegrass Section of the Bluegrass Management Area (Pollack 2008a). The five 2x2m hand excavated units are located at the confluence of Big Bone Creek and Gum Branch. The State Historic Site is an ideal location to examine stratigraphy and integrate archaeological and geological research. Archaeological artifacts from each cultural period found in North America are represented within the State Historic Site's boundaries as well.
as a large number of megamammals from the Pleistocene (Tankersley 2007a). Therefore, climatic and environmental changes at the site may be directly related to human cultural periods and occupations. This thesis hypothesizes that the occurrence of archaeological sites at Big Bone Lick is directly correlated with the natural and anthropogenic landscape evolution. This hypothesis will be evaluated using geochronological data recovered from excavated profiles. Sediment analysis will then be used to help determine periods of aggradation vs. degradation.

The Chronostratigraphy of Big Bone Lick and its Archaeological Implications is important for several reasons. First, as a result of this study, site-specific stratigraphy can be correlated to known stratigraphic information for Boone County, Kentucky. The site-specific data that are presented and analyzed will be useful to apply and integrate into regional chronostratigraphic data. Second, the site-specific stratigraphy and subsequent chronology can be applied to human land use patterns specific to Big Bone Lick, Kentucky. This information can be correlated with regional prehistoric cultural patterns already known. Third, given the site-specific environmental data, human effects on the landscape can be assessed such as the clearing of forests for horticulture, agriculture, and pastoral purposes.

In the next chapter, I briefly introduce the environmental and geological settings of Big Bone Lick, Kentucky. In Chapter Three, I discuss the historical importance of the area. In Chapter Four, I review all previously recorded archaeological work done within the current State Historic Site’s boundaries. In Chapter Five, I outline the various theories useful for the practice of geoarchaeology in gathering environmental data. In Chapter Six, I describe in detail the fieldwork and laboratory methodologies employed for this thesis. In Chapter Seven, I provide all of the data procured during the summer 2012 fieldwork excavations at Big Bone Lick, Kentucky. In Chapter Eight, I correlate the data presented in Chapter Seven and discuss the data in the
context of known information about Big Bone Lick. The final conclusions and recommendations for further research will be contained in Chapter Nine.
Chapter 2: Environmental and Geological Settings of Big Bone Lick, Kentucky

The location for this research is centered within Big Bone Lick State Historic Site, Kentucky. This chapter will detail the environment and geological setting of Big Bone Lick State Historic Site. The purpose of this chapter is to illustrate a background of the environment and landscape in order to place data recovered for this thesis in context.

Location

Big Bone Lick is located in Boone County Kentucky (Figures 1-6) in the archaeological Northern Bluegrass Section of the Bluegrass Management Area (Pollack 2008a). Situated at the confluence of Big Bone Creek and Gum Branch (Tankersley 2007a), Big Bone Lick is located approximately 3.2 km east of the Ohio River, 13 km downstream from Rising Sun, Indiana, and 32 km southwest of Cincinnati, Ohio. Elevations within the Northern Bluegrass Section of the Bluegrass Management Area vary from 20 to 127 m above mean sea level (Striker et. al 2001).

Figure 1: Map of the United States displaying the location of the state of Kentucky
Big Bone State Historic Site was established in 1799, in northern Kentucky (Boone County Kentucky Government 2010). The northern and western borders of the county are formed by the Ohio River. The east is bordered by Kenton County. Grant and Gallatin Counties lie to the south.

Figure 2: Map of Kentucky displaying the location of Big Bone Lick State Historic Site within Boone County

Figure 3: County map of northern Kentucky with Big Bone Lick marked (Boisvert 1982b)
The State Historic Site was established in 1960 and includes 525 acres (Lowthert 1998) featuring a museum and discovery trail. The State Historic Site is centered on Big Bone Lick, an area of saline and sulfur springs that result from a mineral-rich wetland environment seasonally created by a water table that rises in association with spring snow melts and heavy rain (Lowthert 1998).
Current Climate and Environment

Boone County, Kentucky has a temperate and humid climate. The annual average temperature is around 54°F. The average temperature for January is 33°F and the average temperature for July is 76°F. No regular wet or dry seasons occur because there is well-distributed annual rainfall of approximately 40 inches. Occasional droughts may happen but not enough seasonal dryness occurs to prevent total crop failures. The average growing season for Boone County is 186 days.

Big Bone Lick lies within the Western Mesophytic Forest Region. This type of forest has a varied assortment of species including beech, tulip poplar, basswood, sugar maple, chestnut, sweet buckeye, red oak, white oak, and hemlock. Black walnut, sour gum, and hickory occur in more mature stands. The trees generally grow on uplands and slopes. It is likely that prior to agricultural deforestation, the forest extended into the floodplains as well (Lowthert 1998).

Soils

The factors that determine the kind of soil that forms in an area are the climate, the composition of the parent material, the topography, the plant and animal life, and time. Soil is then formed by the interaction of these five factors. Boone County contains up to four different soil associations. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern. Big Bone Lick contains 23 soils (Table 1) and only two of the four soil associations found in Boone County, Kentucky. The soil associations located within the Historic Site are the Wheeling-Huntington-Alluvial association in the floodplain areas and the Eden-Cynthiana association on the adjacent
hill slopes and uplands (Weisenberger et. al. 1973). Figure 4 displays the soils located within the boundaries of the State Historic Site. Each soil area is highlighted in yellow and the abbreviations of the soil type are placed within the boundary of the soil.

The agricultural potential is low. Modern farming practices require the addition of lime and fertilizer to meet the desired yield (Weisenberger et. al. 1973). However, the floodplains of the area provide natural replenishment to the soil. Big Bone Creek floods yearly during the spring, and deeply buried archaeological deposits are evidence that it has been flooding for quite some time (Lowthert 1998).

Table 1: Soils located within Big Bone Lick State Historic Site Boundaries

<table>
<thead>
<tr>
<th>Map Symbol of Soils</th>
<th>Soil Unit Name</th>
<th>Acres in AOI</th>
<th>Percent of AOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1D</td>
<td>Alluvial land, steep, (wheeling, 25 to 30 percent slopes, rarely flooded)</td>
<td>6.6</td>
<td>0.9%</td>
</tr>
<tr>
<td>AsA</td>
<td>Ashton silt loam, 0 to 2 percent slopes (occasionally flooded)</td>
<td>2.6</td>
<td>0.4%</td>
</tr>
<tr>
<td>AsB</td>
<td>Ashton silt loam, 2 to 6 percent slopes (occasionally flooded)</td>
<td>3.5</td>
<td>0.5%</td>
</tr>
<tr>
<td>Av</td>
<td>Avonburg silt loam (0 to 4 percent slopes)</td>
<td>10.8</td>
<td>1.6%</td>
</tr>
<tr>
<td>BrC</td>
<td>Brashear silt loam, 6 to 12 percent slopes</td>
<td>4.3</td>
<td>0.6%</td>
</tr>
<tr>
<td>BrD</td>
<td>Brashear silt loam, 12 to 20 percent slopes</td>
<td>15.6</td>
<td>2.2%</td>
</tr>
<tr>
<td>BsD3</td>
<td>Brashear silt loam, 12 to 20 percent slopes, severely eroded</td>
<td>9.4</td>
<td>1.4%</td>
</tr>
<tr>
<td>EdD2</td>
<td>Eden silt loam, 12 to 20 percent slopes, eroded</td>
<td>72.2</td>
<td>10.4%</td>
</tr>
<tr>
<td>EdE2</td>
<td>Eden silt loam, 20 to 35</td>
<td>283.9</td>
<td>41.0%</td>
</tr>
<tr>
<td>Map Symbol of Soils</td>
<td>Soil Unit Name</td>
<td>Acres in AOI</td>
<td>Percent of AOI</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------------------------</td>
<td>--------------</td>
<td>----------------</td>
</tr>
<tr>
<td>percent slopes, eroded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eg</td>
<td>Egam silty clay loam, (Woolper 0 to 4 percent slopes)</td>
<td>18.3</td>
<td>2.6%</td>
</tr>
<tr>
<td>FcC</td>
<td>Faywood silty clay loam, 6 to 12 percent slopes</td>
<td>7.8</td>
<td>1.1%</td>
</tr>
<tr>
<td>FcD</td>
<td>Faywood silty clay loam, 12 to 20 percent slopes</td>
<td>12.1</td>
<td>1.7%</td>
</tr>
<tr>
<td>LkA</td>
<td>Licking silt loam, 0 to 2 percent slopes</td>
<td>2.4</td>
<td>0.3%</td>
</tr>
<tr>
<td>LkB</td>
<td>Licking silt loam, 2 to 6 percent slopes</td>
<td>5.9</td>
<td>0.9%</td>
</tr>
<tr>
<td>LIC</td>
<td>Licking silt loam, 6 to 12 percent slopes</td>
<td>40.1</td>
<td>5.8%</td>
</tr>
<tr>
<td>LlD</td>
<td>Licking silt loam, 12 to 20 percent slopes</td>
<td>5.2</td>
<td>0.7%</td>
</tr>
<tr>
<td>Ln</td>
<td>Lindside silt loam (0 to 3 percent slopes, occasionally flooded)</td>
<td>8.6</td>
<td>1.2%</td>
</tr>
<tr>
<td>Nk</td>
<td>Newark silt loam (0 to 2 percent slopes, occasionally flooded)</td>
<td>17.5</td>
<td>2.5%</td>
</tr>
<tr>
<td>NlB</td>
<td>Nicholson silt loam, 0 to 6 percent slopes</td>
<td>5.3</td>
<td>0.8%</td>
</tr>
<tr>
<td>No</td>
<td>Nolin silt loam (0 to 3 percent slopes, occasionally flooded)</td>
<td>114.0</td>
<td>16.4%</td>
</tr>
<tr>
<td>RsB</td>
<td>Rossmoyne silt loam, 0 to 6 percent slopes</td>
<td>24.4</td>
<td>3.5%</td>
</tr>
<tr>
<td>RsC</td>
<td>Rossmoyne silt loam, 6 to 12 percent slopes</td>
<td>5.7</td>
<td>0.8%</td>
</tr>
<tr>
<td>W</td>
<td>Water</td>
<td>9.9</td>
<td>1.4%</td>
</tr>
<tr>
<td>WoC</td>
<td>Woolper silty clay loam, 6 to 12 percent slopes</td>
<td>7.1</td>
<td>1.0%</td>
</tr>
</tbody>
</table>
Topography and Geology

One of the largest and most reliable salt springs in eastern North America is found at Big Bone Lick. Figure 5 displays the current topography of Big Bone Lick, Kentucky. The salt from the Lick naturally originates hundreds of feet below the surface in the porous Ordovician-age
limestone (Tankersley 2007a). The limestone formed during the Ordovician period when the Cincinnati area was at the bottom of an ocean. One of the layers of marine sediments, possibly the Mount Simon Sandstone or St. Peter Sandstone, is likely to be the source of the sulfurous brine at Big Bone Lick (Heeden 2008).

Figure 5: Topographic map of Big Bone Lick, Kentucky. Rising Sun and Union Quadrangles

Ocean levels dropped in the Cincinnati and other regions around the globe at the end of the Ordovician period (Potter 1996). The ocean’s water level lowered due to Late Ordovician glaciation in Africa and Saudi Arabia that temporarily transferred part of the volume of the world’s ocean to a continental ice sheet (Potter 1996).
The Cincinnati region rose above sea level when the continental plate below the area expanded upward during the latest part of the Ordovician and into the early Silurian period around 470 to 420 million years ago (Heeden 2008). The Appalachian Orogeny, the result of three separate continental collisions at the end of the Paleozoic between 325 million to 260 million years ago, created the Appalachian and Allegheny mountain chains. In the Cincinnati area, the Cincinnati Arch developed as an indirect result of the aforementioned continental collisions (Potter 1996) (Figure 6).

Figure 6: Relationship between surface bedrock (planview) and the Cincinnati Arch (cross section) (Heeden 2008)

About two million years ago, just prior to the Pleistocene, this area had a rolling to flat surface that was drained by low-gradient streams. Stream sediments in the uplands near Big Bone Lick provide evidence of these preglacial streams, most notably the Old Kentucky River (Figure 7) (Heeden 2008).
The Ohio River Valley area has also been shaped by at least three Ice-Aged glaciers: the pre-Illinois, the Illinois, and the Wisconsin (Figure 8). The pre-Illinois glacier advanced and retreated one to two million years ago, which resulted in the current Ohio River drainage system. During an interglacial stage, the Big Bone Creek drainage system was created in the northern Kentucky region. The Illinois glaciation that formed from 300,000 to 130,000 years ago did not quite reach the Lick (Heeden 2008).
Approximately 70,000 years ago the last North American ice sheet, the Wisconsin glacier, pushed into the Cincinnati region and began its retreat about 19,500 years ago. Even though the nearest portion of the glacier was thirty miles north of Big Bone Lick, the glacial meltwater and debris that poured into the Ohio River directly affected the current topography of the Lick and surrounding areas (Heeden 2008). The sediments moving down the Ohio River often became blocked at the mouths of tributaries, which form dams. Each dam of glacial debris caused erosional sediments to settle at the bottom of the ponded stream (Heeden 2008).
Following the retreat of the Wisconsin glacier, Big Bone Creek became embedded in early Woodfordian deposits and went back to its original course by the late Woodfordian around 15,000 years ago. Erosion and the alluvial deposits formed a modern terrace at Big Bone Lick that was 147 meters above mean sea level. Big Bone Creek began to flow in a southwesterly direction that was adjacent to the present southern hillside at the Lick between 12,000 and 10,000 years ago (Tankersley 1985).

Following the glaciation, the brine, which is under high hydrostatic pressure, began to reach the surface via fault planes and bedrock fractures through the glacial colluvium (Tankersley 2007a). Salt and sulfur spring water accumulated on the surface and formed back-swamp areas with seasonal overbank flooding (Tankersley 1985). It is safely assumed that the flow of salt water was active during the late Pleistocene because it currently does not appear to be affected by climatic conditions or surface moisture (Tankersley 2007a). The newly created salt springs formed a reliable local source of water and minerals that continually attracted fauna and humans (Tankersley 1985).

Big Bone Creek then developed into two separate channels during the Holocene around 800 to 600 BP (Lowthert 1998). As a result of the creek channels splitting the silt deposits around the Lick were removed and redeposited many times. New channels exposed portions of the fossiliferous strata that had been buried in even early historic times. The southwest channel of the creek was reduced to an oxbow by 1831 (Tankersley 1985). The only back-swamp area that remained was the area immediately around the Big Spring. Today the oxbow and the back-swamp area near the Big Spring have dried completely. The spring now seeps directly into Big Bone Creek and the terraces at Big Bone Creek are currently being subjected to headward erosion (Lowthert1998). Extensive portions of the terrace have been removed, leaving only
isolated fragments (Tankersley 1985).

Erosional silt is still carried by the Ohio River and continues to be deposited at the Lick during backwater floods. Sediment coring in the area of the Lick has shown that there is up to 10 meters of fill presently resting above the bedrock on the valley bottom (Heeden 2008). Ken Tankersley has previously examined the geomorphology at Big Bone in 1981 comparing the geomorphological features along the Ohio River Valley, stratigraphic data from drill sampling and profile sectioning, paleontological specimens, provenienced archaeological materials, and subsequently comparing radiocarbon dates in 1982 (Figure 9). All of these features have been compared and the data from Tankersley’s previous study indicate that sections of uneroded, non-reworked Pleistocene and Holocene deposits exist in specific, geographically limited areas of the Lick (Tankersley 1985).

The oldest alluvial deposits at the Lick are early Woodfordian age around 22,000 years ago. A radiocarbon date of 17,000±600 14C BP that was collected from a sample in 1807 is thought to be associated with these deposits. Unfortunately, the exact stratigraphic provenience of the sample is unknown (Tankersley 1985). The early Woodfordian alluvium is made up of lacustrine deposits, which are typically blue, gray or green laminated; or thinly bedded clays, clayey silts, or silts. This alluvium occurs in the floodplain below the water table at an elevation of approximately 134 meters and extends up the valley slopes to an elevation of 155 meters. These deposits superimpose and are in contact with local bedrock. Vertebrate fossils are found sporadically as isolated bones throughout the deposits (Tankersley 1985).
Terraces at elevations between 146 and 147 m represent Late Woodfordian aged alluvium. This depositional event began approximately 15,000 years ago. The terrace deposits are composed of leached silt and silty clay. The alluvium is superimposed by an early Woodfordian lacustrine deposits at an elevation of approximately 142 meters (Tankersley 1985). At the interface of these deposits is a heavily oxidized zone that contains disarticulated vertebrate fossils, which exhibit signs of redeposition. These fossils are thought to be a mixture of early Woodfordian and late Woodfordian fauna and tend to have been heavily mineralized with little protein content (Tankersley 1985).
The remnants of two Wisconsin-aged terraces are present along the Ohio River. The first terrace was formed approximately 3,000 years ago, also late Woodfordian, and is about four meters above the floodplain. The second terrace is located about five meters above the first and has been radiocarbon dated to 18,520±500 and 19,940±300 years ¹⁴C BP. There has been a third terrace identified as a possible Illinoisan about four meters above the second. However, the majority of this terrace has been destroyed. Two small remnants of it can still be found near the confluence of Big Bone Creek and the Ohio River (Lowthert 1998).

Another terrace was identified during the University of Nebraska State Museum excavations from 1962-1966 (Schultz et. al 1963). The remnants of this terrace are composed of lacustrine clayey silt, which was deposited at the time of the Tazewell advance from the Wisconsin ice sheet around 18,000 years ago. The clayey silt represents backwater deposition in Big Bone Valley, which culminated about 18,500 years ago when the Ohio River was dammed by glacial outwash. Two additional terraces were acknowledged as being created after the Tazewell by intervals of erosion and deposition. These two terraces that are currently periodically flooded by Big Bone Creek are between three to seven meters thick (Schultz et. al 1963). An actual date has not been given to the levels, as analysis from the wood samples recovered from these terraces has not been published.
Chapter 3: Prehistoric Cultures and European Development

This chapter will detail the prehistoric cultures of Big Bone Lick State Historic Site. A history of European contact and interest at the Lick is presented as well as modern development of the area. The purpose of this chapter is to illustrate a background of the various peoples that have relied on and impacted the environment and landscape.

Past Environments and Cultures

To date there have been no prehistoric environmental reconstructions that span the entire history of Big Bone Lick. The Pleistocene environment has been the most studied due to the high concentrations of paleontological fossils that date to this time. This bias is not surprising, as the paleontological aspects of the salt springs have attracted the most attention. Environmental data has been presented from two recent projects at the State Historic Site. The first was from the University of Nebraska State Museum, however little information has been published on the results (Lowthert 1998). The other project was from Ken Tankersley in 1981, whose main focus was the Paleoindian environment (Tankersley 1985) and has been previously discussed in the geology section. Where specific environmental data are not known, I apply general environmental information from the surrounding region and the state of Kentucky.

The Pleistocene started about 1.8 million years ago and ended 10,000 years ago. The massive glaciers that covered most of North America often characterize this epoch. Due to stadials and interstadials of the glaciers movement, this epoch is also notable for its massive climatic fluctuations (Hofreiter and Stewart 2009). During a switch from stadial to interstadial the average temperature may have globally increased as much as 5-10°C within a few decades.
The global temperature was up to 21°C colder than it is today during a glacial maxima. These massive climatic and environmental changes directly impacted the distribution and genetic diversity of plants and animals in the area (Hofreiter and Stewart 2009).

Toward the end of the Pleistocene, the climate began to warm and North America was marked by the extinction of 35 species of megafauna known for their great size (Woodman and Athfield 2009). The mammals native to Kentucky during the Ice Age included mammoth, mastodon, bison, ground sloth, giant beaver, tapir, deer, caribou, moose, bear, horse, musk ox, stag-moose, and peccary. Many of these animals either became extinct or moved north as the glaciers retreated (Funkhouser and Webb 1973). It was around this same time that paleoindians, in the form of the hunter-gatherer Clovis culture, began to show up on the archaeological record in Kentucky. Notable hypotheses for the extinction of the megafauna include the dramatic climate changes, human hunting, or a combination of both these pressures (Tankersley 2002).

Even though a warming trend had begun, Kentucky’s climate around 11,450 BP was still cooler and moister than it is today (Tankersley 1996). During the following 1,500 years, most of the state was an ever-changing mixture of vegetation (Tankersley 1996). Some of these environs may have included patches of open grasslands, closed boreal forests, and/or tundra of open spruce parklands (Ellis et. al 1998). Toward the end of the Paleoindian period around 9,950 BP, the region was increasingly becoming a closed-canopy mixed deciduous hardwood forest (Tankersley 1990).

Clovis people responded to the environmental changes brought on via the retreating glaciers by adjusting their subsistence patterns (Pollack 2008a). The nature of the Paleoindian to Archaic transition in terms of human culture is considered one the major developments seen in the archaeological record of eastern North America (Ellis et. al 1998). The settlements began to
shift from open areas of low relief, such as the Bluegrass and Pennyroyal regions in the state of Kentucky, to the more rugged, closed terrain of the mountains (Tankersley 1996).

This shift in settlements may have resulted from a major switch in subsistence patterns. Big game animals that were rapidly becoming extinct could no longer be the focus of the Paleoindian diet in Kentucky. As a result, they had to switch to generalized foraging, in which smaller animals, plants, and other forest resources made up the bulk of their nourishment. These new resources were more plentiful in mountain regions (Tankersley 1996), where people began to occupy rock shelters and caves in eastern, central, and western Kentucky (Pollack 2008a). Late Paleoindians became increasingly familiar with the landscapes they occupied. This resulted in exploitation of more diverse local resources and an increased understanding of their particular environmental settings (Pollack 2008a).

Evidence of subsistence change in the archaeological record during the Pleistocene-Holocene transition can be seen in tool assemblages (Ellis et al. 1998). A difference in point notching, the switch to using more local raw material and the overall increase in the amount and variety of tools are important factors in suggesting the subsistence change. The alterations in the tool assemblages would have reflected the need to have more long-term substantial occupations with increased population (Ellis et al. 1998).

During the Archaic Period, 9,950-2,950 BP, the number and average size of hunter-gatherer bands increased. Kentucky’s climate was, again, not consistent (Jefferies 1996). There was a continued replacement of Pleistocene vegetation with mixed deciduous forests, and by the middle Archaic all Pleistocene environmental remnants were gone (Lowthert 1998). A warm, dry period, called the Hypsithermal climatic interval, began to affect hunter-gatherers across the midcontinent from 8,950 to 4,950 B.C. (Jefferies 1996).
Paleoenvironmental and cultural data from Kentucky suggest that a major shift in settlement and mobility strategies occurred toward the end of the Hypsithermal around 4950 BP. The impact of even a major climatic event such as the Hypsithermal probably varied across Kentucky due to the size of the state as well as its physiographic and environmental diversity (Pollack 2008a). Although fairly diverse due to regional environmental changes, archaic groups in Kentucky during this time have been characterized as subsisting on many different types of plants and animals. Specialized gathering and processing of wild plant seeds may have also helped in the development of gardening (Jefferies 1996). Environmental conditions toward the end of the Archaic and up until European contact were similar to today (Jefferies 1990).

The millennia spanning 2,950 to 950 BP are known as the Woodland Period. A hunter-gatherer livelihood, ceramic production, burial mounds, earthworks, and horticulture define this cultural period (Railey 1996). There is a continuity of material culture between Woodland with Late Archaic, particularly with stone tool technology. The main weapons used were the spear and atlatl. These weapons used notched and stemmed projectile points. Small triangular points are first seen around Late Woodland times. These may have been the marker for the introduction of the bow and arrow (Railey 1990).

Food collection also remained a prevailing subsistence pursuit and people began living in small communities for varying lengths of time (Pollack 2008a). Subsistence strategies were carried out on a seasonal basis. In the spring and summer important activities may have included planting and tending gardens, gathering plant foods, and fishing. In the fall, the intensive harvesting of seeds from domesticated and semi-domesticated plants occurred. Gathering and storage of mass products occurred during October. Late fall and winter activities were centered on hunting deer and other game (Railey 1990).
After the Woodland Period, the Fort Ancient people came to the middle Ohio River Valley from 950 to 200 BP (Pollack 2008b). Towards the end of this cultural period, the Fort Ancient were actively associating with European explorers as shown by the number of European trade items found in Late Fort Ancient sites. Fort Ancient subsistence practices and their environmental focus appear to have developed early and stabilized quickly. The people cultivated maize, beans, and squash. Hunting, fishing, and wild plant foods continued to be important aspects of their culture (Sharp 1996). With an increase in village sizes, there may have been an increased intensification in food procurement and cultivation over time as well (Pollack 2008b).

Ceramics are the most common diagnostic Fort Ancient artifact class. Ceramic vessels were made from locally available clays and are grit, limestone, sandstone, and/or shell tempered. The ceramics were decorated with incising, punctuations, or notching. Flaked stone tools were often made of locally available chert of high to medium quality. Characteristic Fort Ancient projectile points are small, generally isosceles triangles (Pollack 2008b).

Kentucky Fort Ancient settlements consisted of autonomous villages and small camps organized by kinship (Pollack 2008b). Fort Ancient village sites were often located on Late Pleistocene terraces and Holocene floodplains (Tankersley 1992a). Burial mounds were prevalent until late in the cultural period (Sharp 1996).

