Digital Technology and a New Era for Archaeology: Cooper's Ferry, Idaho

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Digital Technology and a New Era for Archaeology: Cooper’s Ferry, Idaho

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Abstract

The field of archaeology has a longstanding set of traditional research methods. I argue in favor of implementing a new series of digital and three dimensional methods that will not only change how archaeology is conducted, but will open the door to invaluable new information that was previously inaccessible. This project draws on my experience at the 2015 Cooper’s Ferry field school conducted by Oregon State University. OSU is on the cutting edge of these new digital technologies, as they aim to discover new information about Western Stemmed Tradition peoples that thrived in the Great Basin around 13,000 years ago. The responsibility of