The beginning of the Fort Ancient period also marks the start of the Little Ice Age, which would continue until sometime in the nineteenth century. The environment during this time became slightly more open than the previous closed canopy. Small, open patches of grasslands appeared along major streams inside of the closed-canopy mixed mesophytic, deciduous forests. While slightly cooler than it had been previously, the climate and environment did not revert
back in any degree to the changes that occurred during the Pleistocene (Tankersley 1992a). Deciduous forests characterized Big Bone Lick with oak hickory as the dominant vegetation just prior to European settlement in the 1700s (Widga 2006). Stream piracy, when Big Bone Creek diverted from its own bed and flowed down different channels, occurred by exposing the late Pleistocene fossil bearing deposits. The fossil remains were collected and traded throughout the Ohio River Valley into historic times (Tankersley 1987).

Toward the end of the Fort Ancient period, just prior to 300 BP, herds of bison began to enter the Ohio Valley for the first time since the end of the Pleistocene (Tankersley 1992a) and were subsequently extinct from the area by 150 BP due to over hunting (Tankersley 1986). In Eastern North America the Holocene bison, B. bison bison, did not have high populations and were not spread out uniformly across the landscape. Although the prairie grasses attracted bison, salt springs attracted them more. Woodland bison developed a seasonal movement from the valley prairies feeding grounds to the salt licks (Jakle 1968). The bison also adjusted their traces to included canebrakes and freshwater springs located in the lowlands of Kentucky (Jakle 1968).

A major buffalo trace known by the Shawnee as the Alanant-o-wamiowiee, “The Buffalo Trace,” crossed into Kentucky at the mouth of the Licking River and went south to Big Bone Lick and Drennon’s Licks as shown in Figure 10. The trace went from Frankfort to Lower Blue Lick, May’s Lick, Limestone Crossing (Maysville) and across the Ohio River again (Jakle 1968).

These traces that were referred to and followed in historic times, not only provided routes throughout the state of Kentucky for the Fort Ancient to follow, but also created ample opportunity for ambushing game during seasonal migrations. The trails leading to and from Big Bone Lick were significantly strategic. The mineral resources that the bison sought were located in a narrow, steep walled valley that is more than 70 meters above the floodplain (Tankersley
Bison would approach the springs from the south on the trace. At the Lick, they would graze on open patches of vegetation surrounding the salt springs. This made the bison extremely vulnerable as both Big Bone Creek and Gum Branch valleys are blind. Once the bison were inside the Lick, hunters could easily block the entrance. The floodplain's nearly vertical cliff edges were two to seven meters high and bison were likely stampeded over the edges and killed (Tankersley 1992a).

Figure 10: Map of Buffalo Traces in the Ohio Valley with Big Bone Lick circled (Jakle 1968).
There are only two sites within the Fort Ancient cultural sphere that date to after 300 BP when the bison were in the area. These are Big Bone Lick and the Madisonville site located in southwestern Ohio approximately 40 km from Big Bone Lick. The presence of bison at these two sites could be a marker for change from the prehistoric to the protohistoric subsistence strategy. The switch in subsistence strategy cannot only be seen by the massive amounts of bison bones found at the Lick, but also by way of the increase in the number and diversity of animal processing tools such as bone beamers and flaked-stone unifacial end scrapers (Tankersley 1992a).

It is also quite possible that Indians utilized both of these sites with ethnic ties to the Illinois, a Central Algonquian group, whose subsistence strategies were largely based on bison hunting. These Algonquians may have been pushed down into the area from continued warfare with the Iroquois (Tankersley 1992a). The Shawnee, who might be successors of the Fort Ancient, are an Algonquian speaking tribe from Kentucky known during the historical time period.

*European Contact and Development*

Changes to the natural environment occurred after European contact. Different land use strategies, such as intensive agriculture and logging, employed by Europeans have greatly affected the native plant species of Kentucky (Lowthert 1998). The introduction of foreign invasive plant species and diseases has pushed some native plants into being endangered or even to extinction. Major examples of these invasives from the early twentieth century include Dutch elm disease and the chestnut blight. However, recent research suggests that although foreign species may invade an area, rarely do those species completely replace the native plants. Paleoethnobotanical research of plants in Kentucky shows a connection to modern native
Kentucky plants that are still in existence such as paw paw, honey locust, marsh elder, green briar, and giant ragweed (Lowthert 1998).

Europeans first recorded the location of Big Bone Lick in 1729. Captain Charles Lemoyne de Longueil provided military support for a French mapping expedition at this time from Lake Ontario to the headwaters of Ohio. Indian guides assisted Longueil and his local American troops downstream to a bison trace that eventually led them to Big Bone Lick. The local Indian guides told Longueil that their people had come to the Lick in ancient times (reviewed in Tankersley 2002).

Indians were acquainted with this locality for generations due to the salt availability and the Lick attracting animals into a common place allowing for good hunting (Kindle 1935). It was also a place of healing for the Indians because salt is an essential mineral for both people and animals (Tankersley 2002). Brine from saline springs has been a major source of dietary salt for North Americans, starting with Indian agriculturalists (Heeden 2008).

Longueil also found giant leg bones, jaws, and ivory tusks of an extinct, elephant-like creature while on the expedition (reviewed in Tankersley 2002). When he asked the Indian guides about the bones, they told him their ancestors had hunted and killed the enormous animals. This find was later recorded on Jacques Nicolas Bellin’s 1744 map of what was then the land between New France and Louisiana. Big Bone Lick was referred to as “the place where they found the elephant bones” (Tankersley 2002:49). Figure 11 illustrates an early map with Big Bone Lick mentioned from 1784 by John Filson.

A fur trader, Robert Smith, set up an Indian trading post just outside Twigtwee village, about fifteen miles north of Big Bone Lick (reviewed in Tankersley 2002). In 1744, he was able to verify Longueil’s earlier discovery when he found numerous mastodon bones at the Lick.
Smith relayed this information in 1751 to Colonel Christopher Gist, an employee of the Ohio Land Company of Virginia. Gist then went to the Lick, collected a tooth that weighed more than four pounds, and sent this specimen to Benjamin Franklin and the American Philosophical Society. This group was the first scholarly society in America (reviewed in Tankersley 2002).

Exploration and possible excavations of the bones in the area had to be put on hold during the French and Indian War from 1754-1763 (reviewed in Tankersley 2002). Many Indians, including the Shawnee, and backwoodsmen such as Daniel Boone, Simon Kenton, and John Findley, still frequented the Lick during the war in order to acquire salt. This was an essential mineral for life on the frontier, specifically after blockades cut off shipments from the West Indies (reviewed in Tankersley 2002).

Mary Ingles, who was taken captive by the Shawnee, was brought to the Lick on a salt procurement expedition in October 1756 (Duvall 2009). Salt making parties camped for several weeks at a time around the Lick due to the enormous amount of time involved in extracting salt from the brine water. The Shawnee considered the area around the Lick to be very secure due to the steep ravines and large rivers in the area. Therefore, no precautions were taken by the Shawnee to keep track of the captives that were brought with the party (Duvall 2009).

It was here that Mary Ingles made her escape and went back to her native Virginia (Heeden 2008). Years later, Ingles recalled a Frenchman in their company at Big Bone Lick “sitting on one of the big bones cracking walnuts.” The mastodon bones were so abundant that they were often used as camp furniture for those gathered at the Lick (Tankersley 2002:50).
Figure 11: “Kentucke” map by John Filson, 1784 “Bones found Here” at Big Bone Lick (Lafferty 1956)
After the war, Benjamin Franklin and the American Philosophical Society sponsored Colonel George Croghan, an Indian agent of the Pennsylvania Colony, to obtain a sample of bones from Big Bone Lick in 1765 (Tankersley 2002). Croghan had found a buffalo trace leading to the Lick that was “spacious enough for two wagon loads to go abreast” (Kindle 1935:450). However, the expedition was captured by a group of Kickapoo and Mascoutin. Croghan signed new peace treaties with the Indians a year later and organized another expedition including military support and Indian guides. Croghan successfully obtained a sample in 1767 and proceeded to divide it into two shipments. Both boxes were sent to England. One box was sent to Lord Shelbourne, minister to the American Colonies, and the other box to Benjamin Franklin (reviewed in Tankersley 2002).

Franklin speculated that the bones belonged to an elephant-like creature that lived when the climate was different from the present. Upon his return from England, he recommended that the American Philosophical Society acquire a complete skeleton (reviewed in Tankersley 2002). In spite of the curiosity that the fossils were creating, it is important to note that religion was present within science at this time. Geology was in its infancy and people often sought biblical explanations for the bones found at Big Bone Lick (Eiseley 1945). Thomas Jefferson, then governor of Virginia, even remarked “Such is the economy of nature that no instance can be produced of her having permitted any one race of her animals to become extinct, of her having formed any link in her great work so weak as to be broken” (Eiseley 1945:86). Therefore if the animal existed, it still exists and people sought explanations of the fossil remains in the immediate historical past (Eiseley 1945).

Kentucky politician, Robert McAfee, described the Lick on July 5, 1773:

“We went to see the Big Bone, which is a wonder to see the large bones that lie there,
which have been of several large big creatures. The lick is about 200 yards long and as wide, and the waters and mud are of a saline smell. There are several other licks on the same creek, and the same taste and smell; and there is very fine land on the same creek which was surveyed that day” (Jillson 1936:20-2; Lowthert 1998:24).

On May 12, 1774, Governor Thomas Jefferson awarded Big Bone Lick and several thousand surrounding acres to Colonel William Christian as a military grant for his services in the war between Great Britain and France (Tankersley 2002). The economic importance of salt can be gauged by Big Bone Lick’s high real estate value at the time. The potential profitability of the salt springs allowed Christian to sell the 1,000-acre tract including the Lick to David Ross in 1780 for 1,350 pounds (Heeden 2008). This was almost six times the selling price of a neighboring tract of the same size that lacked the springs (Heeden 2008).

Ross and his partner proceeded to make salt at the Lick as well as lease property of the springs to other salt manufacturers (Heeden 2008). While excavations were continuing around the salt lick, a small fortification was built to protect the salt workers and their equipment from Indian raids (Lambert 1971). In 1790, eighteen soldiers were also added to help protect the workers safety (Heeden 2008).

Thomas Jefferson proceeded to interview local Indians that used the Lick about where the bones may have come from. Even though he was not the first person to record Indian traditions that referred to the extinct fossil remains, Jefferson’s Notes on Virginia, written in 1782, was the first widely circulated literature on the topic. The book retells the Delaware Indian’s legend that the animals that left behind the bones are still alive, but living elsewhere. The Shawnee have similar stories about these animals, but there is no reference to the animals still in existence (Eiseley 1945).
Jefferson also interviewed a white man named Stanley in *Notes on Virginia* about the massive bones. Stanley was captured by Indians and led across the Rockies (Eiseley 1945). On this trip, the Indians had informed Stanley of giant animals that still existed in that area. Stanley later recalled to Jefferson that the Indian’s description of the giant animals sounded much like that of an elephant. Jefferson concluded “The traditional testimony of the Indians, that this animal still exists in the northern and western parts of America” (Eiseley 1945:85).

During the booming salt industry phase at Big Bone Lick, General William Henry Harrison conducted a massive excavation in 1785. The excavation was on behalf of Thomas Jefferson and the American Philosophical Society (Tankersley 2002). Unfortunately the collection was lost when the boat transporting it was overturned in the Ohio River just below Pittsburgh. French General Colland had also conducted excavations at the Lick at the same time as Harrison (Tankersley 2002). Jefferson contacted Colland and in 1797 his collection was turned over to Jefferson as a token of thanks by the French government. Knowing that the Delaware said that these animals were still alive, Jefferson instructed Lewis and Clark to look for these animals in the course of their exploration of the Louisiana Territory in 1803 (Tankersley 2002).

In 1784, Charles Wilson Peale, an artist from Philadelphia, was given a commission to draw some large bones from Big Bone Lick. The illustrations, along with the bones, were displayed in Philadelphia. The exhibit brought crowds of curious people. However, formal commercial advertisement to the public of a new museum being opened did not appear in newspapers until 1786. A brochure that one of Peale’s sons wrote described the exhibit as “The splendid and valuable establishment, founded in 1785, is the first in the United States,”
Peale had developed the first natural history museum in North America based on specimens found at Big Bone Lick.

Towards the end of the 1700s, the population of settlers had grown enormously along the Ohio River, especially near the port of Cincinnati. Kentucky became an official state in 1792. All commodities required by pioneers became highly prized, which included salt. People on the frontier used salt in a variety of ways including making soap, manufacturing leather, dyeing fabric, producing cheese, and for meat preservation. Due to the perishable nature of salt, it was very expensive to transport over the Alleghenies and a local source of salt was highly valued.

In addition to being local, Big Bone Lick’s location close to the Ohio River made the salt easily transportable to other ports, including the newly established town of Cincinnati. As early as April 15, 1794, “Good old Kentucky salt” was advertised for sale in Cincinnati in some of the first Ohio Valley newspapers. The low price of labor and cheapness of fuel were also incentives for the salt’s exploitation.

The only downside was that the saline springs were not as saturated with salt as everyone had hoped. It took about five or six hundred gallons of the saline water to produce one bushel of salt. Two furnaces were erected to speed the process of evaporating the water from the salt, but the operation still proved too expensive to be profitable long term. The salt business was finally abandoned in 1812.

Big Bone Lick also enjoyed a number of years as one of the most celebrated health and watering resorts in this part of the Ohio Valley. The mild medicinal properties of the springs, the historic background of the salt making industry, and the prehistoric association of ongoing mastodon bone recovery made the Lick popular. In 1800, a large hotel named the
Clay House was erected in honor of Henry Clay, the famous statesman from Lexington (Lambert 1971). The main building was built shortly after 1800 (Jillson 1936). The structure stood west of the springs on the old road to Louisville. Northeast of the Clay House stood a row of bathhouses and an open pavilion. However, the popularity eventually began to wane, possibly due to the drying of the salt springs and by 1847 the place was deserted (Lambert 1971).

While the commercial enterprises at the salt lick were declining, a medical doctor from Cincinnati named William Goforth recovered five tons of bones within one year of excavations in 1804. Thomas Ashe managed to con Goforth out of the bones in 1806 (reviewed in Tankersley 2002). These bones were then displayed in museums throughout England. Ashe later sold them to The Royal College of Surgeons and private collectors in Scotland and Ireland. Around this same time, the Lewis and Clark expedition returned and had failed to find any living animals that were as large as those left by the elephant-like bones found at Big Bone Lick. Jefferson realized that the bones in question might actually be much older than previously thought and organized another expedition to the Lick (reviewed in Tankersley 2002).

Captain William Clark, his brother General George Rogers Clark, and William Goforth excavated at the Lick in 1807 (reviewed in Tankersley 2002). Aside from a large amount of bones, numerous stone tools and weapons were also uncovered (Figure 12). Three of these stone tools are flaked-stone points, known today as Clovis points. This was clear evidence for the direct association between Ice Age Americans and mastodon bones. Unfortunately these artifacts were not associated with detailed notes. Therefore, their association with the bones and the archaeological significance has been lost (Tankersley 2002).

Jefferson, now the President, placed three hundred bones from Big Bone Lick on display at the White House in 1808. The specimens included an almost complete mastodon skull, four
complete lower jaws, and four tusks. One of the tusks was 10 feet long. After Jefferson left office, he donated a musk ox skull to the American Philosophical Society and moved the rest of the collection to his Monticello home. Today the musk ox skull has been curated by the Academy of Natural Sciences in Philadelphia. Unfortunately most of the collection at Monticello was eventually ground into fine powder and used as fertilizer (Tankersley 2002).

William Goforth kept the archaeological artifacts that had been found with the bones excavated in 1807 (Tankersley 2002). In 1817, Goforth left his artifact collection to his medical successor, Daniel Drake. They were then donated to the Western Museum of Cincinnati, Ohio in 1818. Thomas Cleany purchased the collection in the 1850s and donated them to the Cincinnati Art Museum in 1887. Today this collection is curated at the Cincinnati Museum of Natural History (Tankersley 2002).

Figure 12: Fluted bifaces from Big Bone Lick. (A) found by E. Crawford in the 1960s; (B) found by a local collector, date unknown; (C) found by J.D. Moore in the 1930s; (D) found by W. Goforth 1803-1807; (E) found by a local collector, date unknown; (F) found by a local collector 1898; (G) and (H) found by W. Goforth 1803-1807 (Tankersley 2009a)
Throughout the nineteenth century Big Bone Lick was known around the world as the foremost paleontological site (Jillson 1936). This notoriety encouraged visits in 1841 by Charles Lyell, the father of modern geology (reviewed in Tankersley 2002). Lyell provided this description of the Lick:

“situated in a nearly level plain, in a valley bounded by gentle slopes. There are two springs on the southern or left bank, rising from marshes, and two on the opposite bank, the most western of which, called Gum Lick, is at the point where a small tributary joins the principle stream. The quaking bogs on this side are now more than fifteen acres in extent, but all the marshes were formerly larger before the surrounding forest was partially cleared away. The removal of the tall trees allowed the sun’s rays to penetrate freely to the soil, and dry up parts of the morass” (Jillson 1936:106; Lowthert 1998:25).

Nathanial Southgate Shaler, Harvard geologist, visited in 1868 (Tankersley 2002). Shaler excavated close to one ton of bison bones from the site, which are now curated at the Peabody Museum (Striker et. al 2001). The large accumulation of bison bones that Shaler found was concentrated in several distinct alluvial strata, likely indicating the result of massive bison kills by prehistoric hunters. Unfortunately, as with most of these early excavations, cultural artifacts of possible significance were not mentioned in the bison bone deposits (Tankersley 1986).

The physical appearance of Big Bone Lick changed dramatically by the early part of the nineteenth century. Each group to visit the Lick took fossils, bones, and artifacts with them (Jillson 1936). Most of these collections, due to the dangers of the journey, were lost. Some collections went to private buyers or were displayed in museums in England. The bones themselves then became a purely commercial pursuit. One collection from Big Bone sold for $5,000, which was a great deal of money for the time period (Jillson 1936).
The region around the Lick quickly became privately owned farm land during the nineteenth century and much of the twentieth century, with the exception of the area immediately around the salt springs (Striker et. al 2001).

The collection and study of paleontological remains and to a lesser extent archaeological artifacts has been occurring around Big Bone Lick for the past 250 years (Lowthert 1998). These uncontrolled excavations were regularly conducted at Big Bone Lick until 1960, when the area became a State Historic Site. Even though artifacts have been collected over the years, the lack of detailed provenience for these collections means that they can provide little information to archaeologists (Striker et. al 2001). Many of the artifacts that may have been collected here are also housed by private collectors and lost entirely to the scientific community.

The mid-twentieth century saw more detailed collecting. Ellis Crawford, director of Covington’s William P. Behringer Memorial Museum, unearthed a mastodon jawbone from the channel of Big Bone Creek in 1960 (Heeden 2008). Later in 1962, Crawford helped excavate the Lick again with the University of Nebraska State Museum. During the extensive field studies, geology and paleontology were at the forefront (Schultz et. al 1963; Schultz et. al 1967). A naturalist visiting the Lick in 1962, Edwin Way Teale, reviewed the faunal record and concluded that “The fossil lode at Big Bone Lick is far from exhausted” (Heeden 2008:136).
Chapter 4: Previous Archaeological Research

Since the State Historic Site was created in 1960, archaeological investigators wishing to conduct surveys within the State Historic Site must obtain proper permitting. This has put an end to improperly documented excavations within the State Historic Site boundaries. Unfortunately, most of Big Bone Lick has also been affected on the surface by various human caused disturbances such as plowing and the construction of roads, buildings, campsites, and the interpretive trail around the State Historic Site (Striker et. al 2001).

Additionally the University of Nebraska State Museum was responsible for destroying approximately 0.6 acres of the State Historic Site when they conducted a paleontological survey at Big Bone Lick from 1962-1966 (Schultz et. al 1963, Striker et. al 2001). In order to find the stratigraphic layers that housed the fossils, the survey bulldozed large areas of the State Historic Site, essentially stripping away what Schultz (et. al 1963) refers to as overburden. This term was not defined in specific measurements and it is quite possible that the overburden removed contained the majority of the archaeological deposits (Lowthert 1998) close to the surface.

This chapter presents all recorded archaeological sites beginning in 1932 within Big Bone Lick State Historic Site boundaries. The most important aspect of Big Bone Lick is the presence of archaeological deposits from every era of human occupation in North America. There are a total of 25 archaeological sites with 61 prehistoric and historic components identified within Big Bone Lick State Historic Site. Table 2 lists the 25 archaeological sites and Figure 13 identifies the sites on a topographic map of the State Historic Site. There are 13 sites with 39 components located on the floodplain of Big Bone Creek and Gum Branch, 10 sites with 20 components located on toe slopes or terraces, and two sites with two components are located on ridge crests.
(Lowthert 1998). Five sites contain Paleoindian components, six contain Archaic components, five contain Woodland components, 11 contain Fort Ancient components, and 11 contain historic components (Striker et. al 2001). Table 3 compiles all of the previous radiocarbon dates taken within the State Historic Site boundaries discussed within this chapter for easy reference.

Table 2: Big Bone Lick State Historic Site Previous Archaeological Sites

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Site Name (if applicable)</th>
<th>Time/Cultural Period</th>
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</thead>
<tbody>
<tr>
<td>15Be1</td>
<td>The Miller Site</td>
<td>Unknown prehistoric</td>
</tr>
<tr>
<td>15Be4</td>
<td>n/a</td>
<td>Unknown prehistoric</td>
</tr>
<tr>
<td>15Be18</td>
<td>n/a</td>
<td>Fort Ancient</td>
</tr>
<tr>
<td>15Be265/101A</td>
<td>n/a</td>
<td>Archaic/ Early Woodland/ Middle Woodland/ Late Woodland/ Ft Ancient</td>
</tr>
<tr>
<td>15Be266/102A</td>
<td>n/a</td>
<td>Fort Ancient</td>
</tr>
<tr>
<td>15Be267</td>
<td>n/a</td>
<td>Fort Ancient</td>
</tr>
<tr>
<td>15Be268</td>
<td>n/a</td>
<td>Fort Ancient</td>
</tr>
<tr>
<td>15Be269</td>
<td>n/a</td>
<td>Pleistocene/ Paleoindian/ Late Woodland/ Fort Ancient/ 18th-19th century salt works</td>
</tr>
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<td>15Be270</td>
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<td>Pleistocene/ Paleoindian/ Middle Woodland/ 19th century Euro-American</td>
</tr>
<tr>
<td>15Be271</td>
<td>n/a</td>
<td>Paleoindian/ Archaic/ Woodland/ Fort Ancient</td>
</tr>
<tr>
<td>15Be272</td>
<td>The Glacken Site</td>
<td>Paleoindian/ Archaic/ Woodland/ Fort Ancient</td>
</tr>
<tr>
<td>15Be273</td>
<td>n/a</td>
<td>Archaic/ Fort Ancient</td>
</tr>
<tr>
<td>Code</td>
<td>Site Name</td>
<td>Time Period</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------</td>
<td>--------------------------------------------------</td>
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<td>The Buffalo Rise Site</td>
<td>Pleistocene/ Late Woodland/ Fort Ancient</td>
</tr>
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<td>15Be441</td>
<td>n/a</td>
<td>Unknown prehistoric/historic homestead site AD 1851-1950</td>
</tr>
<tr>
<td>15Be442</td>
<td>Upson Downs Site</td>
<td>Fort Ancient</td>
</tr>
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<td>15Be443</td>
<td>n/a</td>
<td>Unknown prehistoric</td>
</tr>
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<td>15Be444</td>
<td>Baker Site</td>
<td>Historic homestead site AD 1820-1950</td>
</tr>
<tr>
<td>15Be445</td>
<td>Baker Cemetery Site</td>
<td>Historic homestead, cemetery</td>
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<tr>
<td>15Be446</td>
<td>Metcalf Flats Site</td>
<td>Unknown prehistoric/historic recent historic period</td>
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<td>15Be447</td>
<td>Matchless Day Site</td>
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<tr>
<td>15Be448</td>
<td>Hot Letter Site</td>
<td>Unknown prehistoric</td>
</tr>
<tr>
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<td>Unknown prehistoric/ 19th – 20th century</td>
</tr>
<tr>
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<td>Unknown prehistoric/ 19th – 20th century</td>
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<tr>
<td>15Be451</td>
<td>n/a</td>
<td>Unknown prehistoric/ 19th – 20th century</td>
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<td>15Be452</td>
<td>n/a</td>
<td>Late Woodland/ Fort Ancient/ early 19th century</td>
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Table 3: Previous Radiocarbon Dates within Big Bone Lick

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Year</th>
<th>Investigator</th>
<th>Object Dated</th>
<th>Location</th>
<th>Date (14CBP) ± 1 SD</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1807</td>
<td>W. Clarke, R. Clarke, W. Goforth</td>
<td>Unknown Sample</td>
<td>Thought to be associated with oldest alluvial deposits: Woodfordian Age</td>
<td>17,000.</td>
</tr>
<tr>
<td>2</td>
<td>1962</td>
<td>University of Nebraska</td>
<td>In situ Pleistocene faunal deposits</td>
<td>15Be270 top of gravel Pleistocene layer</td>
<td>10,600</td>
</tr>
<tr>
<td>3</td>
<td>1962</td>
<td>University of Nebraska</td>
<td>Ground sloth faunal remains</td>
<td>15Be270 3.5 m deep at interface of gray silt and black gravel layer</td>
<td>18,000</td>
</tr>
<tr>
<td>4</td>
<td>1981</td>
<td>University of Cincinnati – Kenneth Barnett Tankersley</td>
<td>Cordmarked ceramic sherds</td>
<td>15Be269 ceramics located with Bison bison remains</td>
<td>530</td>
</tr>
<tr>
<td>5</td>
<td>1982</td>
<td>University of Kentucky – Richard A. Boisvert</td>
<td>four different pit features found</td>
<td>15Be272 The Glacken Site</td>
<td>4,090 to 8,820</td>
</tr>
<tr>
<td>6</td>
<td>1982</td>
<td>University of Kentucky – Richard A. Boisvert</td>
<td>Merom Trimble projectile point</td>
<td>15Be272 The Glacken Site</td>
<td>3,460</td>
</tr>
<tr>
<td>7</td>
<td>1993</td>
<td>3/D Environmental Group – Don Miller and Ken Duerkson</td>
<td><em>Bison bison</em> molar</td>
<td>15Be269</td>
<td>120</td>
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</table>
Figure 13: Topographic map illustrating all site boundaries located within Big Bone State Park (Striker et. al. 2001)
Previously Recorded Archaeological Sites

15Be1 includes a mound of unknown origin and a small mound and cemetery (Figure 13, Table 2) (Striker et. al 2001). The site was record by Webb and Funkhouser in 1932. The mound measured 5 m by 8 m in circumference and 1.8 m tall. Artifacts located on the surface of the mound were reported to have been collected and donated to the Behringer-Crawford Museum in Covington, KY (Fenwick and Weinland 1978; Weinland 1977).

In 1996, B. Jo Stokes and William H. Lowthert IV probed the soil around 15Be1, which revealed disturbed soils with mixed prehistoric and historic artifacts. The mound was cored as part of the Boone County Mound Survey Project. The core showed that the mound was composed of yellow orange clay on top of medium brown silty alluvial deposits. Recent research at the State Historic Site supports the idea that this mound may in fact be related to some type of historical construction (Lowthert 1998).

15Be4 was recorded as a small mound and cemetery in 1932 by archaeologists Webb and Funkhouser. The location and detailed information on this site has been lost. It is possible that the site has been disturbed or destroyed by construction and/or agricultural plowing within the State Historic Site (Lowthert 1998).

15Be18 was recorded by William Haag, Claude Johnston, and John Cotter (Figure 13, Table 2). This site is located in the bottom of Big Bone Creek. The excavation found small scraps of mammoth bone from erosional areas along the bank of Big Bone Creek as well as other faunal remains and lithic material. The artifacts have been kept at the University of Kentucky, Lexington (Haag, Johnston, and Cotter 1938; Lowthert 1998).

The Behringer-Crawford Museum, located in Covington, Kentucky, conducted an excavation at site 15Be18 in 1997 (Lowther 1998). The crew found 40 prehistoric artifacts and
labeled 15Be18 as a multi-component site with Hopewell and Fort Ancient Cultures present. The diagnostic artifacts include a McWhinney projectile point, a Brewerton-like projectile point, a microblade fragment, Ohio Flint Ridge Adena projectile points, Raccoon side-notched projectile point, Fort Ancient Triangular projectile points, and shell tempered pottery (Kreinbrink and Harper 1997). Kreinbrink and Harper (1997) concluded that the area was most likely used as a hunting area around the mineral springs with periodical or seasonal use (Kreinbrink and Harper 1997).

15Be101A/15Be101B has been relabeled as 15Be265 and 15Be266 respectively (Figure 13, Table 2). Northern Kentucky University recorded a large dual component site 15Be101A/15Be101B. The site had two concentrations of artifacts labeled A and B that were located in a plowed field (Lowthert 1998). The location of the site was not properly recorded at the Office of the State Archaeology, and these sites were re-recorded during the 1981 excavations by Tankersley as sites 15Be265 and 15Be266 (Figure 13) (Striker et. al 2001).

The artifacts that were collected by Northern Kentucky University from site 15Be101A appear to be from the Early to Middle Fort Ancient Period, and site 15Be101B artifacts were categorized as having multiple cultural components. Northern Kentucky University has not published any detailed information or an analysis of the artifacts that they found at Big Bone Lick (Lowthert 1998).

In 1981, Tankersley found Archaic, Early to Late Woodland, and Fort Ancient components at the site now designated as 15Be265. The artifacts included numerous diagnostic artifacts such as an Early Archaic Hardin Barbed projectile point, Late Archaic McWhinney projectile points, an Early Woodland Adena Ovate Basin projectile point, a Terminal Late Woodland Chesser Side Notched projectile point, and a Fort Ancient crude triangular point along
with 13 Fort Ancient shell tempered ceramic sherds. The profile yielded a diagnostic blade core and prismatic microblade that signify the Hopewell culture of the Middle Woodland period (Tankersley 1981; Lowthert 1998). Additional testing of site 15Be265 by Stokes and Lowthert in 1995 recovered a Late Archaic Stemmed projectile point, a Late Archaic three-quarter grooved axe fragment, and Fort Ancient shell tempered ceramic sherds (Lowthert and Stokes 1995; Lowthert 1998).

15Be266 has been labeled as Fort Ancient (Striker et. al 2001; Tankersley 1981). James Hopgood led the excavations for Northern Kentucky University field school of this site in 1975. The artifact assemblage they found included a high percentage of shell-tempered ceramics, thicker strap handles, and incised designs that could date to the Anderson Phase of the Middle Fort Ancient. Also collected were Early to Middle Fort Ancient Type 2 triangular projectile points and Type 3 triangular projectile points that fall within the date range of 3,150 - 3,350 BP (Hopgood 1975; Hopgood and Wagner 1977; Lowthert 1998).

In 1981, Tankersley conducted a surface survey and creek bank profile of site 15Be266. Diagnostic Fort Ancient artifacts recovered include shell tempered ceramics, Type 2 and Type 3 triangular projectile points, and a Triangular drill (Tankersley 1981; Lowthert 1998). A fire pit feature was encountered between 40 cm-100 cm in the creek bank profile. This level also produced Fort Ancient material. A possible hearth feature was uncovered with a unifacial flake tool in the profile at 284 - 296 cm (Tankersley 1981).

Historic artifacts from 15Be266 were encountered during Lowthert and Stokes investigations in 1995. Artifacts include historic ceramics that date to the 1880s, glass, machine cut nails, and wire nails. They were mostly concentrated in the southeast corner of the site away from where previous prehistoric artifacts had been found. These artifacts could indicate either a
farmstead or a homestead that is no longer in the area (Lowthert and Stokes 1995; Lowthert 1998).

In 2003, Big Bone Lick State Historic Site hired Cultural Resource Analysts, Inc. to conduct an archaeological survey for construction within the park. The boundaries of the project included site 15Be266. The Principle Investigator for the project, Jessica Allgood, noted that 31 historic artifacts falling into the date range of mid-nineteenth to twentieth centuries were found. No prehistoric material was encountered (Allgood 2003; Allgood, Richmond, and Andrews 2003).

Site 15Be267 consists of a light lithic scatter (Figure 13, Table 2). Only two high level fluvial lithic materials were found (Tankersley 1981). This may represent the locale of a specialized activity such as lithic tool manufacture or hunting (Lowthert 1998).

15Be268 consists one non-diagnostic reworked biface along with the second phalange of a Pleistocene horse (*Equus complicatues*) (Figure 143 Table 2). A Fort Ancient Triangular projectile point was located on the surface along with numerous chert debitage that was not collected (Tankersley 1981). Site 15Be268 may represent the locale of a specialized activity such as hunting and or gathering (Lowthert 1998).

15Be269 was recorded by Tankersley in 1981 (Figure 13, Table 2). A test pit revealed a densely consolidated organic sandy gravel layer found at approximately three meters below the surface of the floodplain and 35 cm thick (Tankersley 1981; 1986). This stratum contained the remains of a single disarticulated adult bison, six retouched flakes, five flakes, one ground stone, one basalt scraper, and one Late Archaic Merom projectile point. The artifacts appear to be in a primary context and some of the bison bones exhibited cut marks. The composition of the deposit suggests that the bison was probably killed and butchered on a low gravel bar.
immediately below the high floodplain embankment of Big Bone Creek. Cordmarked ceramic sherds were found among the bison remains. The sherds are associated with a 530 $^{14}$C BP date that falls within the Fort Ancient time period (Table 3) (Tankersley 1981; 1986). A fire pit found at 15Be269 could have been from the historic salt works that took place at the Lick in the late 1700s to 1815. However, no artifacts were recovered to definitively age the thermally altered feature (Tankersley 1981).

The 15Be269 site boundaries were recorded in 1981 to include another profile close by. The profile was opened by the University of Nebraska and named the KEN-3 site. There were numerous artifacts located within the Ken-3 block (Schultz et. al 1967). A Merom Cluster Late Archaic projectile point was recovered approximately 1.8 meters below the benchmark and is the only prehistoric diagnostic artifact recovered. Two drilled slate gorgets, one stemmed knife, and a possible stemmed projectile point with a portion of the base missing were all found in association with the Merom Cluster point (Lowthert 1998). The University of Nebraska also found the remains of an early pioneer salt works and associated historic objects at the location of site 15Be269 in 1966. One of the artifacts included a well preserved barrel from the early 1880s (Schultz et. al 1967; Striker et. al 2001).

A feature from site 15Be269 was excavated in 1993 by archaeologists Miller and Duerksen with the consulting firm 3/D Environmental Group, Inc., and several volunteers. The feature had been found because it was eroding into Big Bone Creek (Lowthert 1998). The feature measured approximately 130 cm x 120 cm and was defined by a layer of burnt clay surrounding the artifacts. The majority of the artifacts were found at the top of the feature, and there were no artifacts found in the surrounding matrix outside of the burnt clay layer (Miller and Duerksen 1995; Lowthert 1998). A Late Woodland date was concluded by the presence of two Jacks Reef-
type projectile points which are firmly assigned to this time period in northern Kentucky as well as thin walled, limestone tempered cordmarked pottery sherds. A Late Fort Ancient presence was concluded based on three triangular projectile point fragments and thin walled, shell-tempered plain surface ceramic sherds. The shell-tempered ceramics resemble post-550 BP Madisonville Horizon ceramics recovered from other Fort Ancient sites in the area. The bison teeth have a date of 120 $^{14}$C BP, which is at the time of the Madisonville Horizon (Table 3) (Miller and Duerksen 1995; Lowthert 1998). The feature may have been continuously used as a boiling pit, where heated rocks are transferred into the water, as no charcoal was found that would suggest a hearth (Lowthert 1998).

In 1998, Stokes and Lowthert conducted investigations at site 15Be269. These investigations included a 1 x 1 meter unit, numerous shovel tests, and remote sensing via magnetometer. A profile of a feature was recorded as eroding into a stream. The investigations determined that there could also be a Late Archaic house and a Late Woodland midden located there (Lowthert and Stokes 1995; Striker et. al 2001).

The midden level was 30 cm – 50 cm with a high density of limestone and shell-tempered pottery. An analysis of surface treatment on the body and rim sherds dates to the Late Woodland to Fort Ancient Periods. Two additional crude projectile points were found that could be a variety of the Late Archaic Stemmed Cluster. The deposits are continuous over a 45 m$^2$ area suggesting that the midden may represent a specialized activity site in association with the saline springs or a large structure (Lowthert and Stokes 1995; Lowthert 1998).

Three Paleoindian projectile points were recovered from site 15Be269. J.D. Moore found a Clovis projectile point and a late Paleoindian Agate Basin projectile point approximately 125
meters south of the Big Spring. Ellis Crawford found a Clovis projectile point from the area around the Big Spring as well (Tankersley 1985).

15Be270 was recorded by Ken Tankersley in 1981 (Figure 13, Table 2). Tankersley recovered a heavily patinated secondary decortication retouched flake at the interface of two soil layers and directly underneath a mastodon bone. Even though the artifact was found in direct physical association with mastodon bones, it appeared to be in a secondary context (Tankersley 1981; 2009a).

The mastodon bones were part of an in situ layer of Pleistocene deposits found in gravel below the water table. A total of 20 faunal remains at this level were uncovered and include the Pleistocene horse (*Equus complicates*), proboscideans (*Mammut* sp. or *Mammuthus* sp.), and the Pleistocene bison (*B. bison antiquus*). A radiocarbon date of 10,600 ± 250 ^14^C BP, provided by the University of Nebraska excavations, was given to the top of this gravel Pleistocene layer (Table 3). A secondary decortication flake was found at the interface of the gravel layer and a greenish gray lacustrine clay layer directly underneath a mammoth bone. Directly above the gravel layer there was one brick fragment and two historic glazed ceramic sherds (Tankersley 1981).

The southern end of site 15Be270 had previously been designated as KEN-1 by The University of Nebraska State Museum survey (Schultz et. al 1967). Approximately two meters of what they deemed as “barren surficial material” was removed by bulldozing over an area of 40 x 55 m (Schultz et. al 1963:1168). The area was then laid into a grid with each square being three meters and excavated one at a time. As work progressed, several squares were excavated simultaneously (Schultz et. al 1963). These methods most likely affected the integrity of the site.
These authors identified three zones or layers as Zone A (2-3 m), Zone B (3-4 m), and Zone C (4-5 m). Zone A contained both buff-brown soil and mottled silt. The remains found include faunal bones of various domesticated animals, bison, white-tailed deer, and historic artifacts (Schultz et. al 1963). Zone B contained dark gray to dark brown humic silt and sand. The remains found include the Pleistocene bison (*B. bison antiquus*), the woodland musk ox (*Symbos cavifrons*), wapiti/elk (*Cervus canadensis*), white-tailed deer (*Odocoileus virginianus*), and the Pleistocene horse (*Equus complicatus*). The abundant bones of *B. bison antiquus* in Zone B were associated with wood, roots, nuts, leaves, broken shells of large mollusks, and pieces of flint (Schultz et. al 1963). Two projectile points were also found in this layer: an Early Archaic Rice Lobed and a Late Archaic Stemmed. Other artifacts from this zone date to the Middle Woodland Period. Zone B is believed to be the remnants of a midden (Lowthert 1998). Zone C contains blue-gray silt. Vertebrate remains recovered from this layer include the giant ground sloth (*Glosotherium harlanii*), the American mastodon (*Mammut americanum*), the Pleistocene bison (*B. bison antiquus*), barren ground caribou (*Rangifer tarandus*), stag-moose (*Cervalces scotti*), and the Pleistocene horse (*Equus complicatus*). The ground sloth had been dated to 18,000 $^{14}$C BP (Table 3) (Schultz et. al 1963).

15Be271 was recorded in 1981 by Tankersley. Paleoindian, Archaic, Woodland, and Fort Ancient components were subsequently found at the site (Figure 13, Table 2) (Striker et. al 2001). Paleoindian flaked stone artifacts recovered from the surface collections include two fluted drills, a spurred end scrapper, and two unifacially flaked stone tool fragments with old blade scars, a heavy patina, and utilization wear. Five projectile points were found. These include one Early Archaic Stemmed, two Late Archaic Stemmed, one Early Woodland Adena Ovate Base, and a Late Fort Ancient Type 5 triangular (Lowthert 1998).
15Be271 was revisited in 1982 by the University of Kentucky field school with Richard Boisvert (Lowthert 1998). Three 1x1 meter test pits showed that the artifacts are apparently limited to the plow zone (Boisvert 1982a; Striker et. al 2001). The controlled surface survey of 2,800 m² revealed that this was a multi-component site with the majority of artifacts dating to the Late Archaic. Two Late Archaic Stemmed, one Rossville, two Otter Creek, and four Brewerton Side-Notched projectile points were recovered (Boisvert 1982a; Lowthert 1998).

The Glacken Site, 15Be272, was first recorded in 1981 by Tankersley (Figure 13, Table 2) (Striker et. al 2001). The artifacts found included 39 projectile points including one Late Paleoindian Meserve, three Kirk, one Thebes, one Early to Middle Archaic Brewerton, 13 Late Archaic McWhinney, five Late Archaic Merom-Trimble, two Early Woodland Adena, six Late Woodland Chesser, and seven Fort Ancient Triangular (Tankersley 1981). One of the Fort Ancient Triangular projectile points has been identified more specifically as a Type 6 with a date of 500 - 200 BP (Tankersley 1981; Lowthert 1998). Human bones were located on the surface at the northeastern portion of the site indicating a possible human burial that was eroding (Tankersley 1981).

The following year (1982), the University of Kentucky field school lead by Boisvert conducted a controlled surface survey of the site 15Be272. Approximately 4,200 m² of the site was surveyed and 4,000 artifacts were recovered. Boisvert also conducted excavations of four test pits and a block excavation at the summit of the site (Boisvert 1982a and 1986; Striker et. al 2001). The test pits proved negative for cultural material, but were strategically placed according to high surface concentrations of recovered artifacts. A disturbed midden was found at the western portion of the site on the steep bank of Big Bone Creek. Erosion and rodent dens compromised the stratigraphic integrity of the midden. The block excavation revealed 12
features below the plowzone (Boisvert 1982a, 1982b, and 1986). The twelve pit features include one adult male burial, one child burial in an earth oven, nine additional earth ovens or roasting pits, and one charcoal concentration in a shallow pit. Most of the twelve pit features appear to have been used in food preparation, especially the extensive exploitation of deer (Boisvert 1982a, 1982b, and 1986; Lowthert 1998).

Only one of the pits used in cooking preparation has evidence of in situ burning. There is also no evidence of heat alteration on the sides or bottoms in any of the pits. The rocks had to have been heated outside the pits and then transferred into them for the purpose of baking food. Charcoal and burned clay are found scattered inside the features, which was most likely an accident when the rocks were transferred to the pits. The large earth oven that exhibits signs of in situ burning has a layer of wood charcoal and ash at the base (Boisvert 1982b).

Two features contained diagnostic projectile points: a fragmentary Late Archaic MacIntire-like point was associated with a burial in Feature 1 and a Merom-Trimble point was recovered during flotation analysis of Feature 7 (Boisvert 1986). Other diagnostics found on the surface and plowzone support the Late Archaic period association. These twelve projectile points include five additional Merom-Trimbe, five Stemmed with lanceolate blades comparable to the McWhinney point type, a MacIntire-like, and a Gary or Morrow Mountain. In addition to the Late Archaic artifacts, an Early Archaic Kirk projectile point and two Madison projectile points were collected. The artifacts outside the Late Archaic association were found at the southern end of the site well removed from the Late Archaic component (Boisvert 1986).

Faunal remains indicate that the Glacken site was occupied during the fall and winter. The faunal assemblage is mainly comprised of deer and boxed turtle. However, there are also two fish, six birds, and a very small number of mussels. Plant food preparation is only found at
Feature 5 where there is a concentration of charred hickory nuts (Boisvert 1986). Four radiocarbon dates from each feature determined that the calibrated ages range from 4,090 – 2970 $^{14}$C BP (Table 3). A Merom-Trimble projectile point was associated with a date of 3,460 $^{14}$C BP, providing additional information on the temporal placement of this point type (Pollack 2008a).

Another possible explanation of the pit features is that they were used to process salt (Lowthert 1998). Historically, the Shawnee gathered in the Fall to process salt at the Lick (Jillson 1936; Tankersley 2002). Faunal remains at 15Be272 support the presence of people at the Lick during the Fall (Pollack 2008a). Although the site now lies approximately 300 meters south of the saline springs (Boisvert 1986), the salt marshes and saline springs may have been much larger and more numerous in the past than they are presently (Tankersley 1985). Therefore, these pits may have actually been closer to the salt springs at one time (Lowthert 1998).

The burials at the Glacken site appear to be indicative of ceremonial activity and date to the Late Archaic. There is clear evidence of post-mortem mutilation of the adult. The position of the right leg would have required the cutting of ligaments and tendons behind the knee. Red ochre was found on the cranial bones of the adult and coating a layer of limestone slabs underneath the child. This site was most likely a camp site as the presence of a child between the ages of 18-36 months would be highly unlikely in a hunting party (Boisvert 1986).

15Be273 was found by Tankersley in 1981 (Figure 13, Table 2). The surface survey located two Late Archaic projectile points, two Woodland projectile points, one Hopewell microblade, one Fort Ancient Triangular projectile point, and two Fort Ancient Triangular preforms (Tankersley 1981). The University of Kentucky field school in 1982 revisited this site and conducted a surface survey. Archaic and Fort Ancient material was present (Boisvert 1982a;
Lowthert 1998; Striker et. al 2001). One Late Archaic single Stemmed projectile point and three other possible Late Archaic projectile points were found (Lowthert 1998).

15Be436, an unknown prehistoric site, Site 15Be437, an unknown prehistoric and historic site, and site 15Be438, an unknown prehistoric site, were identified in 1995 by archaeologists working for the Kentucky Department of Transportation (Figure 13; Table 2) (Lowthert 1998). No further information has been published on these sites to date.

The Buffalo Rise Site, 15Be440, was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). Stokes and Lowthert recovered artifacts from the plowzone to a depth of 20 cm. The artifacts recovered include 64 flaked-stone artifacts and 24 ceramics. There is limestone and grit tempered ceramics that date to the Late Woodland, and incised, cordmarked, and smoothed shell tempered ceramics that date to the Fort Ancient. One non-diagnostic biface was also found (Lowthert and Stokes 1995; Lowthert 1998; Striker et. al 2001). The Buffalo Rise site could indicate an extensive occupation due to the high concentration of artifacts and the preservation of ceramics in an open habitation site. A light scattering of non-diagnostic historic artifacts was also present, but there were no identifiable historic structures or features in the immediate area (Lowthert and Stokes 1995; Lowthert 1998).

In 1962, the University of Nebraska State Museum excavated a portion of the Buffalo Rise site named KEN-2. The area was identified as a higher terrace of post-Tazewell age and is approximately seven meters above the normal water lever of Big Bone Creek. The creek bank was cleared of vegetation for a length of 24 meters and the exposed surfaces were examined in three-meter intervals. The fossils that were found appear in a single zone located between 3.5 meters and five meters below the ground surface. This zone is comprised of iron-stained,
calcareous, gravelly, sandy silt that is 30 cm - 100 cm thick and overlies a blue clayey silt. The faunal assemblage was found to be fairly uniformed throughout the 24 meters length. The paleontological remains include giant ground sloth (*Glossotherium harlanii*), bear (*Ursus americanus*), the American mastodon (*Mammut americanum*), mammoth (*Mammuthus sp.*), the Pleistocene bison (*B. bison antiquus*), the woodland musk-ox (*Symbus cavifrons*), stag-moose (*Cervales scotia*), white-tailed deer (*Odocolius virginianus*), and the Pleistocene horse (*Equus complicates*) (Schultz et. al 1963; Schultz et. al 1967).

15Be441 was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). This site includes a light prehistoric lithic scatter, historic artifacts, and the remains of two structures. Prehistoric artifacts include three flakes and a non-diagnostic biface fragment. Historic artifacts include nails and ceramics that date from 1851-1950 along with a large amount of architectural debris. Local informants have stated that the architectural remains are from an old barn and a cistern or root cellar. Part of the barn’s foundation was used for the current foundation of the State Historic Sites’ museum (Lowthert and Stokes 1995; Lowthert 1998). This site has had significant disturbances by the construction of the present museum and gift shop, the installation of a boardwalk trail, and the Discovery Trail (Striker et. al 2001).

The Upson Downs Site, 15Be442, was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). Construction of tennis courts, a playground, walking trail, and restroom facility within Big Bone Lick State Historic Site may have hurt the integrity of this site, and these areas were unable to be surveyed (Striker et. al 2001). Lowthert and Stokes found several prehistoric diagnostic artifacts during their shovel testing and surface surveying. These artifacts include a Type 2 Triangular
projectile point dating from 950-650 BP, incised ceramic sherds, shell-tempered sherds, and thin ceramic strap handles which all suggest that the site was Early to Middle Fort Ancient (Lowthert and Stokes 1995; Lowthert 1998). A buried Fort Ancient midden and two Archaic Period pit features were encountered during the shovel testing. The midden deposit and its size suggest a small but intensive occupation at the site. There was an Early to Middle Archaic Big Sandy projectile point found at the base of the Fort Ancient midden. This implies that the site was first used in the Early to Middle Archaic before being used as a midden during the Fort Ancient. The two shallow Archaic pit features contain heavy concentrations of burnt sandstone and lithic debitage (Lowthert and Stokes 1995; Lowthert 1998).

A small lithic scatter, Site 15Be443, was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). Four flakes were recovered from four shovel tests. Unfortunately the site appears to have been heavily impacted by the construction of a water or sewer plant near the site. A manhole cover and pipe are located in the middle of the site (Lowthert and Stokes 1995; Lowthert 1998).

The Baker Site, 15Be444, was first surface surveyed in 1995 by Stokes and Lowthert (Figure 13, Table 2). When recorded initially the site consisted of historic surface scatter dating from the 1880s to the early 1900s. These artifacts include glass container fragments, historic ceramics, machine-cut nails, and wire cut nails. During the surface survey a number of features were also noted: a standing wooden structure that an employee at the State Historic Site stated was an old smoke house, a large amount of limestone blocks, and a limestone root cellar (Lowthert and Stokes 1995; Lowthert 1998).
The Behringer-Crawford Museum Junior Curator Program with Kreinbrink as the lead field director revisited site 15Be444 in 2000. Historic artifacts recovered include ceramics, glass, and metal artifacts that fall within the 1850-1920 time range. Kreinbrink also identified five features: Feature 1 is a large pile of undressed limestone slabs, Feature 2 is a pile of bricks and brick fragments situated adjacent to the limestone pile, Feature 3 is an in-ground dry-laid limestone cistern, Feature 4 is an above-ground dry-laid limestone root cellar covered with earth, and Feature 5 is a wood frame shed (Kreinbrink and Harper 2001; Striker et. al 2001).

Feature 4 has an intact corbeled arch ceiling and stone framed doorway. This is similar in construction, but smaller than the cellar found at Site 15Be445. The historic features of the Baker Site, 15Be444, appear to have been in use during the nineteenth and twentieth centuries. With the exception of the area immediately around the salt springs at Big Bone Lick State Historic Site, much of the rest of the land that now falls within the State Historic Site used to be privately owned (Kreinbrink and Harper 2001; Striker et. al 2001).

The Baker Cemetery Site, 15Be445, was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). The Baker family maintained a large farm with slaves on the property in the nineteenth century (Lambert 1971). The site contains the Baker Cemetery and a root cellar that is located approximately 40 meters southeast of the cemetery (Lowthert and Stokes 1995; Lowthert 1998; Striker et. al 2001). The cemetery has 11 monuments bearing dates from 1870-1927 and corresponds with the historic homestead site associated with the Baker family, early residents of southern Boone County (Striket et. al 2001). The root cellar at the site 15Be445 is much larger than other known historic sites in Boone County. It is an excellent example of vernacular architecture and is constructed of dry-laid limestone slabs supported by a corbeled arch roof. The
structure includes two interior rooms separated by two stone wall buttresses (Striker et. al 2001). Due to the proximity of the campground and miniature golf course, Lowthert and Stokes did not shovel test this area. Therefore, there is the possibility that there are other underground features and artifacts that have not been located at this site (Lowthert and Stokes 1995).

Metcalf Flats Site, 15Be446, was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 14, Table 2). It is a light scatter of eight prehistoric lithic debitage and historic nails, glass, and ceramics. The site has been impacted by a man-made pond and an access road for the State Historic Site (Lowthert and Stokes 1996; Lowthert 1998; Striker et. al 2001).

The Matchless Day Site, 15Be447, was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert. The Matchless Day site is a small scatter of lithic and historic artifacts (Figure 13, Table 2). The area is used for camping, and open fire pits exist on the surface. Six prehistoric lithic artifacts were recovered at depths of 40 cm from shovel testing. The presence of the water table was noted directly, after the 40 cm depth was reached. No sub soil had been encountered yet, which indicates that more archaeological deposits may lie below the water table (Lowthert and Stokes 1996; Striker et. al 2001). Additionally a light scatter of artifacts was found, but they may represent recent camping activities (Lowthert and Stokes 1996; Lowthert 1998).

The Hot Letter Site, 15Be448, was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). The site currently has a swing set and other recreational structures on it. Five prehistoric lithic artifacts were recovered at depths of greater than 40 cm. This indicates the potential of a deeply buried site (Lowthert and Stokes 1996; Lowthert 1998; Striker et. al. 2001).
15Be449 was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). A brick-lined cistern was located at the northeastern edge of the site boundary. The cistern is oval in shape and measures approximately 2 x 1.5 meters. Bricks and limestone were the only artifacts associated with the cistern. Three pieces of nineteenth or twentieth century glass and a prehistoric lithic flake were found west of the cistern in shovel tests (Lowthert and Stokes 1996; Lowthert 1998).

15Be450 was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). Two limestone foundations at site 15Be450 were found located on the toe slope of a large bluff face, 45 meters west of 15Be449. The foundations are 10 meters apart and measure 10 x 7 meters and 7 x 5 meters. The smaller 7 x 5 meter foundation had the remnants of a chimney and has a gully drainage directly underneath that would have provided water runoff from the structure. The foundations had limestone, brick, metal siding, charcoal, and corrugated metal associated with them. Artifacts that correspond with these foundations include 27 pieces of glass, historic ceramics, and metal dating to the late nineteenth century (Lowthert and Stokes 1996; Lowthert 1998; Striker et. al 2001). This site may be the location of a smithy and blacksmith house that has been reported as being located in the vicinity. Due to the close proximity to site 15Be449, the two sites may also be related. A small lithic scatter was found at 15Be450 including two prehistoric lithic flakes and a biface fragment (Lowthert and Stokes 1996; Lowthert 1998).

15Be451 was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). 15Be451 yielded two additional limestone foundations located on a toe slope of a large bluff face. The foundations are approximately 220 meters north of Big Bone Creek and 35 meters east of Site 15Be449. The
foundations measure 7 x 10 meters and 6 x 10 meters and are 10 meters apart. The artifacts found include 52 nails, glass, and ceramics that date to the late nineteenth and early twentieth centuries (Lowthert 1998; Striker et. al 2001). Three prehistoric lithic flakes were also found. The majority of the artifacts were within the foundations. Buried power lines at the north of the site prevented shovel testing site boundaries (Lowthert and Stokes 1996).

15Be452 was located in 1995 with the Kentucky Archaeological Survey (KAS) under the direction of Jo Stokes and William Lowthert (Figure 13, Table 2). Shovel testing in 1995 revealed 83 prehistoric and 23 historic artifacts. Prehistoric artifacts include two bifaces, 77 flakes, two Fort Ancient shell tempered ceramic sherds, and one Late Woodland grit/grog tempered sherd. The ceramics and two biface fragments were located at the eastern edge of the site. Historic artifacts include glass, early historic ceramics, brick fragments, and hand-wrought nails that date from the early nineteenth to early twentieth centuries (Lowthert and Stokes 1996; Lowthert 1998; Striker et. al 2001). A 1x1 meter test unit was excavated in the southwestern portion of the site to investigate a possible feature. The feature appeared to be a pit that had been filled in with bricks. Both prehistoric and historic artifacts were found in the pit and the exact purpose of the feature was unclear. The numerous amounts of historic artifacts could indicate the remains of a historic farmstead at this site (Lowthert and Stokes 1996; Lowthert 1998).

Kreinbrink conducted excavations at site 15Be452 from 2001-2003 under the Behringer-Crawford Museum’s Junior Curator Program. A total of 23 square meters were uncovered with 1x1 meter test units. The majority of the artifacts recovered date to the late eighteenth and early nineteenth centuries. A dense concentration of limestone and brick were found that could have been the remnants of a foundation or chimney. The historic artifacts include domestic items such as plates and cups with hand painted edge decorations and transfer prints; eight buttons were the
only personal items found. Very few prehistoric artifacts were found, all of which date to the Archaic and Woodland periods. These artifacts were located in units stratigraphically below historic artifacts. This indicates that the area has been undisturbed and holds archaeological significance (Kreinbrink and Harper 2004).
Chapter 5: Theory

The following chapter presents the theoretical framework for the methods used at Big Bone Lick State Historic Site. The use of geology in the interpretation of archaeological data is discussed as well as the importance of a contextual archaeological approach.

*Historical Perspectives of the Use of Geology in Archaeology*

In the early nineteenth century information was being compiled on the history of the Earth before modern humans. Geology and antiquarian history were becoming important scholarly fields first joined together the interest of human antiquity (Rapp and Gifford 1985). Many great nineteenth century archaeologists were trained as geologists and natural scientists. Geological stratigraphy dominated the field of archaeology during this time (Rapp and Hill 2006).

Throughout the nineteenth and twentieth centuries, the fields of archaeology and geology developed side by side and there was much overlap and interaction between them. In the 1840s, archaeologists Ephraim G. Squier and Edwin H. Davis used stratigraphic methods to determine if mounds in the Mississippi Valley represented past human behavior (Rapp and Hill 2006). William Henry Holmes, a geologist and member of the Bureau of American Ethnology, became interested in indigenous stone tools and Native American quarry and manufacturing sites. Holmes began one of the first instances of experimental archaeology by trying to recreate stone tools and pottery. By engaging in these recreations, he felt that he could expose ancient ways of life in the Americas (Fernlund 2000).

By the early twentieth century, Nels Nelson, an archaeologist, began excavations at the Pueblo San Cristobal, New Mexico. The excavations were conducted in levels of one foot depths and artifacts from each level were kept separate. This technique applied the geologic law of
superposition and served as an example for future field excavations to help determine the exact sequence of archaeological artifacts. Instead of using arbitrary units of measurement to excavate depths, such as Nels Nelson, Alfred Kidder paid close attention to stratigraphic changes in his excavations of midden deposits at Pecos Pueblo, New Mexico. From the data he collected during his excavations, he was able to determine that certain types of pottery occurred in certain strata insinuating different time periods. Kidder arranged the pottery into a chronological sequence based upon the law of superposition in the stratigraphy (Rapp and Hill 2006).

Geologists began to investigate paleoenvironments as well as the chronology of archaeological sites in the 1920s. Kirk Bryan and Ernst Antevs were the first to employ geochronology and paleoenvironmental methodologies of sites. These new methods aided in establishing that humans lived during the Pleistocene. Their interests in past environments effectively brought both geology and archaeology together with a paleogeomorphic approach to archaeological studies (Rapp and Hill 2006).

During the mid-twentieth century, great technical innovations by earth scientists became employed by archaeologists seeking to establish chronologies. Radiocarbon, potassium-argon, argon-argon, and luminescence dating were all developed during this time and continue to be used today. Raw material identification gained momentum in the 1960s as well. This method, still used today, establishes trade routes and human seasonal migration patterns by analyzing local and non-local chert use in archaeological sites (Rapp and Hill 2006). More recently invented, Geographic Information Systems (GIS) is yet another technical innovation by geographers and geologists. GIS is a system that is designed to capture, store, manipulate, analyze, manage, and present geographical data. Archaeologists use GIS to digitally create and
manipulate the spatial areas of archaeological sites (Schmidt and Gotz 1998; Vermeulen and de Dapper 2000).

Rolfe D. Mandel (2000) has illustrated the importance of geoarchaeology in the Western Hemisphere by highlighting the Great Plains, an area where Mandel says geoarchaeology first emerged and developed due to the search for human antiquity. Although it has been established that there is a Paleoindian Period in the United States, the following Archaic Period is actually the longest of North America’s cultural periods. Great changes in human populations and adaptations to the climate changing from the Pleistocene to the Holocene occurred during this period, and it continues to be an important geoarchaeological area of research. A collection of papers, edited by Arthur Bettis III (1995), were presented at the 1991 annual meeting of the Geological Society of America and sponsored by the Archaeological Geology Division highlighting the magnitude of landscape changes during the Holocene.

Geology has lent itself to archaeology in a number of ways besides relative and absolute dating. Issues of climate change and the sustainability of cultures were recently discussed at the Geoarchaeology 2006 Conference. The papers presented have been compiled and edited by Antony G. Brown, Laura S. Bassell, and Karl W. Butzer (2011). Underwater archaeology is another more recent area that examines sunken archaeological sites. Jean-Daniel Stanley (2007) discusses the importance of geologists and archaeologists working together to place former sites that had been located above water within a precise time frame and define the environmental settings before, during, and after occupation. Climate change information has even been presented by Illya V. Buynevich et al. (2011) regarding the Great Flood hypothesis, which seeks to tie the Biblical Flood to the Black Sea. The study of the effects of geological catastrophes at or
in association with archaeological sites has also been a promising area of study for geoarchaeologists (McGuire et. al. 2000; Wasilewski 2011).

**Geoarchaeology and Archaeological Geology**

American archaeology has been described as either being anthropological archaeology or nothing. While it is true that archaeology can be considered closely related to cultural anthropology, archaeology has also been equally reliant upon geology, biology, and geography. Although it qualifies as a social science due to its objectives, archaeology is heavily dependent on empirical methods and models of the natural sciences (Butzer 1982).

The fields of ethnological anthropology and physical geology can both be directly observed as a dynamic process. In this respect, archaeology can be considered distinct from cultural anthropology and geology as the archaeological record cannot be directly observed in its process of formation. Archaeologists use the observations from these dynamic processes and apply them to an interpretation of the structural matrix of the archaeological record. From this matrix, a chronological and contextual sequence of events that form a particular part of the archaeological record can then be inferred (Rapp and Hill 2006). Two different terms have been used to describe the relationship between geology and archaeology: archaeological geology and geoarchaeology. Though seemingly similar, the definition of both terms is different as is their connection to the geosciences and archaeology (Waters 1992). These distinctions are described below.

Archaeological geology is generally regarded as geology that is pursued with an archaeological bias or application (Butzer 1982). For example, coastal change studies that determine human shoreline migration or the expansion of deltas in archaeologically important
areas could be considered archaeological geology. The making of paleogeomorphic maps of landscape changes in classical archaeological terrains such as ancient Troy are often developed by geologists because of the archaeological significance and thus can be another example of archaeological geology (Rapp and Hill 2006).

In the word “geoarchaeology”, geo modifies the noun archaeology. Therefore, geoarchaeology is a type of archaeology. The term geoarchaeology has been increasingly used since the 1970s to label a variety of research techniques in archaeology that use geoscience in the evaluation of the archaeological record (Rapp and Hill 2006). Geoscience techniques and approaches used to evaluate the archaeological record could include geomorphology, sedimentology, pedology, stratigraphy, geochronology, petrology, petrography, geochemistry, geophysics, marine geology, and climatology. These techniques and methods are applied to archaeological sites in order to investigate and interpret their sediments, soils, and landforms in conjunction with human occupations (Waters 1992).

*Contextual Archaeological Approach*

Environmental archaeology is one of the oldest interdisciplinary connections in the field. The ultimate goal in archaeology is to determine the interrelationships between past human cultures and the environment in which they lived. The environment is a dynamic factor in the analysis of archaeological context (Butzer 1982). The artifacts and their context can be seen as the basic elements of the archaeological record. Archaeologist Karl Butzer (1982:4) states: “For archaeology, context implies a four-dimensional spatial-temporal matrix that comprises both a cultural environment and a non-cultural environment and that can be applied to a single artifact or a constellation of sites.”
General Systems Theory provides a model to analyze complex interrelationships such as those between culture and the environment (Butzer 1982). Biologist Ludwig von Bertalanffy developed General Systems Theory as a body of concepts, which seek to establish the underlying rules that govern a behavior of entities such as living organisms and sociocultural systems. The concept of energy flows is especially important to environmental archaeology. If cultures are adaptive systems then the best way to understand prehistoric ones would be to trace energy flows from the natural world into and through the interrelated parts of a cultural system and then back into the natural world again (Trigger 1989). These basic principles of General Systems Theory are essential to incorporate into the environment within a contextual archaeology (Butzer 1982).

Geography is concerned with the interrelationships between human communities and their environments, with particular attention to space and the socioeconomic phenomena. If identifying primary research objectives minimizes broader concepts such as these, the primary research objectives could be used and applied to areas of spacial archaeology, archaeometry, and environmental archaeology. The primary objective of environmental archaeology would then be to define the characteristics and processes of the biophysical environment that provide a matrix for socioeconomic systems.

Contextual archaeology focuses on the idea that human decision making is multidimensional within the environment. This approach is more concerned with sites than artifacts and aims to highlight the complex systemic interactions among cultural, biological, and physical factors and processes. Karl Butzer (1982:7) specifically emphasizes five central themes of contextual archaeology: space, scale, complexity, interaction, and stability or equilibrium state. These terms were first used in geography and biology, but they also have direct archaeological applications (Butzer 1982).
Topographic features, climates, biological communities, and human groups all exhibit spatial patterning and are rarely distributed evenly. Therefore, humans could analyze all these attributes spatially, such as the use of geographical patterning over time. Analyzing space fits into temporal scales that can involve both macro- and micro-scales necessary for comprehensive interpretation. Flexibility is crucial when analyzing multi-scale spatial and temporal approaches if environments and communities are complex. In a complex environment with unevenly distributed resources, humans and non-human communities interact internally, with one another, and with the living and non-living environment. These interactions are at different scales, fluctuating with degrees of temporal localities, and at unequal rates. In turn, diverse communities are all affected to some extent by negative feedback resulting from internal processes or external inputs, which affects their stability (Butzer 1982).

Application of Contextual Archaeology

The contextual approach is heavily dependent on archaeobotany, zooarchaeology, geoarchaeology, and spatial archaeology. The key to integrating these areas into a general understanding of past human ecosystems is the set of perspectives: space, scale, complexity, interaction, and stability (Butzer 1982). Even though different types of geological dating such as radiocarbon dating can determine the numerical age of stratigraphic levels, geoarchaeological investigations of the stratigraphy are needed to determine the site matrix. Microstratigraphic interpretations provide important spatial framework to an archaeological study. The stratigraphy of the site is then compared to other sites in the general area as well as regional geochronologies, providing a temporal framework (Waters 1992).

After establishing stratigraphic context, archaeologists can then begin to determine the natural processes of site formation based upon the spatial and temporal framework. The analysis
of natural processes of site formation are concerned with understanding the physical, chemical, and biological factors responsible for the burial, alteration, and destruction at a site (Waters 1992). Geoarchaeologists can then reconstruct the landscape that existed around a site or group of sites at the time of occupation based on the evaluation of natural processes. Placing a site or group of sites in an environmental landscape is important because reconstructions of past human behavior are incomplete without the context of their non-cultural environment. The non-cultural environment can further be broken down into the living and non-living environments. The living environment constitutes the biological community of plant and animal resources that existed when the site was occupied. Archaeobotanists and zooarchaeologists study and reconstruct past biological communities. The non-living environment is the geomorphic landscape of the site and its climate. The landscape is a dynamic component of the environment that has changed through time and can be viewed as a platform on which all biological organisms have evolved, lived, and interacted with through time (Waters 1992).

The present landscape at an archaeological site is not the same landscape apparent during past human occupations of the area. It is essential to reconstruct the physical landscape when the site was occupied as well as before and after occupation. This places the human occupation in the context of a cultural, biological, climatic, and landscape context. Accurate and sophisticated interpretations of human behavior emerge when human ecosystems are reconstructed and followed through time using geoarchaeology, archaeobotany, zooarchaeology, and the archaeological record (Waters 1992).
Chapter 6: Methods

The following chapter presents the methodological framework for the data recovered at Big Bone Lick State Historic Site. Fieldwork methods as well as the various laboratory methods are further outlined.

Field Methods

I conducted profiled excavations of natural exposures and chronometric dating of the Holocene floodplain and Late Pleistocene terraces of Big Bone and Gum Branch creeks and their archaeological content. An initial surface survey of Big Bone and Gum Branch creeks within Big Bone Lick State Historic Site was conducted on the 22nd of June 2012 with the help of the University of Cincinnati, Department of Anthropology Field School. Fieldwork began on the 30th of June and continued through the 9th of September. Profiled excavation locations were targeted to increase stratigraphic and chronometric resolution of the archaeological deposits. Natural exposures of terraces (TI and T2) and the floodplain (T0) (Figure 10) were identified first. I then selected the five profiled sites from the identified geomorphic surfaces to help identify natural and anthropogenic depositional and environmental shifts. Profiled excavation sites consist of floodplain and Late Pleistocene terraces varying in elevation from 471-500 feet above sea level (asl). Sediment samples were screened through a 1/8-inch screen. Additional samples were subjected to fine-mesh (<75µm) water screening to recover small vertebrate, invertebrate, and plant fossils for taxonomic identification and potential AMS and stable isotope analysis. Plant and animal fossils for 14C dating and stable isotope analysis were hand excavated from Pleistocene and Holocene strata exposed in the profiles. The depth below the surface, stratum thickness, Munsell soil color, and lithology were all recorded.
With the assistance of University of Cincinnati anthropology undergraduate and graduate students and public volunteers, I hand excavated five 2-m-wide excavation profiles on the terrace and floodplain escarpments (see Figures 14-18). The excavations were held during Saturdays and Sundays from approximately 8 am to 4 pm. Not many days were affected by inclement weather due to a relatively dry summer. Heavy thunderstorms paused excavations in Profile 2 for a few hours on the 15th of June. Thunderstorms during the week made the water level rise in the creek and excavations were not possible on the 11th of August. The final day of excavation was the 25th of August.

The area was revisited on the 9th of September to take stratigraphic samples for stable isotope analyses of the bulk soil organic matter and optically stimulated luminescence (OSL) dating. Kenneth B. Tankersley and I took soil samples from the cleaned surface of each level from all five profiles. The samples were placed in separate plastic bags for particle size analysis. We recorded the depth below the surface, stratum thickness, Munsell soil color, and lithology. Dr. Lewis Owen and I collected Optically Stimulated Luminescence (OSL) samples from Holocene floodplain strata in the profiles. Samples were collected by hammering 10 inch long, 2 inch in diameter steel tubes into cleaned sediment faces. The tubes remained sealed until opened in the laboratory at the University of Cincinnati. All fieldwork photographs are shown in Appendix III.
Figure 14: Profile 1. Base of Excavation.
Figure 15: Profile 2. Second pink flag at 4 m mark.
Figure 16: Profile 3. Base of Excavation.
Figure 17: Profile 4. Base of Excavation.
Figure 18: Profile 5. Base of Excavation.
Laboratory Methods

Stratigraphic units, paleosols, and geomorphic surfaces exposed in the profiled excavations were correlated using Munsell soil colors and particle size analysis. I then assessed the geochronology of the Late Pleistocene and Holocene strata and their archaeological and paleontological content using stratigraphy and accelerator mass spectrometry (AMS) radiocarbon dating.

Uncertainties are inherent in both dating methods. Stratigraphic sections may contain erosional unconformities and post-depositional deformation (e.g., argilliturbation and bioturbation). Radiocarbon samples can be contaminated with older carbon during transport and deposition, with young carbon from sources such as modern roots or burrowing organisms, and in the radiocarbon calibration curve, uncertainty increases with age. Yet despite the inherent uncertainties, these methods are effective and the dating tools substantially complement one another when used together. Therefore applying both dating techniques helped test and control for potential problems.

Particle Size Methods

I prepared and analyzed the soil samples for particle size analysis with the help of Alyssa Atkinson, an undergraduate anthropology student at the University of Cincinnati. Soil samples were prepared in the Ohio Valley Archaeology Lab, Department of Anthropology, at the University of Cincinnati, Ohio.

A 10 ml soil sample from each layer of all five profiles was dried in a glass beaker on a hot plate. The soil was then hand ground with a mortar and pestle. The soil was then put into sieves that measured 2.36mm, 2mm, 1.7mm, 1.18mm, 0.85mm, 0.6mm, 0.42mm, 0.075mm, and <0.075mm respectively. Samples collected from each sieve were then weighed on a digital scale in grams. The textural classification used divided the sieve sizes into the following categories:
>2.36mm = Gravel

2.36mm = Fine Pebbles

2mm-0.42mm = Sand

.075mm = Silt

<0.075mm = Clay

The percentages in each category were then placed into the Textural Triangle (see Figure 19) to determine the particle size of each level in each profile.

Figure 19: Textural Triangle (NRCS Soil Survey 2012).
Stable Carbon and Stable Nitrogen Isotope Methods

I prepared 31 soil organic matter (SOM) samples of excavated sediments at the Ohio Valley Archaeology Laboratory, Department of Anthropology, University of Cincinnati, Ohio. This was done to analyze the stable carbon (δ13C) and stable nitrogen (δ15N) isotope values. After preparing the samples, I sent them to the Geology Department, University of Cincinnati, Ohio for analysis. Two analyses were run for each sediment sample and run in triplicate. Stable carbon isotope values on bulk organic matter was obtained on a DELTAplusXP stable isotope ratio mass spectrometer (IRMS). The δ13C isotopic values of the bulk organic matter were measured with the IRMS relative to Vienna Pee Dee Belemnite (VPDB) carbonate standards.

Identification Methods for Culturally Diagnostic Artifacts and Vertebrates

Kenneth B. Tankersley provided species identifications for recovered vertebrate remains. I examined and identified all cultural artifacts collected during the excavations. Tankersley examined and confirmed my identifications. All of the fossils and artifacts recovered from Big Bone Lick were cleaned and catalogued at the Ohio Valley Archaeology Laboratory, Department of Anthropology, at the University of Cincinnati, Ohio.

Optically Stimulate Luminescence Dating Methods

OSL sediment samples that were collected in the field were taken to the University of Cincinnati where Geology Department head, Lewis Owen, oversaw sample preparation.

Radiocarbon Dating Methods

Various botanical samples were taken throughout profiled excavations in order to have a large enough collection to pull certain samples for radiocarbon dating. Organic materials that once formed the biosphere of different sedimentary layers are those that can be dated by radiocarbon
(Bowman 1990). Kenneth B. Tankersley prepared wood cellulose samples for AMS radiocarbon dating at the Ohio Valley Archaeology Laboratory, Department of Anthropology, University of Cincinnati, Ohio. Samples were then sent for analysis at a commercial laboratory, Beta Analytic.
Chapter 7: Data Analysis

This chapter will present the data that have been gathered at Big Bone Lick State Historic Site during the summer of 2012. The data that will be presented include the current landscape, sediment stratigraphy, archaeosediment stratigraphy, Munsell soil colors, particle size data, stable carbon and stable nitrogen isotope data, artifact analysis, vertebrate paleontological inventory, optically stimulated luminescence dates, and AMS and β-decay radiocarbon dates.

Current Landscape

The focus of this study is to interpret the sediment stratigraphy encountered during profiled excavations and place them into an accurate geological and archaeological chronology of past landscape formations. In order for the data discussed later in this chapter to be useful, it is first necessary to present current landscape models of the area for background geographic information using geographic information systems (GIS) technology. For soil and sediment landscapes, terrain is important because it influences the natural moisture regime and the balance of soil formation and erosion (Butzer 1982). The following Figure 20 illustrates the elevations and topography found currently at Big Bone State Historic Site. The map is scaled at 7.5”. Boone County Geographic Information System (2012) provided the ArcGIS files used in these figures.
Sediment Stratigraphy

Fundamental to the study of time and chronology in archaeology is the concept of stratigraphy. The three principles that are fundamental to stratigraphy are superposition, original horizontality, and original continuity. Superposition is the observation that the layers on the bottom of a stratum were deposited first and are the oldest. Therefore, the top layers were deposited last and are the youngest. Original horizontality describes the observation that sedimentary particles will mostly settle in horizontal layers (Rapp and Hill 2006). Original continuity says that each layer originally extended spatially as a whole and that any discontinuities that now exist are the result of erosion, faulting, and other processes (Banning 2000). These three principles can be used to evaluate the relationships of sediments, artifacts and archaeological features, and ecofacts within the context of time and space (Rapp and Hill 2006).

The stratigraphy of all five profiles include geological and archaeological levels as well as their internal sequences of superpositioning (Butzer 1982). The stratigraphy of the profiles
were examined and initially differentiated in the field based on Munsell soil color and texture of the sediment. Figure 21 illustrates the location of each profile along with existing site locations. Profile 5 is furthest upstream on Gum Branch, Profile 1 is at the intersection of Gum Branch and Big Bone Creek, Profile 4 is at the edge of the stream bed on Big Bone Creek upstream from Profile 1, Profile 2 is upstream from Profile 4, and Profile 3 is the furthest upstream on Big Bone Creek (Figure 21). The profile Figures 22-29 were hand drawn in the field and then digitally traced using Corel Draw version 14.
Figure 21: The location of each profile along with current site boundaries located within the park.
Figure 22: Stratigraphy of Profile 1

Big Bone Lick
Profile 1
Gum Branch
7/7/12

10YR5/4 Firable Silty Clay Loam
10YR7/4 Silt Loam
10YR6/1 Sandy Loam
5YR3/4 Oxidized Sandy Loam
7.5YR4/2 Loamy Sand
Gley 2 7/5B Clay
10YR7/4 Sandy Loam
10YR5/4 Loam
Gley 2 4/5B Clay
10YR5/3 Loam
5YR4/6 Sandy Loam

- Mammuthus sp. or Mammut americanum Rib Fragment
- Mammuthus sp. or Mammut americanum Tibia Fragment
- Mammuthus sp. or Mammut americanum Rib Fragment
- Mammuthus sp. or Mammut americanum Rib Fragment
- Abundant Organics
- Wood
- Wood
- Wood

Top of Bank
0.5m
1m
1.5m
2m
2.5m
3m Stream Level
3.5m Base of Excavation
2m Wide
Figure 23: Stratigraphy of Profile 2. Top half: 0-4 meters
Figure 24: Stratigraphy of Profile 2. Lower half: 4-7meters
Figure 25: Complete stratigraphy of Profile 2
Figure 26: Stratigraphy of Profile 3

Big Bone Lick
Profile 3
Big Bone Creek
8/12/12

* Heavy Kaolinite throughout profile
Figure 27: Stratigraphy of Profile 4

Big Bone Lick
Profile 4
Big Bone Creek
07/29/12

Gley2 7/5B Clay Loam
7.5 YR 5/8 Loam with Fine Pebbles
0.5m
0.6m Base of Excavation
2m Wide

Gley2 7/5B Clay Loam
7.5 YR 5/8 Loamy Gravel
4m Wide
Bottom of Excavation
Figure 28: Planview of Profile 4

2.8m South
In Stream:
Bison B. bison Thoracic Vertebrae
Bison B. bison Juvenile Axis Vertebrae
Retouched Flake Wyandotte
Flake Wyandotte
2 Cores HLFD

Big Bone Lick
Profile 4
Planview
Big Bone Creek
Figure 29: Stratigraphy of Profile 5

Big Bone Lick
Profile 5
Gum Branch
8/19/12

10YR5/4 Sandy Clay Loam

5YR 4/4 Sandy Gravel

5YR 4/3 Gravel with Sand

5YR 3/2 Gravel with Sand

Gley 1 5/5B Clay mottled at 20% with Gley 1 6/10Y Clay
Gravel throughout layer at 10%

Bison B. bison Scapula Fragment

Retouched Flake

Wood

Walnut

310±30 BP

400±10 BP

Stream Level

2m Wide
Natural Sediments Stratigraphy

Profile 1 (Figure 22) illustrates the movement of Big Bone Creek over time. This is shown by the accumulation of soils in the late Holocene from the Profile’s Top of Bank to the 3.2 meter level. At 3.2 meters there is an unconformity in the stratigraphy, i.e., at 3.2 meters to 3.5 meters (base of excavation) a late Pleistocene date has been obtained. There is no soil accumulation from the late Holocene to late Pleistocene at the 3.2 meter mark because this once was the bed of Big Bone Creek in between those time spans. During the late Holocene, the bed of Big Bone Creek moved over a few meters to the west to its current location. This unconformity in the stratigraphy means that there was 3 meters of soil accumulation in the last 500 years in the location of Profile 1 on Gum Branch. This much soil accumulation is evidence of anthropogenic aggradation from deforestation and agricultural practices.

Profile 2 (Figure 23-25) shows similar signs of high level soil accumulation during the Holocene from the Top of Bank to 4.7 meters. At 4.7 meters there is another unconformity in the stratigraphy where soil degradation occurs, meaning that this level used to be the bed of Big Bone Creek as well. The stratigraphy dates to the Pleistocene below this unconformity.

All of Profile 3 (Figure 26) has been dated to Holocene related anthropogenic aggradation. The Base of Excavation at 3.46 meters had not yet revealed an unconformity as Profile 1 and Profile 2 have shown.

Profile 4 (Figures 27-28) is located in the current stream bed of Big Bone Creek. All of this profile has dated to the Holocene. More specifically to the Fort Ancient Period as B. bison bison bones were present. Along with flaked stone artifacts, the presence of B. bison bison bones indicate a possible bison kill site or processing site.
Profile 5 (Figure 29) illustrates late Holocene anthropogenic aggradation from Top of Bank to 3.3 meters. There is an unconformity in the stratigraphy located at 3.3 meters, which is also the current stream level of the Profile. After 3.3 meters, the soils indicate a late Pleistocene age.

Not all of the layers in each profile present regular horizontal sedimentation. There are a few anomalies that will be discussed in further details from Profiles 2 and 3. The term argilliturbation has been used to describe a section of the stratigraphy in level 5 of Profile 2 (Figures 24-25). Argilliturbation refers to the swelling and shrinking of clays, which causes a form of mixing (Rapp and Hill 2006). When the ground becomes wet, water is taken in through the clay and causes it to swell. As the ground dries, water leaves the clay and the ground shrinks and cracks. Layers of shrinking and swelling clays are referred to as Vertisols. The processes that make a vertisol usually occur annually in regions (like Big Bone Lick) that have a wet and dry season (Waters 1992). There were no artifacts in the area of Profile 2 that could have been moved due to the clay swelling and shrinking or argilliturbation.

Profile 3 (Figure 26) exhibits a process known as deformation. In this process the pressure of heavy overlying deposits squeeze the underlying deposits and cause convolutions to form. Lighter sediments then expand upwards into heavier layers, which create laminations. The sandy pillow structures in Profile 3 located at 2.4 meters are products of deformation. These sandy pillows were at one time a sandy horizontal layer. Due to the occurrence of deformation, the denser layer above (consisting of a silty loam with gravel) squeezed the underlying less dense sandy layer into balls or pillows of sand (Butzer 1982; Rapp and Hill 2006).

The stratigraphy in Profile 3 illustrates that it was once completely underwater for a significant period of time. This particular profile was very hard to excavate due to the large
amounts of kaolinite ($\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$) and concretions found throughout the sediment. Sometime in the past, the area encompassing Profile 3 was waterlogged, which produced a gleyed soil, much like those seen at and below the current stream level in other profiles. The gley was the result of a reduction in iron and manganese that entered the soil solution and left behind a gray horizon. When the water evaporated and air entered the soil, the iron and manganese were re-oxidized (Rapp and Gifford 1985). The iron oxides then formed goethite and lepidocrocite. With better drainage, large pore spaces opened up in the soils and became filled with concretions to produce what is known as pseudogleization (Rapp and Gifford 1985). The concretions forming the pseudogleization process were found throughout Profile 3 and gave the sediments an almost rock-like quality.

**Archaeosediment Stratigraphy**

Three different archaeosediments have been documented during the excavations at Big Bone Lick. Two of these layers are from Profile 2 and one is from Profile 4. Profile 2 Feature 1 (Figures 23 and 25) was the last section excavated in 2012. The Feature was visibly seen eroding into Big Bone Creek at the beginning of fieldwork. Profile 2 was then strategically staked out to incorporate this Feature. A burnt earth lense of 2.5Y4/8 surrounded a truncated pit of fire-cracked rock. The pit was approximately 0.5 meters in height and 2 meters wide. Upon excavation, a number of artifacts were recovered including 24 flakes made of Wyandotte, Upper Mercer, Flint-Ridge, and high-level fluvial chert deposits; and one Late Woodland – Newtown diagnostic limestone tempered prehistoric body sherd. Faunal remains recovered include one *Cervus Canadensis* (Elk) tooth, two unidentified burnt mammal bones, and one unidentified calcined mammal bone. The Late Woodland – Newtown Phase that corresponds with the limestone tempered prehistoric pottery sherd dates between 1650 – 950 BP (Pollack and
Henderson 2000). Other artifacts that further the accuracy of the Late Woodland date are the 8 non-local chert flakes (Wyandotte, Upper Mercer, and Flint-Ridge) and an elk tooth, which would culturally be applicable to the Late Woodland Period.

The second archaeostratigraphic layer, located in Profile 2, contains remnants of a human burial (Figures 23 and 25). Heavily disintegrated human remains were discovered in this layer along with non-diagnostic flaked-stone artifacts, a diagnostic Late Archaic McWhinney point recycled into a hafted end-scraper, and red ocher. Non-diagnostic flaked-stone artifacts include two quartzite cores, one metaquartzite fire-cracked rock, one sandstone pitted stone, two high-level fluvial chert deposit preforms, two high-level chert deposit flakes, one Wyandotte chert flake, and one high-level fluvial chert deposit retouched flake. The human remains, red ocher, and the Late Archaic diagnostic flaked-stone point to a Late Archaic period burial. Archaic burials have been known to frequently have red ocher or hematite covering burials, possibly signifying a religious or spiritual significance (Pleger and Stoltman 2009; Rapp and Hill 2006). The entire burial was not exhumed and will most likely continue to erode into Big Bone Creek.

The third archaeostratigraphic layer is located in Profile 4 (Figures 89-90). This profile, unlike the others, was actually situated entirely in the bed of Big Bone Creek and excavated as a unit. A considerable number of artifacts as well as remains from eleven B. bison bison faunal remains were found in and near Profile 4. The artifacts found include nine flakes, six cores, three biface fragments, and one diagnostic cordmarked shell-tempered pottery body sherd. The presence of B. bison bison as well as the pottery sherd indicates a Fort Ancient time period. The number of flaked-stone tools present and the large number of B. bison bison remains including a smashed rib bone (Appendix V, Photograph 31) indicates that Profile 4 is the location of a possible bison kill and/or butchery site.
It is important to note that artifacts can be regarded as particles that can be analyzed in the same manner as natural particles. It is possible that many artifacts have been transported by water before burial or retrieval in a fluvial setting (Brown 1997). The surface artifacts recovered during the excavations were most likely the result of erosional activity into the creek followed by water transportation. The creek’s transportation of artifacts could also have had an unknown impact on sites located in the stream, such as that of Profile 4. However, humans buried the two archaeosediments in Profile 2 when they were deposited into the sediments, and thus are at this time only being subjected to erosional activity by Big Bone Creek.

Along with both natural and archaeosediments, it can be important to remember that major modifications to the natural environment during the Holocene occurred and contributed to sedimentation. These major modifications can directly be related to human activity. Human behavior affects the soil-sediment system in a variety of ways such as erosion and deposition. Human modifications to the landscape include de-vegetation for activities like horticulture, agriculture, and even to improve hunting. De-vegetation through burning, clearance, and grazing disrupts the absorption of water into the soil and increases effects of precipitation. Soil loosening caused by cultivation or animals also increases surface water runoff and erosion (Rapp and Hill 2006). Although historically recent, the human construction of homesteads, resorts, and the State Historic Site facilities such as roads and buildings, all increase runoff, which in turn affects the sedimentation and erosion of Big Bone Creek and Gum Branch. Excavations, such as those from the University of Nebraska, moved large amounts of earth in order to expose the Pleistocene soil horizons. These excavations could have led to a large amount of redepositon and erosion within the Historic Site boundaries.
Munsell Soil Colors

Initially, Munsell Soil Color and texture of the sediment differentiated the profile stratigraphy in the field. Color can be a very valuable visual cue in recognizing soil-horizon materials and processes that are or have been operating in sediment layers (Birkeland 1999). The source rocks, weathering processes, physical and chemical conditions at the site of deposition, and post-depositional changes all affect the color of soils and sediments. The U.S. Soil Survey program adopted the Munsell color charts in 1949 in order to standardize the classification of colors in soils and sediments. The Munsell system uses three coordinates to define color: hue, value, and chroma (Rapp and Hill 2006). In general, the most commonly denoted soil colors are classified as red 2.5YR, a combination of yellow and brown 10YR, and mainly yellow 2.5Y (Birkeland 1999). Although a standardized color chart has greatly improved the scientific classification of color in soils and sediments, it should be noted that there can be standard variability problems as with any visual observations. Soils and sediment color can be affected by factors such as light, moisture content, and dimensions of the areas with individual colors (Rapp and Hill 2006).

The color of soils and sediment generally depends upon the amount of organic material and ferric oxides present. The more organic material and ferric oxide coating the grains the darker the color will be. Overall, red soils are often older than yellow soils and they indicate the presence of drainage (Rapp and Hill 2006). Iron oxides can be a good indicator of soil forming environments because they include several different minerals that have different colors: goethite (FeO(OH), hematite (Fe₂O₃), lepidocrocite (γ-FeO(OH)), and maghemite (Fe₂O₃, γ-Fe₂O₃). Goethite is the most common iron oxide in soils regardless of climatic zone and recognized as 10YR to 7.5YR. The red color in soils is actually not related to the amount of iron oxide present, but to the hematite content and is recognized as 5YR to 5R. Hematite is formed at fairly low
temperatures. Lepidocrocite, 7.5YR, favors non-calcareous clayey soils that undergo anaerobic conditions sometime during each year. Maghemite is ferromagnetic and can be separated from the soil with a hand magnet. Oxidization of magnetite \((\text{Fe}_3\text{O}_4)\) leads to the formation of maghemite and is represented by 2.5YR-5YR hue (Rapp and Hill 2006).

Post-depositional conditions contain a variety of other colors (Rapp and Hill 2006). Gley colors result in soils that have had either iron pigments removed under reducing conditions or the precipitation of iron pigments during oxidizing conditions (Birkeland 1999). In other words, gley's are generally indicative of hydric soils. A mottled appearance from undisturbed soil is the result from the migration in solution of manganese and iron ions leading to patchy accumulations of oxides and hydroxides. The mottling described is also characteristic of gleyed soils. The seepage of colloids, organic material, or iron compounds may result in colored streaks in deposits. Mottling can be an indicator of a soil horizon that is incompletely weathered or disturbed soils (Rapp and Hill 2006).

Post-depositional green colors are the result of mostly hydrous silicates. White or light gray colors can be from a variety of conditions such as source rock, high quartz or sand content, or leaching by moving water (Rapp and Hill 2006). When there is enough leaching of vertically or horizontally moving water the soil particles become free of colloidal coatings of oxides and hydroxides. Brown to Red colors generally indicates pedogenic iron (Birkeland 1999). Reddish and yellowish colors are a result of oxidization from good drainage and aeration. Reds can also be an indication of intense heat, alternating wet and dry environments, and weathering zones (Rapp and Hill 2006).

The texture of the sediment greatly influences the color. The amount of surface area on the particle grain that has to be coated to denote a certain color depends upon the size of the
particle. For example, a coarse grained sediment has a much lower surface area per unit volume than do fine grained sediments. Therefore, it would take much less pigment to color coarse-grained sediments than fine-grained sediments (Birkeland 1999).

Particle Size Data

Particle size analysis examines the sediment’s texture, which depends on the proportion of sand, silt, and clay sizes that are less than 2mm in diameter (Birkeland 1999). Texture refers to the size, shape, sorting, and orientation of particles. The particle size distribution provides an indication of the transport and depositional systems that resulted in the accumulation of the sediments (Rapp and Hill 2006). The variation of particle size can be attributed to a variety of elements such as inherent parent material, mechanical weathering, atmospheric additions of solids to sediments, and neoformation. Texture is one of the most important characteristics in a sediment profile, especially for archaeologists. The variation in texture from horizon to horizon can be used to decipher the pedogenic and geological history of the sediment (Birkeland 1999). These geological horizons can then provide dating and environmental evidence for archaeological surfaces embedded within them.

There are different factors involved in the transportation and creation of clay, silt, sand, and gravel clastic particles. All four types of clastic particles can be found in the particle size analysis conducted on the sediment samples at Big Bone Lick, Kentucky. Clay, silt, sand, and gravel particles found at Big Bone Lick, Kentucky are the result of transportation and secondary deposition of water flow (Waters 1992).

When water flows over unconsolidated sediments, particles either remain stationary or begin to move. Particle sizes will move depending on the size of the particle and the water flow velocity present at any given time. Figure 30 shows the critical erosional velocity needed to
dislodge and move particles of various sizes. The erosional velocity is lowest for sand. Greater velocities are required to move particles of larger or smaller sizes. Higher flow speeds are obviously needed to move larger particles, such as gravels, downstream. However clay and silt also require a much higher flow speed to remove them from the substrate due to the particles collective cohesiveness.

Once particles of any size are set in motion, they will continue to move downstream if the current velocity remains high or even drops below the critical velocity needed to initiate particle size movement. However, for the particle to remain in motion the speed must be higher than the settling velocity of the particle size. Silt and clay are difficult to erode, but once they are moving they can be transported at very low velocities. Most streams do not maintain high flow velocities for very long, so most of the sediments transported during normal flow conditions mainly consist of sand and finer particles. Gravel particles usually only move during flooding episodes when water velocity is extremely high (Waters 1992).

Figure 30: The Hjulstron diagram shows the stream flow velocity need to entrain, transport, and deposit clastic sediments.
Particles are transported in several different ways depending on their size and the speed and turbulence of the water. Fine-grained clay and silt are transported in suspension. These particles can move great distances without coming into contact with the bottom or sides of the channel and are kept from settling by turbulence (Waters 1992). Sand particles are moved by a process known as saltation, meaning sand size particles bounce along the bed of the channel. Traction is the process in which coarser particles, such as gravel, are moved. Because gravel is heavy, it moves by sliding or rolling down the channel (Figure 31). When particle movement ceases, deposition occurs. All stream deposited sediments are referred to as alluvium (Waters 1992).

Figure 31: The transport of clastic sediments (Waters 1992).

Both sections of Big Bone Creek and Gum Branch that were surveyed for this thesis can be classified as a meandering river (Figure 32). Stream flow in a meandering river is confined to a single, highly sinuous channel. The water velocity in a meandering river can usually be either normal flow or overbank flooding, which occurs during rain or snow melt. The gradual movement of the bed and bank of a meandering river can be seen as dynamic, with different areas of the floodplain characterized by erosion, deposition, and stability. Coarse debris (i.e.
gravel, sand, blocks of cohesive sediment, and waterlogged plant debris) on the bottom of the channel is moved during flooding events (Waters 1992).

Figure 32: An example of a typical meandering river (Waters 1992).

Therefore the various particle size distributions found at Big Bone Lick, Kentucky (see Figures 34-38 and Tables 4-13) represent varying degrees of water velocity. The water velocity required to move certain sizes of particles, which have been presented in this section, can then be applied to the particle sizes found in the sediment samples from each profile. Particle size is an important factor to consider when reconstructing past environments as it can indicate periods of rapid water flow (i.e. flooding), normal water flow, and ponded water (i.e. low areas that stagnate during periods of drought, Figure 33).

Figure 33: A representation of the hydrology of a temperate floodplain (Brown 1997).
The following Tables (4-13) and Figures (34-38) provide the detailed information gathered from each profile at Big Bone Lick concerning particle size. The Quantitative Data Tables (Table 4, 6, 8, 10, and 12) list the raw data obtained from the particle size analysis. The level and depth at which each soil sample was collected is displayed under the horizontal row headings of the tables. The mesh size or sieve size information that corresponds with the depth at which the soil was taken is displayed in the vertical column heading. The Qualitative Data Tables (Tables 5, 7, 9, 11, and 13) build off of the Quantitative Data Tables and use the percentages of particle sizes as well as Munsell Soil Color and the Sort or grain size in order to visually represent each sample. The raw data from the Quantitative Data Tables are also placed into the Particle Size Graph to illustrate the composition of the sediments.
### Table 4: Profile 1 Quantitative Data

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<th>Level 2 Stringers 175 cm Mass (g)</th>
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### Table 5: Profile 1 Qualitative Data

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Figure 34: Profile 1 Particle Size

Table 6: Profile 2 Quantitative Data

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<td>0.02</td>
</tr>
<tr>
<td>0.85</td>
<td>0.28</td>
<td>2.4</td>
<td>2.43</td>
<td>3.29</td>
<td>4.94</td>
</tr>
<tr>
<td>0.6</td>
<td>2.14</td>
<td>2.93</td>
<td>1.85</td>
<td>2.18</td>
<td>3.08</td>
</tr>
<tr>
<td>0.42</td>
<td>1.75</td>
<td>1.39</td>
<td>1.6</td>
<td>1.46</td>
<td>1.86</td>
</tr>
<tr>
<td>0.075</td>
<td>7.19</td>
<td>11.11</td>
<td>7.23</td>
<td>14.36</td>
<td>2.88</td>
</tr>
<tr>
<td>&lt;0.075</td>
<td>0.82</td>
<td>3.51</td>
<td>0.43</td>
<td>10.42</td>
<td>15.2</td>
</tr>
<tr>
<td>Totals</td>
<td>17.16</td>
<td>21.34</td>
<td>17.41</td>
<td>34.89</td>
<td>27.98</td>
</tr>
</tbody>
</table>
## Table 7: Profile 2 Qualitative Data

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (cm)</th>
<th>Munsell Soil Color</th>
<th>Sort</th>
<th>Mass (g)</th>
<th>Particle Size %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>400</td>
<td>10YR5/4</td>
<td>Poorly Medium</td>
<td>17.16</td>
<td>53.32% sand; 41.9% silt; 4.78% clay</td>
</tr>
<tr>
<td>2</td>
<td>417</td>
<td>10YR6/1</td>
<td>Fine</td>
<td>21.34</td>
<td>52.06% silt; 31.49% sand; 16.45% clay</td>
</tr>
<tr>
<td>3</td>
<td>445</td>
<td>7.5YR6/8</td>
<td>Well Medium</td>
<td>17.41</td>
<td>56.81% sand; 41.53% silt; 2.46% clay</td>
</tr>
<tr>
<td>4</td>
<td>451</td>
<td>Gley2 5/5B</td>
<td>Fine</td>
<td>34.89</td>
<td>41.16% clay; 29.87% silt; 28.97% sand</td>
</tr>
<tr>
<td>5</td>
<td>475</td>
<td>Gley2 7/10BG</td>
<td>Fine</td>
<td>27.98</td>
<td>54.32% clay; 35.39% sand; 10.29% silt</td>
</tr>
</tbody>
</table>

## Figure 35: Profile 2 Particle Size

![Profile 2 Particle Size](image-url)
**Table 8: Profile 3 Quantitative Data**

<table>
<thead>
<tr>
<th>Mesh (mm)</th>
<th>Level 1 124 cm Mass (g)</th>
<th>Level 2 140 cm Mass (g)</th>
<th>Level 3 200 cm Mass (g)</th>
<th>Level 4 235 cm Mass (g)</th>
<th>Level 5 310 cm Mass (g)</th>
<th>Level 6 330 cm Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.36</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.61</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.7</td>
<td>0.01</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.18</td>
<td>0.04</td>
<td>2.5</td>
<td>3.87</td>
<td>0</td>
<td>4.31</td>
<td>2.13</td>
</tr>
<tr>
<td>0.85</td>
<td>0.7</td>
<td>4.65</td>
<td>2.87</td>
<td>0</td>
<td>3.87</td>
<td>4.02</td>
</tr>
<tr>
<td>0.6</td>
<td>1.61</td>
<td>3.43</td>
<td>3.21</td>
<td>0</td>
<td>3.7</td>
<td>3.35</td>
</tr>
<tr>
<td>0.42</td>
<td>1.7</td>
<td>2.69</td>
<td>2.3</td>
<td>0.72</td>
<td>2.36</td>
<td>2.55</td>
</tr>
<tr>
<td>0.075</td>
<td>3.18</td>
<td>9.48</td>
<td>16.86</td>
<td>7.27</td>
<td>16.03</td>
<td>5.96</td>
</tr>
<tr>
<td>&lt;0.075</td>
<td>8.49</td>
<td>3.94</td>
<td>1.35</td>
<td>9.14</td>
<td>2.17</td>
<td>12.89</td>
</tr>
<tr>
<td>Totals</td>
<td>15.73</td>
<td>26.69</td>
<td>30.46</td>
<td>17.13</td>
<td>32.44</td>
<td>31.51</td>
</tr>
</tbody>
</table>

**Table 9: Profile 3 Qualitative Data**

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (cm)</th>
<th>Munsell Soil Color</th>
<th>Sort</th>
<th>Mass (g)</th>
<th>Particle Size %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>124</td>
<td>10YR5/6</td>
<td>Fine</td>
<td>15.73</td>
<td>53.97% clay; 25.81% sand; 20.22% silt</td>
</tr>
<tr>
<td>2</td>
<td>140</td>
<td>2.5YR4/8</td>
<td>Fine</td>
<td>26.69</td>
<td>49.72% sand; 35.52% silt; 14.76% clay</td>
</tr>
<tr>
<td>3</td>
<td>200</td>
<td>10YR5/4</td>
<td>Fine</td>
<td>30.46</td>
<td>55.35% silt; 40.22% sand; 4.43% clay</td>
</tr>
<tr>
<td>4</td>
<td>235</td>
<td>2.5YR7/3</td>
<td>Fine</td>
<td>17.13</td>
<td>53.36% clay; 42.44% silt; 4.20% sand</td>
</tr>
<tr>
<td>5</td>
<td>310</td>
<td>10YR6/4</td>
<td>Fine</td>
<td>32.44</td>
<td>49.41% silt; 43.9% sand; 6.69% clay</td>
</tr>
<tr>
<td>6</td>
<td>330</td>
<td>Gley1 4/5GY</td>
<td>Fine</td>
<td>31.51</td>
<td>38.24% sand; 40.91% clay; 18.91% silt; 1.94% fine pebbles</td>
</tr>
</tbody>
</table>
Figure 36: Profile 3 Particle Size

Table 10: Profile 4 Quantitative Data

<table>
<thead>
<tr>
<th>Mesh (mm)</th>
<th>Level 1 25 cm Mass (g)</th>
<th>Level 2 60 cm Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.36</td>
<td>0</td>
<td>11.36</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0.13</td>
</tr>
<tr>
<td>1.7</td>
<td>0</td>
<td>1.14</td>
</tr>
<tr>
<td>1.18</td>
<td>0</td>
<td>2.25</td>
</tr>
<tr>
<td>0.85</td>
<td>1.04</td>
<td>1.47</td>
</tr>
<tr>
<td>0.6</td>
<td>3.2</td>
<td>1.39</td>
</tr>
<tr>
<td>0.42</td>
<td>0.95</td>
<td>1.84</td>
</tr>
<tr>
<td>0.075</td>
<td>6.54</td>
<td>10.63</td>
</tr>
<tr>
<td>&lt;0.075</td>
<td>7.01</td>
<td>5.31</td>
</tr>
<tr>
<td>Totals</td>
<td>18.74</td>
<td>35.52</td>
</tr>
</tbody>
</table>
Table 11: Profile 4 Qualitative Data

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (cmbs)</th>
<th>Munsell Soil Color</th>
<th>Sort</th>
<th>Mass (g)</th>
<th>Particle Size %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>124</td>
<td>10YR5/6</td>
<td>Fine</td>
<td>15.73</td>
<td>53.97% clay; 25.81% sand; 20.22% silt</td>
</tr>
<tr>
<td>2</td>
<td>140</td>
<td>2.5YR4/8</td>
<td>Fine</td>
<td>26.69</td>
<td>49.72% sand; 35.52% silt; 14.76% clay</td>
</tr>
<tr>
<td>3</td>
<td>200</td>
<td>10YR5/4</td>
<td>Fine</td>
<td>30.46</td>
<td>55.35% silt; 40.22% sand; 4.43% clay</td>
</tr>
<tr>
<td>4</td>
<td>235</td>
<td>2.5YR7/3</td>
<td>Fine</td>
<td>17.13</td>
<td>53.36% clay; 42.44% silt; 4.20% sand</td>
</tr>
<tr>
<td>5</td>
<td>310</td>
<td>10YR6/4</td>
<td>Fine</td>
<td>32.44</td>
<td>49.41% silt; 43.9% sand; 6.69% clay</td>
</tr>
<tr>
<td>6</td>
<td>330</td>
<td>Gley1 4/5GY</td>
<td>Fine</td>
<td>31.51</td>
<td>38.24% sand; 40.91% clay; 18.91% silt; 1.94% fine pebbles</td>
</tr>
</tbody>
</table>

Figure 37: Profile 4 Particle Size
Table 12: Profile 5 Quantitative Data

<table>
<thead>
<tr>
<th>Mesh (mm)</th>
<th>Level 1 264 cm Mass (g)</th>
<th>Level 2 276 cm Mass (g)</th>
<th>Level 3 300 cm Mass (g)</th>
<th>Level 4 310 cm Mass (g)</th>
<th>Level 5 328 cm Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.36</td>
<td>0.55</td>
<td>4.88</td>
<td>17.29</td>
<td>13.88</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0.21</td>
<td>0.1</td>
<td>1.1</td>
<td>0.41</td>
<td>0</td>
</tr>
<tr>
<td>1.7</td>
<td>0.23</td>
<td>0.16</td>
<td>0.45</td>
<td>0.69</td>
<td>0</td>
</tr>
<tr>
<td>1.18</td>
<td>1.54</td>
<td>1.03</td>
<td>1.2</td>
<td>1.64</td>
<td>0</td>
</tr>
<tr>
<td>0.85</td>
<td>2.35</td>
<td>1.68</td>
<td>1.09</td>
<td>1.3</td>
<td>2.33</td>
</tr>
<tr>
<td>0.6</td>
<td>4.58</td>
<td>2.25</td>
<td>1.25</td>
<td>1.81</td>
<td>2.21</td>
</tr>
<tr>
<td>0.42</td>
<td>1.24</td>
<td>1.87</td>
<td>1.29</td>
<td>1.73</td>
<td>1.68</td>
</tr>
<tr>
<td>0.075</td>
<td>3.28</td>
<td>3.63</td>
<td>2.45</td>
<td>5.16</td>
<td>4.17</td>
</tr>
<tr>
<td>&lt;0.075</td>
<td>5.42</td>
<td>1.06</td>
<td>0.28</td>
<td>2.41</td>
<td>9.32</td>
</tr>
<tr>
<td>Totals</td>
<td>19.4</td>
<td>16.66</td>
<td>26.4</td>
<td>29.03</td>
<td>19.71</td>
</tr>
</tbody>
</table>

Table 13: Profile 5 Qualitative Data

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (cm)</th>
<th>Munsell Soil Color</th>
<th>Sort</th>
<th>Mass (g)</th>
<th>Particle Size %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>264</td>
<td>10YR5/4</td>
<td>Fine Coarse</td>
<td>19.4</td>
<td>52.32% sand; 27.94% clay; 16.91% silt; 2.83% fine pebbles</td>
</tr>
<tr>
<td>2</td>
<td>276</td>
<td>5YR4/4</td>
<td>Poorly Medium</td>
<td>16.66</td>
<td>42.56% sand; 29.29% fine pebbles; 21.79% silt; 6.36% clay</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>5YR4/3</td>
<td>Fine Coarse</td>
<td>26.4</td>
<td>65.49% fine pebbles; 24.17% sand; 9.28% silt; 1.06% clay</td>
</tr>
<tr>
<td>4</td>
<td>310</td>
<td>5YR3/2</td>
<td>Coarse</td>
<td>29.03</td>
<td>47.81% fine pebbles; 26.11% sand; 17.78% silt; 8.30% clay</td>
</tr>
<tr>
<td>5</td>
<td>328</td>
<td>Gley2 5/5B</td>
<td>Fine</td>
<td>19.71</td>
<td>47.29% clay; 31.55% sand; 21.16% silt</td>
</tr>
</tbody>
</table>
Figure 38: Profile 5 Particle Size
Stable Carbon and Nitrogen Isotopes

Stable carbon and nitrogen isotopes were analyzed from organics in the soil samples. Soils below the surface horizon are frequently enriched in $^{15}$N relative to the atmosphere (Hogberg 1997; Zech 2006). Therefore, climate plays a significant role in soil N and N isotope processing and retention (Admundson et al. 2003; Martinelli et al. 1999), which would aid in determining previous atmospheric conditions in the environment. The isotopic composition of $^{15}$N inputs and fractionation during $^{15}$N transformations and loss determine soil $\delta^{15}$N (Evans 2007). More and more sites across diverse ecosystems are measuring the natural abundance of $\delta^{15}$N at regional and global scales (Pardo and Nadelhoffer 2010). The $\delta^{15}$N ratios collected at Big Bone Lick, Kentucky can aid in the regional $\delta^{15}$N scales to provide more information to further researchers.

Examining changes in the chemical remains of plants through stable isotopic ratio analysis (SIRA) of organic carbon ($\delta^{13}$C) can be used for building past vegetative records of the area (Frederick 2000). The photosynthetic cycle strongly fractionates carbon isotopes when plants metabolize atmospheric carbon dioxide (CO$_2$). Plants then convert this CO$_2$ into more complex molecules: C$_3$, C$_4$, and Crassulacean Acid Metabolism (CAM). C$_3$ plants, which include most trees, shrubs, herbs, and cool-season grasses, end up with $\delta^{13}$C average values of -26.5%. C$_4$ plants include maize and sugarcane and have $\delta^{13}$C average values of -12.5%. Plants that use CAM photosynthesis include succulents such as cactus, which are relatively uncommon in this area (Herz 1990).

It should be noted that individual species at any particular site can exhibit local spatial and short-term temporal isotopic variability, and there are differences between species. Moreover, the $\delta^{13}$C values of modern plants have been influenced by changes in the $^{13}$C/$^{12}$C
composition of atmospheric CO$_2$ due to human activity over the past 200 years. So the overall range for $\delta^{13}C$ for C$_3$ and C$_4$ plants were probably different in the past (Heaton 1999).

Stable carbon isotope values of bulk SOM closely resemble the vegetation composition source (i.e., C$_3$, C$_4$, and CAM plants). Independent t-tests of the $\delta^{13}C$ isotope values of bulk SOM were used to determine if the vegetation composition of Big Bone Lick varied through time. The average $\delta^{13}C$ isotope value of bulk SOM from Late Pleistocene sediments ($N_1=4$) was 27.05% (standard deviation 0.493). The average $\delta^{13}C$ isotope values of bulk SOM from Late Holocene age sediments ($N_2=27$) were -25.13% (standard deviation 0.126). The difference between these means was significant ($t(29) = 9.968, p = <0.0002$).

Comparable independent t-tests were calculated for the $\delta^{15}N$ isotope ratios of bulk SOM. The average $\delta^{15}N$ isotope ratio of bulk SOM from Late Pleistocene sediments ($N_1=4$) was 0.9% (standard deviation 2.209). Stable carbon isotope values on bulk SOM indicate a significant variation in the vegetation composition of Big Bone Lick from the Late Pleistocene to the Late Holocene. The average $\delta^{15}N$ isotope values of bulk SOM from the late Holocene age sediments ($N_2=27$) were 2.138% (Standard deviation 1.233). While the difference between these means is significant ($t(29) = 5.396, p = <0.012$), the variation is likely the result of diagenetic processes, influenced by the degradation of organic matter during sedimentation. In other words, resistant $\delta^{15}N$ rations in the Big Bone Lick Quaternary strata are likely isotopically different from the original nitrogen source.

Stable carbon and nitrogen isotope data of bulk SOM from fluvial and lacustrine strata at Big Bone Lick are presented for each profile in the following Tables (14-18). Figure 39 plots the bulk SOM data from the 31 fluvial and lacustrine strata by Geomorphic Unit. Geomorphic Units are discussed more in depth in the Chapter 8: Discussion.
Table 14: Profile 1 stable carbon and nitrogen isotope data of bulk SOM

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (m)</th>
<th>Unit</th>
<th>Mean $\delta^{13}C$ ± 1σ</th>
<th>$\delta^{13}N$ b</th>
<th>$\delta^{15}N$ b ± 1σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-1.5</td>
<td>4</td>
<td>-25.1 ± 0.04</td>
<td>2.67</td>
<td>0.74</td>
</tr>
<tr>
<td>2</td>
<td>1.5-2.5</td>
<td>4</td>
<td>-25.0+ 0.04</td>
<td>2.76</td>
<td>0.74</td>
</tr>
<tr>
<td>2 Stringers</td>
<td>2-2.25</td>
<td>4</td>
<td>-25.3+ 0.04</td>
<td>0.29</td>
<td>0.74</td>
</tr>
<tr>
<td>3</td>
<td>2.25-2.6</td>
<td>4</td>
<td>-25.1+ 0.05</td>
<td>2.83</td>
<td>0.04</td>
</tr>
<tr>
<td>4</td>
<td>2.25-2.4</td>
<td>4</td>
<td>-25.2+ 0.05</td>
<td>2.3</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>2.25-2.5</td>
<td>4</td>
<td>-25.2+ 0.05</td>
<td>1.19</td>
<td>0.04</td>
</tr>
<tr>
<td>6</td>
<td>2.4-2.5</td>
<td>4</td>
<td>-25.6+ 0.05</td>
<td>1.97</td>
<td>0.04</td>
</tr>
<tr>
<td>7</td>
<td>2.55-2.6</td>
<td>4</td>
<td>-25.6+ 0.05</td>
<td>2.13</td>
<td>0.04</td>
</tr>
<tr>
<td>8</td>
<td>2.6-2.65</td>
<td>4</td>
<td>-25.4+ 0.05</td>
<td>2.83</td>
<td>0.04</td>
</tr>
<tr>
<td>9</td>
<td>2.65-2.7</td>
<td>4</td>
<td>-25.6+ 0.05</td>
<td>2.47</td>
<td>0.04</td>
</tr>
<tr>
<td>10</td>
<td>2.7-3</td>
<td>4</td>
<td>-25.6+ 0.05</td>
<td>1.75</td>
<td>0.04</td>
</tr>
<tr>
<td>11</td>
<td>3-3.2</td>
<td>4</td>
<td>-15.9+ 1.91</td>
<td>0.74</td>
<td>0.08</td>
</tr>
<tr>
<td>12</td>
<td>3.2-3.5</td>
<td>2</td>
<td>-26.8+ 0.15</td>
<td>1.01</td>
<td>1.18</td>
</tr>
</tbody>
</table>

Table 15: Profile 2 stable carbon and nitrogen isotope data of bulk SOM

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (m)</th>
<th>Unit</th>
<th>Mean $\delta^{13}C$ ± 1σ</th>
<th>$\delta^{13}N$ b</th>
<th>$\delta^{15}N$ b ± 1σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-4.5</td>
<td>4</td>
<td>-26.1 ± 0.15</td>
<td>0.27</td>
<td>1.18</td>
</tr>
<tr>
<td>2</td>
<td>4.5-5</td>
<td>4</td>
<td>-25.9± 0.15</td>
<td>0.97</td>
<td>1.18</td>
</tr>
<tr>
<td>3</td>
<td>4.75-6.15</td>
<td>2</td>
<td>-26.5± 0.15</td>
<td>0.61</td>
<td>1.18</td>
</tr>
<tr>
<td>4</td>
<td>6.15-6.25</td>
<td>2</td>
<td>-27.6± 0.03</td>
<td>4.06</td>
<td>1.05</td>
</tr>
<tr>
<td>5</td>
<td>6.25-7</td>
<td>2</td>
<td>-27.3± 0</td>
<td>0.06</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Table 16: Profile 3 stable carbon and nitrogen isotope data of bulk SOM

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (m)</th>
<th>Unit</th>
<th>Mean $\delta^{13}C$ ± 1σ</th>
<th>$\delta^{13}N$ b</th>
<th>$\delta^{15}N$ b ± 1σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-1.2</td>
<td>2/3</td>
<td>-27.7 ± 0.09</td>
<td>-4.24</td>
<td>0.14</td>
</tr>
<tr>
<td>2</td>
<td>1.2-1.5</td>
<td>2/3</td>
<td>-27.2± 0.09</td>
<td>-0.09</td>
<td>0.14</td>
</tr>
<tr>
<td>3</td>
<td>1.5-2.25</td>
<td>2/3</td>
<td>-28.0± 0.09</td>
<td>-6.49</td>
<td>0.14</td>
</tr>
<tr>
<td>4</td>
<td>2.25-3</td>
<td>2/3</td>
<td>-27.3± 0.09</td>
<td>-0.52</td>
<td>0.14</td>
</tr>
<tr>
<td>5</td>
<td>3-3.25</td>
<td>2/3</td>
<td>-28.1± 0.09</td>
<td>-7.04</td>
<td>0.14</td>
</tr>
<tr>
<td>6</td>
<td>3.25-3.46</td>
<td>2/3</td>
<td>-28.0± 0.09</td>
<td>-5.80</td>
<td>0.14</td>
</tr>
</tbody>
</table>
Table 17: Profile 4 stable carbon and nitrogen isotope data of bulk SOM

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (m)</th>
<th>Unit</th>
<th>Mean $\delta^{13}\text{C}^a \pm 1\sigma$</th>
<th>$\delta^{15}\text{N}^b$</th>
<th>$\delta^{15}\text{N}^b \pm 1\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-0.45</td>
<td>4</td>
<td>-26.7 $\pm$ 0.09</td>
<td>0.57</td>
<td>0.14</td>
</tr>
<tr>
<td>2</td>
<td>0.45-1</td>
<td>4</td>
<td>-27.0 $\pm$ 0.09</td>
<td>-1.49</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Table 18: Profile 5 stable carbon and nitrogen isotope data of bulk SOM

<table>
<thead>
<tr>
<th>Level</th>
<th>Depth (m)</th>
<th>Unit</th>
<th>Mean $\delta^{13}\text{C}^a \pm 1\sigma$</th>
<th>$\delta^{15}\text{N}^b$</th>
<th>$\delta^{15}\text{N}^b \pm 1\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-2.65</td>
<td>4</td>
<td>-26.7 $\pm$ 0.09</td>
<td>-3.06</td>
<td>0.14</td>
</tr>
<tr>
<td>2</td>
<td>2.65-2.75</td>
<td>4</td>
<td>-27.1 $\pm$ 0.09</td>
<td>-7.88</td>
<td>0.14</td>
</tr>
<tr>
<td>3</td>
<td>2.75-3.1</td>
<td>4</td>
<td>-27.6 $\pm$ 0.09</td>
<td>-7.24</td>
<td>0.14</td>
</tr>
<tr>
<td>4</td>
<td>3.1-3.4</td>
<td>4</td>
<td>-26.8 $\pm$ 0.09</td>
<td>-1.80</td>
<td>0.14</td>
</tr>
<tr>
<td>5</td>
<td>3.4-4.1</td>
<td>4</td>
<td>-27.5 $\pm$ 0.09</td>
<td>-2.01</td>
<td>0.14</td>
</tr>
</tbody>
</table>

$\delta^{13}\text{C}^a = ((R_{\text{sample}}/R_{\text{standard}})-1)*1000$, where $R = ^{12}\text{C}/^{13}\text{C}$ and the standard is VPDB

$\delta^{15}\text{N}^b = ((R_{\text{sample}}/R_{\text{standard}})-1)*1000$, where $R = ^{15}\text{N}/^{13}\text{N}$ and the standard is Air.

Figure 39: $\delta^{13}\text{C}$ isotope values and $\delta^{15}\text{N}$ isotope ratios of bulk SOM samples plotted by Unit.
Culturally Diagnostic Artifact Inventory

The following Figures 40-46 displayed below represent all of the temporally and culturally diagnostic artifacts found during the profile excavations at Big Bone Lick State Historic Site. The photograph numbers associated with each figure correspond with the full photograph catalogue located in Appendix IV. The complete artifact spreadsheet is located in Appendix I. Profiles 1 and 3 did not produce any cultural artifacts.

Independently dated diagnostic artifacts found within sediments were to help determine the age of the sediment layer. When non-diagnostic artifacts were uncovered, stratigraphic layers and associations with other diagnostic artifacts were used as the primary method for inferring the age of the artifacts as well as the subsequent stratigraphic layer in which the artifacts were found.

The initial surface collection survey (preformed on the 22\textsuperscript{nd} of June 2012 with the Ohio Valley Field School, Anthropology Department, University of Cincinnati, Ohio) yields two diagnostic pottery sherds (Figures 40 and 41). One is a grit tempered body sherd dating to the Middle Woodland, and the second is a cord marked shell tempered body sherd dating to the Fort Ancient time period.

The majority of artifacts from Profile 2 were located in an archaeologically stratigraphic horizon occurring from approximately 200cm – 240cm. A hafted end scraper was found at 200 cm (Figure 42). The scraper was made of high-level fluvial deposits. The artifacts from this layer are most likely from the Archaic Period based on radiocarbon dates obtained from below this layer and a diagnostic artifact found in Feature 1 above this layer dating to the Late Woodland. Human remains, red ochre, and a number of other non-diagnostic artifacts were also found in this level.
A side scraper (Figure 43) found in Profile 2 Level 5 at 470 cm is made of Upper Mercer non-local chert. A radiocarbon date of 4,170±30 BP was assigned to the 4.5 meter level just above the side scraper and another radiocarbon date of 20,870±90 BP was assigned just below this artifact at approximately 5 meters. Two optically stimulated luminescence dates of 5,200±100 BP and 5,100±100 BP are located just above the side scraper and below the radiocarbon date of 4,170±30 BP.

Feature 1, located in Profile 2, is from a burnt earth type feature. The only diagnostic artifact found in the feature was a limestone tempered ceramic body sherd (Figure 44) that dates to the Late Woodland/Newtown Phase time period.

Artifacts from Profile 4 (Figure 46 and 47) are from a probable B. bison bison kill or processing site dating to the Madisonville/Late Fort Ancient time period. Recovered high-level fluvial and Laurel cherts are representative of local sources. The recovered Wyandotte and Ohio Flint Ridge are non-local cherts. One diagnostic cordmarked shell tempered ceramic body sherd (Figure 46) was found. All of these artifacts were found in close proximity to B. bison bison bone fragments described later in this chapter under the Vertebrate Paleontological Inventory subheading.

A retouched flake (Photograph 51, Appendix IV) was found in Profile 5 at 260 cm. A radiocarbon date from Profile 5 was assigned to a B. bison bison scapula of 310±30 BP that was also found at 260 cm. The radiocarbon date on the B. bison bison means that the retouched flake is most likely from the Madisonville/Late Fort Ancient time period.
Figure 40: (Photo 10) Surface Survey of Big Bone Creek. Prehistoric Pottery. Grit tempered body sherd. Middle Woodland.

Figure 41: (Photo 11) Surface Survey of Big Bone Creek. Prehistoric Pottery. Cordmarked and shell tempered. Fort Ancient.

Figure 42: (Photo 21) Profile 2. Level 1, 200 cm. Hafted end scraper. Recycled McWhinney projectile point. High-level fluvial deposit.

Figure 43: (Photo 23) Profile 2. Level 5, 470 cm. Side scraper. Upper mercer chert.
Figure 44: (Photo 29) Profile 2. Feature 1. Prehistoric pottery. Limestone temper. Woodland.

Figure 45: (Photo 46) Profile 4. Level 2. 45 cm. Bifacial fragment. McWhinney projectile point. High-level fluvial deposit.

Figure 46: (Photo 48) Profile 4. Level 1, 10 cm. Prehistoric pottery. Cord marked and shell tempered.
The most common raw material procured for flaked stone tool and weapon manufacture at Big Bone Lick was chert. Composed of between 75 – 99% quartz, chert is made up of interlocking, roughly equal granular grains and fractures conchoidally when struck. It can be almost any color and accommodate a wide variety of impurities that affect its workability in flaked-stone tool and weapon manufacture. High-level fluvial chert was found as the predominant source of chert material at Big Bone Lick and can be seen as somewhat inferior to certain non-local chert sources. However the advantage of high-level fluvial chert is that it is found in the gravel beds of the creeks of Big Bone Lick, which makes it an easy local source from glacial outwash. Figures (47-48) illustrate the amount of local versus non-local chert material found during the fieldwork.

Figure 47: Types of Chert Found

![Chert Types Graph](image)
Quartzite was present in Profile 2 and is composed chiefly of quartz sandstone with silica cement. It fractures conchoidally which allows it to be worked into sharp tools and is thus, desirable for tool manufacture (Rapp and Hill 2006). Also located in Profile 2 was a pitted stone made of sandstone. Leakey classified pitted stones as part of a pair consisting of a hammer-type element and an anvil-type element. The stones are usually thought of as a bi-product of a particular task such as that of cracking nuts (Goren-Inbar et al. 2002).

The primary raw material of paste for ceramics was local clay-rich sediments. Coarser sediment particles were used for temper (i.e. grit tempered or limestone tempered pottery) common in Middle to Late Woodland pottery. Fossil shells also made a good temper because calcium carbonate has the same thermal expansion as the average clay (Rapp and Hill 2006). Shell was the preferred temper of the Fort Ancient culture. Cordmarked decoration is easy to apply to pottery and common among Woodland and Fort Ancient time periods.

Figure 48: Local versus Non-Local Chert

Local Vs. Non-Local Chert Sources

- Non-Local Chert, 17
- Local Chert, 51
The same processes that created the archaeological record shaped the modern landscape (Butzer 1982; Waters 1992). Archaeological remains become incorporated into the sediments of a layer if the occupation correlates with a period of deposition such as active flooding. The vertical spatial separation between archaeosediments is determined by the rate at which sediments accumulate in between the two episodes. Sedimentation rates are not constant and often vary from one environment to the next and from one time period to the next in the same environment. The same factors that are working to create sedimentation such as deposition, erosion, and stability also work to preserve, arrange, and fragment the evidence of human activity on the landscape (Waters 1992).

Vertebrate Paleontological Inventory

The principles of biostratigraphy have been useful in indicating the relative age of the vertebrate paleontological specimens found at Big Bone Lick, Kentucky. The most useful indicators of specific age intervals with fauna are the remains of those that have a wide geographic distribution as well as appear and/or become extinct over a short amount of time (Rapp and Hill 2006). For example, the Pleistocene’s cold-climate megafauna were replaced with the temperate-climate fauna of the Holocene in a relatively short amount of time (Banning 2000).

At Big Bone Lick, Pleistocene megafauna and Holocene mammals were easily distinguishable based on stratigraphic levels as well as morphology, thus aiding in the stratigraphic correlation of all five profiles from the excavations in 2012. Appendix V presents all of the photographs taken of faunal specimens found for this thesis excluding the disintegrated human bone samples that were found in the archaeological layer from 200 cm – 230 cm in Profile 2. The following photograph numbers correspond to the same photograph numbers in Appendix V. The complete faunal spreadsheet is located in Appendix I.
A total of 42 faunal fragments were found during the course of the fieldwork at Big Bone Lick State Historic Site. Profile 3 was the only profile surveyed that did not have faunal remains recovered. The complete faunal assemblage includes the presence of historic *B. bison bison* (American Bison), historic *Cervus canadensis* (Elk), *Homo homo sapiens* (Human), Pleistocene *Mammut americanum* (American Mastodon), Pleistocene *Mammuthus sp.* (Wooly Mammoth), modern *Odocoileus virginianus* (White-Tailed Deer) as well as several unidentified bones.

Two *B. bison bison* thoracic vertebrae (photographs 2-3, Appendix V) were located during the initial surface survey conducted on the 22nd of June 2012 with the Ohio Valley Field School, Anthropology Department, at the University of Cincinnati, Ohio. Two *B. bison bison* scapulas (Photograph 4,5,19, Appendix V), epicondyle (Photograph 6-7, Appendix V), rib fragment (Photograph 8, Appendix V), and two teeth (Photograph 18, Appendix V) were located along the bank surface of Profile 1. Profile 4 contained a large amount of *B. bison bison* remains (Photographs 29-38, Appendix V) including a metapodial, four ribs plus one smashed rib, scapula, tibia, juvenile axis (cervical vertebra), and thoracic vertebrae. The large collection of bison bones along with the artifact assemblage found within and adjacent to the profile could indicate either a bison kill or processing site of the Madisonville Fort Ancient time period. A *B. bison bison* scapula (Photograph 39, Appendix V) was found in Profile 5 Level 1 at 260 cm and points to a Fort Ancient time period.

A *Cervus canadensis* (Elk) tooth (Photograph 26, Appendix V) was found in Feature 1 above Profile 2. A diagnostic pottery sherd (Photograph 29, Appendix V) was also located in this feature that most likely dates to the Late Woodland/Newtown Phase time period.

During the excavation of Profile 2, a layer from 200 cm – 230 cm was found to have several flaked stone artifacts, red ochre, and weathered bone that were very fragile. My crew and
I took great care to cut out the sediment holding the disintegrated bone and bag it. The sediment was later dissolved in water to extract the disintegrated bone at the Ohio Valley Archaeology Lab at the University of Cincinnati. The bone was put aside to dry and later identified as *Homo homo sapiens* (Human) by Kenneth B. Tankersley. Most of the disintegrated bone was not excavated. Samples were taken out in order to make the profile wall smooth. However, it appears the majority of the burial was left intact.

An immature proboscidean long bone fragment (Photograph 9-10), a Proboscidea tusk fragment (Photograph 11, Appendix V), an immature *Mammut americanum* (American Mastodon) tooth (Photograph 15-17, Appendix V), and three unidentified Pleistocene mammal bone fragments (Photographs 12-14, Appendix V) were located on the bank surface of Profile 1. Three Pleistocene mammal bones were found in Level 12 of Profile 1. The bones are two *Mammuthus* sp. (Wooly Mammoth) or *Mammut americanum* (American Mastodon) rib fragments (Photograph 21, Appendix V) found at 330 cm and a *Mammuthus* sp. (Wooly Mammoth) or *Mammut americanum* (American Mastodon) tibia fragment (Photograph 22, Appendix V) found at 335 cm. The larger of the two rib bones found at Level 12 was used for stable isotope dating. Another rib fragment (Photograph 20) of either a *Mammuthus* sp. (Wooly Mammoth) or *Mammut americanum* (American Mastodon) was found in the backfill pile after Profile 1 was excavated. A *Mammut americanum* (American Mastodon) deciduous calf molar (Photograph 23-25, Appendix V) was located in Profile 2 Level 4 at 450.8 cm.

An *Odocoileus virginianus* (white-tailed deer) antler from the initial surface survey was found along Big Bone Creek.

Two additional unidentified burnt mammal bones (Photograph 27, Appendix V) and an unidentified calcined bone (Photograph 28, Appendix V) were found in Feature 1 above Profile
2. Although, these bones were unable to be identified, the bones were found with the elk tooth, previously mentioned, as well as a piece of pottery that dates to the Late Woodland/Newtown Phase time period.

Optically Stimulated Luminescence Dates

Optically Stimulated Luminescent (OSL) dating determines the time elapsed since a sediment sample was last exposed to daylight (Aitken 1998). The method relies on the interaction of ionizing radiation with electrons in semi-conducting minerals within buried sediment, which results in metastable accumulation of charge. Illumination of the sediment releases the charge as a measurable emission of photons (luminescence). The method assumes that mineral grains, during or immediately prior to the transport, were exposed to daylight to set them to their geological zero residual level. On burial, daylight exposure ceased and essentially the luminescence signal begins to accumulate due to the radiation arising from the decay of ambient radioisotopes that include U, Th, and K. Given that, as a first approximation, the radiation exposure (the dose rate - \(D_R\)) is constant over the timescales of interest, the luminescence buildup (equivalent dose – \(D_E\)) in the minerals in proportion to the duration of burial and the concentration of the radioisotopes in the sample environment. The depositional age (A) of the sample is thus a ratio of luminescence acquired and the rate of luminescence acquisition (i.e., \(A=D_E/D_R\)) (Murray and Olley 2002; Porat 2006; Singhvi and Porat 2008; Jain and Singhvi 2001; Murray and Wintle 2000, 2003).

The infrared stimulated luminescence (IRSL) signals for the OSL samples were at background levels, which show the measured samples were free from feldspar contamination. The four OSL dates from the Late Holocene fluvium (Geomorphic Unit 4) range from 5,200 - 400 BP (w5.2 ka to w0.4 ka) (Tables 19-20). The OSL dates taken for this thesis can be visually
seen in the Profile Drawings located in Figures 23-30. The results of the OSL dating of the sediments in Profiles 2, 3, and 5 are presented in Table 19-20.

Table 19: OSL Dates. Dose Rate Estimation for Samples

<table>
<thead>
<tr>
<th>Profile</th>
<th>Sample</th>
<th>U (ppm)</th>
<th>Th (ppm)</th>
<th>K (%)</th>
<th>Water Content (%)</th>
<th>Cosmic Dose Rate (µGy/a)</th>
<th>Total Dose Rate (Gy/ka)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BBL 1</td>
<td>3.30±0.033</td>
<td>11.2±1.12</td>
<td>2.88±0.14</td>
<td>10.5±2.1</td>
<td>98.62±20</td>
<td>3.90±0.23</td>
</tr>
<tr>
<td>2</td>
<td>BBL 2</td>
<td>3.30±0.33</td>
<td>12.3±1.23</td>
<td>2.95±0.15</td>
<td>9.721±1.94</td>
<td>98.62±20</td>
<td>3.29±0.151</td>
</tr>
<tr>
<td>5</td>
<td>BBL 3</td>
<td>2.50±0.25</td>
<td>8.5±0.85</td>
<td>2.48±0.12</td>
<td>5.787±1.16</td>
<td>115±23</td>
<td>2.81±0.13</td>
</tr>
<tr>
<td>1</td>
<td>BBL 7</td>
<td>2.220±0.22</td>
<td>7.5±0.75</td>
<td>2.19±0.11</td>
<td>3.721±0.74</td>
<td>115±23</td>
<td>3.46±0.16</td>
</tr>
</tbody>
</table>

*BBL4 dose rate yet to be done

Table 20: OSL Dates. Equivalent dose and dates estimated using single aliquot regenerative (SAR) method. Each date was estimated feeding data in software written by Grün (1991).

<table>
<thead>
<tr>
<th>Profile</th>
<th>Sample</th>
<th>Number of disks*</th>
<th>Weighted Mean (Gy)</th>
<th>Mean (Gy)</th>
<th>Dose rate (Gy/ka)</th>
<th>Weighted Mean Age (ka)</th>
<th>Mean Age (ka)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BBL1</td>
<td>23(24)</td>
<td>20.05±0.1</td>
<td>20.51±2.38</td>
<td>3.90±0.23</td>
<td>5.1±0.1</td>
<td>5.3±0.6</td>
</tr>
<tr>
<td>2</td>
<td>BBL2</td>
<td>22(24)</td>
<td>21.02±0.01</td>
<td>21.47±2.33</td>
<td>3.29±0.15</td>
<td>5.2±0.1</td>
<td>5.3±0.06</td>
</tr>
<tr>
<td>5</td>
<td>BBL3</td>
<td>22(24)</td>
<td>1.59±0.001</td>
<td>1.91±0.71</td>
<td>2.81±0.13</td>
<td>0.4±0.01</td>
<td>0.6±0.2</td>
</tr>
<tr>
<td>1</td>
<td>BBL7</td>
<td>21(24)</td>
<td>3.27±0.002</td>
<td>3.61±1.39</td>
<td>3.46±0.16</td>
<td>0.9±0.02</td>
<td>1.1±0.4</td>
</tr>
</tbody>
</table>

*Inside bracket total number of aliquot measured and outside bracket the aliquot were considered for age estimation
*dose rate for BBL4 sample was used same as BBL3 as they were from same site and horizon. Dose rate yet to be measured for sample BBL4.

Radiocarbon Dates

Radiocarbon remains the main chronometer for the period of the past 50,000 years. Profile 2 yielded two dates between 25,050±4,590 $^{14}$C Cal BP. One sample from Profile 5 yielded a date between 480±300 $^{14}$C Cal BP (Table 21). The radiocarbon dates can be visually seen in the Profile Drawings (Figures 23-30).
Table 21: Radiocarbon dates obtained for this thesis

<table>
<thead>
<tr>
<th>Profile</th>
<th>Depth</th>
<th>Location</th>
<th>Sample</th>
<th>Measured δ¹³C yrs BP ±1σ</th>
<th>Calibrated yrs BP ±2σ</th>
<th>Unit</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>450cm</td>
<td>30cm from W Wall</td>
<td>Conifer Wood</td>
<td>4170±30</td>
<td>4840±4590</td>
<td>4</td>
<td>B-decay</td>
</tr>
<tr>
<td>2</td>
<td>510cm</td>
<td>SW Corner</td>
<td>Wood</td>
<td>20870±90</td>
<td>25050±24550</td>
<td>2</td>
<td>AMS</td>
</tr>
<tr>
<td>5</td>
<td>296cm</td>
<td>NE Corner</td>
<td>Wood</td>
<td>310±30</td>
<td>480±300</td>
<td>4</td>
<td>AMS</td>
</tr>
</tbody>
</table>
Chapter 6: Discussion

This chapter will present the discussion of the new information presented in this thesis. I will then correlate this information with known information at Big Bone Lick State Historic Site. The correlation of new information with what is already known is important in order to place the new information in the context of a broader material knowledge from Big Bone Lick State Historic Site.

Stratigraphic Correlations for Profiles

Sediment analysis can be used to determine whether stratigraphic contexts in different excavation areas are really part of the same layer. If the sediments were deposited at the same time, by the same process of transport and deposition, they may be closely similar in their sediment characteristics (i.e. color, texture, material culture, and faunal content) (Banning 2000). Therefore determining the stratigraphic correlations of the five profiles excavated during the summer of 2012 can be a very useful tool in examining the geology of the area during the Late Pleistocene to Holocene time periods.

Five stratigraphic profiles were dated for this thesis that correspond to Big Bone Lick’s Geomorphic Units 2, 3, and 4 (Figure 51). The radiocarbon and OSL dates obtained from these units are remarkably similar given the range of uncertainties of both dating methods. For example, a radiocarbon date of 4,170±30 BP of Profile 2 was obtained from the same stratum that yielded two OSL dates of 5,200±100 BP and 5,100±100 BP. Similarly, a radiocarbon date of 310±30 BP was obtained from the same stratum that yielded an OSL date of 400±10 BP. Both dating methods were effective in dating the stratigraphic units and substantially complement one another. The artifact and faunal dates match the radiocarbon and OSL dates as well. This
collaboration provides confidence in the age estimates for Quaternary landforms and units that have been dated for this thesis.

The stratigraphy in all five profiles also corroborated late Pleistocene soil accumulation. The growth of soils in the late Pleistocene was followed by an unconformity in the stratigraphy that resulted from soil erosion and degradation resulting from the movement of the bed of Big Bone Creek. The mid to late Holocene, in all profiles, then accumulated large amounts of anthropogenic aggradation.

It is important to note that a similar stratigraphic sequence to what has been observed at Big Bone Lick State Historic Site can also be seen in paleochannels and channel fragments found in neighboring tributary drainage basins of the glaciated Ohio River Valley (Gray 1984; Ray 1974; Tankersley 2007b; 2009b; Tankersley et al. 1983).

The correlation of all of the profiles is illustrated in Figure 49. The profiles are arranged in accordance with their physical location. The correlations of all profiles were decided upon based on soil stratigraphy, dating methods employed, archaeological stratigraphy, and vertebrate paleontological stratigraphy.
Figure 49: The Correlation of Big Bone Lick Quaternary Stratigraphy in each profile.
Previous radiocarbon dating of Late Pleistocene fossils at Big Bone Lick was performed in three phases. The first series of dates were conventional β-decay radiocarbon measurements made between 1965 and 1981. This work established that the stratigraphy extended from the present to at least 17,200 ± 600 14C Cal BP. It also suggested that there was significant physical mixing of recent and Late Pleistocene fossils and sediments (Levin et al. 1965, 1967; Tankersley 1986, 1987, 1992a, 1992b). Accelerator Mass Spectrometry (AMS) dating was first used in 1981. Samples of mammoth and mastodon bone, tooth and tusk dentine from Geomorphic Unit 3 were submitted to the Oxford University Accelerator Mass Spectrometry laboratory, England (Tankersley 2009a; Tankersley et al. 2009). Unfortunately, these fossils could not be dated because the specimens contained insufficient collagen for analysis (John Gowlett, pers. comm.)

More recently, seven additional radiocarbon dates were obtained—two associated with a Late Holocene *B. bison bison* kill site, one from Post-Holocene Climatic Optimum fluvium, one from Early Woodfordian Tazewell age lacustrine sediments, and three from mastodon fossils in stratigraphic association with terminal Late Pleistocene sediments in Geomorphic Unit 3. Table 22 shows all radiocarbon dates taken to date at Big Bone Lick, Kentucky including the three that were taken for this thesis. Table 21 in Chapter 7 Data Analysis has isolated the three specific radiocarbon dates taken for this thesis. Appendix II displays the radiocarbon dating results from Beta Analytic Inc. for this thesis.
Geomorphic Units

Four distinctive geomorphic surfaces, labeled as Units 1-4 (Figure 50), have been identified and dated previously at Big Bone Lick. The units are described as: a pre-glacial Teays age high-level fluvial deposit (>400,000 BP), two late Pleistocene terraces labeled as Terrace 1 (T1) and Terrace 2 (T2), a Holocene surface labeled Terrace 0 (T0), and the last distinctive surface is in the form of elevated portions of the floodplain adjacent to the terraces (Figure 50) (Tankersley et al. 2013, in preparation). Paleochannels and channel fragments of varying scales are evident with
a stratigraphic sequence similar to that found in the neighboring drainage basin tributaries to the glaciated Ohio River Valley (Gray 1984; Ray 1974; Tankersley 2007b, 2009b; Tankersley et al. 1983).

Figure 50: Quaternary geology of Big Bone Lick, Kentucky and the location of exploratory excavation units and cores (A) and a cross-section of Tazewell, Cary, and Post-Cary terraces (B) (Tankersley et al. 2013, in preparation).

Unit 1 is the oldest stratigraphic level (> 400,000 BP). It consists of pre-glacial fluvial deposits on ridge-tops at elevations > 207 meters above sea level (ASL) (Tankersley et al. 2013, in preparation). The unit is approximately 7 meters thick and composed of deeply weathered, yellowish-brown clayey silt and sand with abundant rounded to subangular pebbles and cobbles of chert, quartz, and limonitic concretions. There are no chronometric dates for Unit 1 and faunal remains have not been reported (Tankersley et al. 2013, in preparation). None of the profiles for this thesis have corresponded to Unit 1.

Unit 2 consists of T2, an Early Woodfordian Tazewell age lacustrine deposit ca. 18,000 – 19,000 Cal BP. As illustrated in Figure 50, T1, and Unit 4 in T2 cover Unit 2. T2 is both the
highest and oldest terrace measuring 152 meters ASL and 1-4 meters thick. The unit is composed of a distinctive light gray to brownish-gray stiff clay, clayey silt, gravel in clay, and silty clay (Tankersley et al. 2009; Tankersley et al. 2013, in preparation). Heavily mineralized, discolored (black to gray), and disarticulated remains of *Bootherium bombifrons* (Harlan’s Musk Ox), *Equus complicates* (Complex Tooth Horse), *Paramylodon Harlani* (Harlan’s Ground Sloth), and *Mammuthus columbi* (Columbian Mammoth), *Megahyllodon jeffersonii* (Jefferson’s Ground Sloth) were previously located. A conventional β-decay counting radiocarbon date of 22,086-19,311 14C Cal BP (W-1617; Table 22) was previously obtained on wood cellulose from the cranium of *Bootherium bombifrons* recovered from Unit 2 (Tankersley et al. 2013, in preparation). One AMS radiocarbon date in Profile 2 was taken of 20,870±90 BP (25,050±24,550 14C Cal BP) from Unit 2 as well (Table 21).

During the time of the radiocarbon dates for Unit 2 (25,050-19,311 14C Cal BP), the greatest volume of melt-water and outwash from the Laurentide ice sheet was channeled into the Ohio River following the initial waning phase of Wisconsinan glaciation (Ray 1974). Aggradation of the Ohio River from glaciofluvial outwash and the formation of a valley train soon dammed the mouths of tributary valleys. As this Tazewell Age outwash grew thicker, the depth of ponding in the tributaries increased until the valley train reached its maximum level. Backwaters in the ponded tributaries formed widespread shallow lakes extending for miles from the main valley (Potter 1996; Ray 1974; Tankersley 2007b, 2009b; Tankersley et al. 2013, in preparation).

River degradation at this time of maximum ice recession resulted in a prominent Tazewell Age terrace (Tankersley et al. 2013, in preparation). Stable carbon isotope values from bulk soil organic matter (SOM) in Profiles 1-3 (Tables 14-16) correspond to Unit 2. These values
range from -26.5 to -27.6 for this thesis. These numbers suggests an environment dominated by C₃ vegetation. Carbon isotope values from proboscidean bone collagen and *Mammut americanum* enamel from Unit 2 are consistent with browsers in a C₃ dominant environment (Tankersley et al. 2013, in preparation). These finding are surprising given the temporal association of Unit 2 with the Last Glacial Maximum and its close geographic proximity to the ice margin (i.e. 50 km). We expected to find more evidence of C₄ vegetation (Tankersley et al. 2013, in preparation).

Unit 3 is a silt-dominated Late Woodfordian Cary and Post-Cary Age alluvium that is 2-4 meters thick. Unit 3 lies about 5 meters below T1 and 3-5 meters above T0 (Figure 50). In some areas, it is covered with a layer of Holocene alluvium. Unit 3 is composed of a weathered yellowish-gray to brown gravel in clay, gravel in silt, gravel in silty clay, and silty clay (Tankersley et al. 2009; Tankersley et al. 2013, in preparation). The Unit also has stringers of upper Ordovician limestone and siltstone pebbles, yellowish orange calcareous concretions, and reddish brown limonitic concretions. The disarticulated remains of *Rangifer tarandus* (Caribou), *Cervalces scotti* (Elk Moose), *B. bison antiquus* (Pleistocene Bison), and *Mammut americanum* (American Mastodon) have been previously uncovered in the Unit. Fossils occur in three conditions—pristine, broken, and abraded. Recent excavations indicate that freshwater bivalves, gastropods, and plant remains (i.e., wood, twigs, moss, and fruit) are ubiquitous throughout the Unit (Tankersley 2007b, 2009b, Tankersley et al. 2009; Tankersley et al. 2013, in preparation). Vertical and lateral accretion of sediments during the Late Pleistocene were deposited in lithologically similar, but temporally distinct strata.

Previous radiocarbon dates for Unit 3 range from 14,179 – 12,880 ¹⁴C Cal BP (Table 22). At this time, continued degradation of the Ohio River subsequent to the time of maximum ice
recession and an ensuing re-advancement resulted in a prominent post-Tazewell, Cary Age
terrace (Tankersley et al. 2013, in preparation). Early Paleoindian artifacts such as Clovis spear
points, spurred end scrapers, flake knives, and mastodon bones with human mediated cut marks
also occur in Unit 3. Two of the youngest radiocarbon dates from Unit 3 range from 13,3039-
11,714 ^14^C Cal BP (Table 22) and overlap with the established age range of the Allerod and
Clovis technological complex (Tankersley et al. 2009). δ^{13}C values and δ^{15}N ratios obtained
from *Mammut americanum* bone collagen (Tankersley et al. 2013, in preparation) from Unit 3
consistent with mastodons browsing on a wide range of resources in a mosaic environment
dominated in C3 vegetation with season variations (Cerling et al. 2011; Metcalfe 2011).

Unit 4 is a fossiliferous, silt-dominated Holocene fluvium ca. 5,000 ^14^C Cal BP. The Unit
is 4-8 meters thick. Silt extends from the T0 surface to 143-144 meters ASL and is 2-4 meters
thick (Figure 50) (Tankersley et al. 2013, in preparation). Unit 4 consists of Upper Ordovician
limestone and siltstone pebbles, cobblestones, slabs, and well-rounded igneous and metamorphic
rocks. The disarticulated remains of *B. bison bison* (American Bison), *Cervus canadensis* (Elk),
and *Odocoileus virginianus* (White-tailed Deer) are especially abundant in the silty sandy gravel
beds as well as weathered and stream-worn Late Pleistocene vertebrate fossils. Wood charcoal,
freshwater bivalves, gastropods, and plant remains are abundant and ubiquitous (Tankersley et
al. 2013, in preparation). Profiles 2, 4, and 5 feature Late Archaic (ca. 5,500-2,500 BP), Early to
Late Woodland (ca. 2,500-1,100 BP), and Early to Late Fort Ancient (ca. 1,100-300 BP) artifacts
and features that occur in stratigraphic succession in Unit 4. Radiocarbon dates range from
4,170±30 (Profile 2) to 310±30 BP (Profile 5) (4,840-300 ^14^C Cal BP) (Table 21) and OSL dates
range from 5,200±100 BP (Profile 2) to 400±10 BP (Profile 5) (Tables 19-20).
The radiocarbon and OSL dates from Unit 4 are also consistent with artifact typology (Appendix I). Partially articulated bison bones, flaked-stone spear points and arrowheads, flake knives, scrapers, and shell tempered Madisonville cordmarked pottery are especially abundant in Unit 4 just below the water table in Profile 4. The artifacts and faunal remains of Profile 4 in Unit 4 represent Late Fort Ancient kill and butchering activities during the Little Ice Age (Tankersley 1986, 1990). Previous and new radiocarbon dates obtained for this thesis range from 550±50 BP to 310±30 BP (650-300 ^14C Cal BP), and OSL dates from Profile 5 of 400±10 BP were obtained for the same stratum that contains evidence of Late Fort Ancient bison kill and butchering activities in Profile 4.

Most of the δ13C values from bulk SOM (Profiles 1, 2, 4, 5; Tables 14, 15, 17, and 18) in Unit 4 range from -25.0 to -28.0 suggesting an environment dominated by C3 vegetation. A single δ13C value of -15.9 was obtained from a stratum that dates to the Little Ice Age and is likely associated with Late Fort Ancient maize (Zea mays) agriculture (Tankersley et al. 2013, in preparation). Carbon isotope values and δ15N ratios obtained on modern bison bone collagen (Profile 4) from Unit 4 (Tankersley et al. 2013, in preparation) are consistent with bison browsing on C3 vegetation. It is interesting to note that the δ13C values obtained in Little Ice Age modern bison collagen are lower than those obtained from bone collagen of Late Pleistocene proboscideans, which suggests that a more open and mosaic environment existed during the Late Pleistocene than during the Late Holocene Little Ice Age (Tankersley et al. 2013, in preparation).

Although Unit 3 and Unit 4 are discrete entities, in many areas, Unit 3 is overlain by Unit 4 and is texturally indistinguishable. Presently, Late Pleistocene events in the formation of the floodplain cannot be distinguished from more recent Holocene events (Ray 1974). Since the floodplain formed during the Late Pleistocene and Holocene, there are no visible vertical or
horizontal separations between Units 3 and 4 (Tankersley et al. 2013, in preparation). As a result, previous investigators have generally combined them into a single Unit (e.g., Ray 1974; Swadley 1969). The alluvial surface of Unit 4 was created by lateral accretion of channel deposits and by overbanks during Late Holocene flooding. The narrow bedrock river valley has inhibited the shifting of Big Bone Creek. So, T0 and Unit 4 are restricted in areal extent (Ray 1974).

There is a ca. 5,000-year unconformity between Unit 2 and Unit 3, which spans 19,000-14,000 BP from the Oldest Dryas and the Bolling Oscillation. A 7,000-year unconformity between Unit 3 and 4, which spans 12,000-5,000 BP, from the Younger Dryas to the Holocene Climatic Optimum is also present (Tankersley et al. 2013, in preparation). These unconformities are associated with intensive periods of floodplain degradation and the transition from cool and dry to warm and moist climates. The most intensive interval of Holocene floodplain aggradation, ≥ 4 meters, occurred during the Late Holocene between ca. 5,000 and 300 $^{14}$C Cal BP. During this time, there was a dramatic increase in human population, sedentary livelihood, silvaculture, horticulture, and agriculture. These anthropogenic processes would have dramatically increased erosion and accelerated floodplain aggradation as seen in all Profiles.
Chapter 9: Conclusions

A key element of stratigraphic studies is the chronology. Without adequate chronologies it is nearly impossible to draw correlations with either archaeological or other paleoenvironmental information (Frederick 2000). Often site-specific studies in geoarchaeology are underemphasized due to the traditionally large spatial scales that Quaternary geologists use. Relying solely on a regional scale in geoarchaeology can bias the archaeological record. It is equally important to incorporate geologic information at specific sites within a region. Doing so can significantly influence identification and interpretation of site and regional scale archaeological patterns (Linse 1993).

In this thesis, I have conducted a detailed stratigraphic analysis of Big Bone Lick State Historic Site, Kentucky. This historic site is centered on Big Bone Lick, an area of saline and sulfur springs that result from a mineral-rich wetland environment seasonally created by a water table that rises in association with spring snow melts and heavy rain (Lowthert 1998). The salt lick has consistently attracted animals and people making it an ideal place to have a site-specific chronostratigraphic study in which all cultural and faunal ranges are represented. The data collected for this study were excavated during the summer of 2012 and analyzed during the fall of 2012. Specifically, I examined the stratigraphy of five profiles, particle size analysis, stable carbon isotope and stable nitrogen isotope data from soil organic matter, artifacts, vertebrate paleontology, optically stimulated luminescence dates, and radiocarbon dates. These data were then placed in the context of data previously gathered at the state historic site in order to gain a larger perspective of the geomorphic units and the environment.

This study has confirmed the location of three distinctive geomorphic surfaces and stratigraphic units that represent significant depositional events at Big Bone Lick, Kentucky. The
Units previously found and correlated with this thesis’ profiles date to 25,000-19,000 BP (T2, Unit 2), 14,000-12,000 BP (T3, Unit 3), and 5,000 BP to the present (T4, Unit 4). The depositional and erosional record at Big Bone Lick is very similar to that in the Ohio River valley. My data indicate that Late Pleistocene and Holocene aggradation and degradation in the Big Bone Lick and the Ohio River valleys were broadly synchronous. Stable isotope data obtained on bulk organic matter, bone collagen, and enamel demonstrate that the landscape was dominated by C₃ vegetation from the Last Glacial Maximum to the present, with more open mosaics occurring during the Late Pleistocene (Tankersley et al. 2009). These data are in agreement with isotope data obtained from profiles for this thesis on herbivore collagen and enamel (Tankersley et al. 2013, in preparation). Significant periods of degradation occurred during the transition of climatic periods between cold and dry to warm and moist climatic periods, from the Older Dryas to Bolling Oscillation and from the Younger Dryas to the Holocene Climatic Optimum. By 5,000 BP, anthropogenic processes resulted in significant alteration of upland and lowland vegetation, which led to an increase in erosion and floodplain aggradation.

Although the information gained from this study has been substantial, it has remained at a broader investigational scale for archaeological purposes. I recommend further analysis of the geoarchaeology at Big Bone Lick State Historic Park, Kentucky, specifically, the areas of micromorphology and the micro-analysis of plant remains, in order to gain information on a much finer environmental and archaeological scale. There is a lot more information to be gained from continued research at Big Bone Lick in order to advance environmental and climatic knowledge of the area and region.
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Yochelson, Ellis L.

Zech, Michael
Appendix I: Data Spreadsheets
## Artifact Inventory Spreadsheet

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## Artifact Inventory Spreadsheet

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## Vertebrate Paleontological Inventory

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<th>Time Period</th>
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<td>20-100 cm</td>
<td>General</td>
<td>8/25/2012</td>
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<td>20-100 cm</td>
<td>General</td>
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<td>Fort Ancient</td>
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<td>In N wall, 181 cm from E wall</td>
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<td>259 cm from E Wall, 20 cm from N Wall</td>
<td>7/29/2012</td>
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<td>Rib Fragment</td>
<td>Fort Ancient</td>
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<td>51 cm</td>
<td>44 cm from N Wall, 104 cm from W Wall</td>
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<td>Scapula Fragment</td>
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Appendix II: Radiocarbon Dates from Beta Analytic
October 8, 2012

Dr. Kenneth B. Tankersley
University of Cincinnati
Department of Anthropology
481 Braunstein Hall
Cincinnati, OH 45221
USA

RE: Radiocarbon Dating Result For Sample BBL-P2-4.5m

Dear Dr. Tankersley:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis proceeded normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of analysis was previously invoiced. As always, if you have any questions or would like to discuss the results, don’t hesitate to contact me.

Sincerely,

[Signature]

Darden Hood
## REPORT OF RADIOCARBON DATING ANALYSES

**Dr. Kenneth B. Tankersley**

**University of Cincinnati**

**Report Date:** 10/8/2012  
**Material Received:** 10/1/2012

<table>
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<th>Measured Radiocarbon Age</th>
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<td>Beta - 331826</td>
<td>4170 +/- 30 BP</td>
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**SAMPLE:** BBL-P2-4-5m  
**ANALYSIS:** AMS-Standard delivery  
**MATERIAL/PRETREATMENT:** (wood); acid-alkali/acid  
**2 SIGMA CALIBRATION:** Cal BC 2640 to 2640 (Cal BP 4590 to 4590)

---

**Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5688 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.**

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by **(*)**.

The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6; lab.mult=1)

Laboratory number: Beta-331826

Conventional radiocarbon age: 4180±30 BP

2 Sigma calibrated results: Cal BC 2590 to 2830 (Cal BP 4840 to 4780) and
(95% probability) Cal BC 2820 to 2660 (Cal BP 4770 to 4610) and
Cal BC 2640 to 2640 (Cal BP 4590 to 4590)

Intercept data

Intercepts of radiocarbon age
with calibration curve: Cal BC 2870 (Cal BP 4820) and
Cal BC 2800 (Cal BP 4750) and
Cal BC 2780 (Cal BP 4730)

1 Sigma calibrated results: Cal BC 2880 to 2860 (Cal BP 4830 to 4810) and
(68% probability) Cal BC 2810 to 2750 (Cal BP 4760 to 4700) and
Cal BC 2720 to 2700 (Cal BP 4670 to 4650)

References:

Database used
INTCAL09

References to INTCAL09 database

Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
September 24, 2012

Dr. Kenneth B. Tankersley
University of Cincinnati
Department of Anthropology
481 Braunein Hall
Cincinnati, OH 45221
USA

RE: Radiocarbon Dating Result For Sample BBL.+Profile2

Dear Dr. Tankersley:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis proceeded normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice has been sent separately. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don’t hesitate to contact me.

Sincerely,

[Signature]

Darden Hood
President
REPORT OF RADIOCARBON DATING ANALYSES

Dr. Kenneth B. Tankersley
University of Cincinnati

Report Date: 9/24/2012
Material Received: 9/17/2012

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<td>MATERIAL/PRETREATMENT: (wood): acid-alkali-acid</td>
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<td>2 SIGMA CALIBRATION:</td>
<td>Cal BC 23100 to 22600 (Cal BP 25050 to 24560)</td>
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Notes:
- Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5688 years). Quoted errors represent ±1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.
- The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by **.
- The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-258:lab. mult=1)

Laboratory number: Beta-330554

Conventional radiocarbon age: 20860±90 BP

2 Sigma calibrated result: Cal BC 23100 to 22600 (Cal BP 25050 to 24550)
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 22990 (Cal BP 24940)

1 Sigma calibrated result: Cal BC 23050 to 22900 (Cal BP 25000 to 24850)
(68% probability)

References:

Database used
INTCAL09

References to INTCAL09 database

Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates

Beta Analytic Radiocarbon Dating Laboratory

4955 S.W. 74th Court, Miami, Florida 33155 • Tel: (305) 667-5467 • Fax: (305) 663-0964 • E-Mail: beta@radiocarbon.com

Page 3 of 3
October 22, 2012

Dr. Kenneth B. Tankersley
University of Cincinnati
Department of Anthropology
481 Braunstein Hall
Cincinnati, OH 45221
USA

RE: Radiocarbon Dating Result For Sample BBL-Profile5

Dear Dr. Tankersley:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis proceeded normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice has been sent separately. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don’t hesitate to contact me.

Sincerely,

Darden Hood
REPORT OF RADIOCARBON DATING ANALYSES

Dr. Kenneth B. Tankersley

University of Cincinnati

Report Date: 10/22/2012

Material Received: 9/17/2012

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<td>Beta - 300555</td>
<td>310 +/- 30BP</td>
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SAMPLE: BBL_Profile5
ANALYSIS: RadiometricPLUS Standard delivery
MATERIAL/PRETREATMENT: (wool): acid/alkali/acid
2 SIGMA CALIBRATION: Cal AD 1470 to 1650 (Cal BP 480 to 300)

Dates are reported as RCYBP (radio-carbon years before present. *present = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5688 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured $\Delta^{13}C/\Delta^{12}C$ ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by **.

The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12= -24.3; lab. mult=1)

Laboratory number: Beta-330555

Conventional radiocarbon age: 320±30 BP

2 Sigma calibrated result: Cal AD 1470 to 1650 (Cal BP 480 to 300)
(95% probability)

Intercepts of radiocarbon age with calibration curve:
- Cal AD 1520 (Cal BP 420) and
- Cal AD 1560 (Cal BP 390) and
- Cal AD 1630 (Cal BP 320)

1 Sigma calibrated results:
- Cal AD 1500 to 1500 (Cal BP 450 to 450) and
- Cal AD 1510 to 1600 (Cal BP 440 to 350) and
- Cal AD 1620 to 1640 (Cal BP 330 to 310)

References:

Database used
- IntCal09

References to IntCal09 database

Mathematics used for calibration scenario
- A Simplified Approach to Calibrating C14 Dates

Beta Analytic Radiocarbon Dating Laboratory
495 SW 74th Court, Miami, Florida 33155 • Tel: (305) 667-5167 • Fax: (305) 663-0964 • E-Mail: beta@radiocarbon.com
Appendix III: Fieldwork Photographs
Surface Survey

Photo 1: Surface Survey of Big Bone Creek. View West. 6-22-12.

Photo 2: Surface Survey of Big Bone Creek. View North. 6-22-12.

Photo 3: Surface Survey of Big Bone Creek. View North West of Gum Branch tributary. 6-22-12.

Photo 4: Surface Survey of Big Bone Creek. View East. 6-22-12.
Photo 5: Profile 1. Opening View with vegetation. Facing West. 6-30-12.

Photo 6: Profile 1. Opening View. Facing West. Gum Branch. 6-30-12.

Photo 7: At Profile 1. Facing West. Opposite side of bank on Gum Branch with salt spring. 6-30-12.

Photo 8: At Profile 1. Facing West. Opposite side of bank on Gum Branch. Close up of salt spring. 6-22-12.
Photo 9: At Profile 1. Gum Branch. View South to opening at Big Bone Creek. 7-1-12.

Photo 10: At Profile 1. Gum Branch. View North towards Profile 5. 6-30-12.

Photo 11: Profile 1. Gum Branch. View of salt spring to the left of the profile. 6-30-12.

Photo 12: Profile 1. Top view of a layer possibly associated with the salt springs to the left of the profile. 250 cm. 6-30-12.
Photo 13: Profile 1. Top view of a layer possibly associated with the salt springs to the left of the profile. 250 cm.
6-30-12.

Photo 14: Profile 1. Leaf preserved in the band of heavily abundant organics. 250cm – 300cm. 6-30-12.

Photo 15: Profile 1. Leaf preserved in the band of heavily abundant organics. Up Close. 250 cm – 300 cm.
6-30-12.

Photo 16: Profile 1. Top view of a layer possibly associated with the salt springs to the left of the profile. 250 cm.
6-30-12.
Photo 17: Profile 1. Gum Branch. Site view of first day. 6-30-12.

Photo 18: Profile 1. Gum Branch. End of first day. 2 m ruler. Wood found in the bottom of profile. 6-30-12.

Photo 19: Profile 1. Up close of wood found at the base of stream level. 7-1-12.

Photo 20: Profile 1. Up close of the grains of the wood found at the base of stream level. 7-1-12.

Photo 22: Profile 1. Gum Branch. Site view end of second day. View South East. 7-1-12.

Photo 23: Profile 1. Gum Branch. End of day. 2 m rulers. 7-1-12.

Photo 24: Profile 1. Silt stringers in second stratigraphic layer. 7-1-12.
Photo 25: Profile 1. Silt stringers from second stratigraphic layer up close. 7-1-12.

Photo 26: Profile 1. Silt stringers. Charcoal concentration in the right hand corner. 7-1-12.

Photo 27: Profile 1. Charcoal concentrations up close. 7-1-12.

Photo 28: Profile 1. Above stream level finished. 7-7-12.
Photo 29: Profile 1. Layer 12. Uncovering the *Mammuthus* sp. or *Mammut americanum* rib. 7-7-12

Photo 30: Profile 1. Layer 12. Uncovering the *Mammuthus* sp. or *Mammut americanum* rib. 7-7-12

Photo 31: Profile 1. Layer 12. Uncovering the *Mammuthus* sp. or *Mammut americanum* rib. 7-7-12

Photo 32: Profile 1. Base of Excavation. 7-7-12
Profile 1 – Shovel Test Pit

Photo 33: Shovel test to the right of Profile 1. Gum Branch. 6-30-12

Profile 2

Photo 35: Profile 2. Big Bone Creek. Opening. View South. 7-14-12

Photo 36: At Profile 2. Big Bone Creek. View to the North. 7-14-12
Photo 37: At Profile 2. Big Bone Creek. View to the East. 7-14-12

Photo 38: At Profile 2. Big Bone Creek. View to the West. 7-14-12

Photo 39: Profile 2. Pink flags/scales mark areas where decayed human bones, charcoal, and red ochre were found. End of Day. 7-14-12.

Photo 40: Profile 2. Charcoal found around 200 cm with decayed human bone. 7-14-12
Photo 41: Profile 2. Charcoal found around 200 cm with decayed human bone. 7-15-12

Photo 42: Profile 2. Charcoal found around 200 cm with decayed human bone. 7-15-12

Photo 43: Profile 2. Charcoal found around 200 cm with decayed human bone. 7-15-12

Photo 44: Profile 2. Charcoal found around 200 cm with decayed human bone. 7-15-12
Photo 45: Profile 2. Decayed human bone. 7-15-12

Photo 46: Profile 2. Decayed human bone. 7-15-12

Photo 47: Profile 2. Decayed human bone. 7-15-12

Photo 48: Profile 2. Stratigraphy of step. Small scale placed where charcoal found around 200 cm with decayed human bone. 7-15-12
Photo 49: Profile 2. End of Day. 7-21-12

Photo 50: Profile 2. Above stream level profile finished. Pink flag marks decayed human bone level. 2 m scale. 7-22-12

Photo 51: Profile 2. Big Bone Creek. Above stream level profile finished. Pink flag marks decayed human bone level. 2 m scale. 7-22-12

Photo 52: Profile 2. Big Bone Creek. Pink flag marks 400 cm. Stratigraphy changes below stream level. 7-22-12
Photo 53: Profile 2. Mollusks found at 445 cm. 7-22-12

Photo 54: Profile 2. Side Scraper found at 465 cm. In situ. 7-22-12

Photo 55: Profile 2. Side Scraper found at 465 cm. 7-22-12

Photo 56: Profile 2. Side Scraper found at 465 cm. 7-22-12
Photo 57: Profile 2. Below stream level. End of Day. Lower pink flag is 4 m mark. 7-22-12

Photo 58: Profile 2. Big Bone Creek. Below stream level. 7-29-12

Photo 59: Profile 2. Below stream level. End of Day. Pink flag in SW corner location of walnut. 7-22-12

Photo 60: Profile 2. Bioturbation at 470 cm. 7-22-12
Photo 61: Profile 2. Bioturbation at 470 cm. Top view. 7-22-12

Photo 62: Profile 2. SW corner stratigraphy. 7-22-12

Photo 63: Profile 2. End of Day. Orange flag is 4 m mark. 8-4-12

Photo 64: Profile 2. End of Day. Orange flag is 4 m mark. 8-4-12
Photo 65: Profile 2. Sediment changes at 500 cm. Magnetite. 8-4-12

Photo 66: Profile 2. Sediment changes at 557 cm. Magnetite. 8-8-12

Photo 67: Profile 2. Sediment changes at 600 cm. Possible large animal footprint. 8-8-12

Photo 68: Profile 2. Water screen samples taken from wall every 20 cm from 4m to 6m. 9-15-12
Photo 69: Profile 2. Feature 1. Opening view. 6-22-12

Photo 70: Profile 2. Feature 1. Cleaned Opening View. 7-21-12

Photo 71: Profile 2. Feature 1. Close up of burnt limestone. 7-15-12

Photo 72: Profile 2. Feature 1. Opening area view from top of bank. Facing East. 7-29-12
Photo 73: Profile 2. Feature 1. Opening view of area on top of bank. View North. 7-29-12

Photo 74: Profile 2. Feature 1. Opening view of area on top of bank. View East. 7-29-12

Photo 75: Profile 2. Feature 1. Opening view of area on top of bank. View West. 7-29-12

Photo 76: Profile 2. Feature 1. Bottom of plow zone. View North. On top of bank. 8-11-12
Profile 3

Photo 77: Profile 3. Opening of profile. 7-29-12

Photo 78: Profile 3. End of Day. 7-29-12

Photo 79: Profile 3. View South East. 7-29-12

Photo 80: Profile 3. View West. 7-29-12
Photo 81: Profile 3. View West 7-29-12

Photo 82: Profile 3. Base of Excavations. 8-12-12

Photo 83: Profile 3. Ending Stratigraphy. 8-12-12

Photo 84: Profile 3. Ending Stratigraphy. 8-12-12
Profile 4

Photo 85: Profile 4. Big Bone Creek. Opening Planview. 7-22-12

Photo 86: At Profile 4. Big Bone Creek. View South East. 7-22-12

Photo 87: At Profile 4. Big Bone Creek. View South where additional *Bison bison* bones were found in water. 7-22-12

Photo 88: Profile 4. East Wall. Base of Excavation. 7-29-12
Photo 89: Profile 4. View East Wall. Flags mark where artifacts were found. 7-29-12

Photo 90: Profile 4. West wall. 7-29-12

Photo 91: Profile 4. View West. Flags mark where artifacts were found. 7-29-12
Profile 5

Photo 92: Profile 5. Gum Branch. Opening. View North. 8-12-12

Photo 93: At Profile 4. Gum Branch. View South East toward Profile 1. 8-12-12

Photo 94: At Profile 5. Gum Branch. View West. 8-12-12

Photo 95: Profile 5 – End of Day. Above stream profile finished. 8-19-12
Photo 96: Profile 5. End of Excavation stratigraphy. 8-19-12

Photo 97: Profile 5. End of Excavation. Close up of below stream level stratigraphy. 8-19-12

OSL Sampling

Photo 98: Profile 1. 9-9-12

Photo 99: Profile 1. 9-9-12
Photo 108: Profile 5. 9-9-12
Appendix IV: Artifact Photographs
Surface Survey

Photo 1: Surface Survey of Big Bone Creek. Stalactite

Photo 2: Surface Survey of Big Bone Creek. Core. High-level fluvial deposit.

Photo 3: Surface Survey of Big Bone Creek. Core. High-level fluvial deposit.

Photo 4: Surface Survey of Big Bone Creek. Bipolar Core. High-level fluvial deposit.
Photo 5: Surface Survey of Big Bone Creek. Utilized Flake. High-level fluvial deposit.

Photo 6: Surface Survey of Big Bone Creek. Utilized Flake. High-level fluvial deposit.

Photo 7: Surface Survey of Big Bone Creek. Flake. High-level fluvial deposit.

Photo 8: Surface Survey of Big Bone Creek. Flake. High-level fluvial deposit.
Photo 9: Surface Survey of Big Bone Creek. Flake. High-level fluvial deposit.

Photo 10: Surface Survey of Big Bone Creek. Prehistoric Pottery. Grit tempered body sherd. Middle Woodland.

Profile 2


Photo 13: Profile 2. Level 1. 210 cm. Quartzite core and shatter. High-level fluvial deposit.

Photo 14: Profile 2. Level 1. 220 cm. Metaquartzite fire cracked rock.

Photo 15: Profile 2. Level 1. 235 cm. Sandstone pitted stone.
Photo 16: Profile 2. Backfill pile. 0-200 cm. Preform. High-level fluvial deposit.

Photo 17: Profile 2. Backfill pile. 0-200 cm. Preform. High-level fluvial deposit.

Photo 18: Profile 2. Backfill pile. 0-200 cm. Flake. High-level fluvial deposit.


Photo 23: Profile 2. Level 5. 470 cm. Side scraper. Upper mercer chert.
Profile 2 – Feature 1

Photo 24: Profile 2. Feature 1. Quartz fire cracked rock.


Prehistoric pottery. Limestone temper. Late Woodland - Newtown

Photo 29: Profile 2. Feature 1. Prehistoric pottery. Limestone temper. Late Woodland - Newtown

Profile 4


Retouched flake. Wyandotte chert.


High-level fluvial deposit.


Photo 34: Profile 4. Level 1. 10 cm. Flake. High-level fluvial deposit.

Photo 36: Profile 4. Level 1. 29 cm. Flake. High-level fluvial deposit.

Photo 37: Profile 4: Level 1. 29 cm. Core. High-level fluvial deposit.

Photo 38: Profile 4. Level 1. 30 cm. Bifacial perform fragment with hinge fragment. Laurel chert.

Photo 40: Profile 4. Level 1. 32 cm. Preform. Wyandotte chert.

Photo 41: Profile 4. Level 2. 34 cm. Core. High-level fluvial deposit.

Photo 42: Profile 4. Level 2. 35 cm. Core. Wyandotte chert.

Photo 43: Profile 4. Level 2. 36 cm. Decortication flake. High-level fluvial deposit.
Photo 44: Profile 4. Level 2. 36 cm. Decortication flake. High-level fluvial deposit.

Photo 45: Profile 4. Level 2. 36 cm. Utilized flake. Ohio-flint ridge chert.


Photo 47: Profile 4. Level 2. 55 cm. Utilized flake. High-level fluvial deposit.
Prehistoric pottery. Cord marked and shell tempered. Fort Ancient.

Profile 5


Appendix V: Vertebrate Paleontological Photographs
Surface Survey

Photo 1: Surface Survey of Big Bone Creek. *Odocoileus virginianus* (White-Tailed Deer) antler.

Photo 2: Surface Survey of Big Bone Creek. *B. bison bison* (American bison) thoracic vertebrae.

Profile 1


Photo 22: Profile 1. Level 12, 335 cm. *Mammuthus primigenius* (Woolly mammoth) or *Mammut americanum* (American mastodon) tibia fragment.
Profile 2


Profile 2/Feature 1

Photo 26: Profile 2. Feature 1. *Cervus Canadensis* (Elk) tooth.


Profile 4


Photo 34: Profile 4. Level 1, 18 cm. *B. bison bison* (American bison) rib fragment.

Photo 35: Profile 4. Level 2. 33 cm. *B. bison bison* (American bison) scapula fragment.

Photo 36: Profile 4. Level 2. 34 cm. *B. bison bison* (American bison) rib fragment.
Profile 4


Photo 38: Profile 4. Level 2. 51 cm. *B. bison bison* (American bison) rib fragment.

Profile 5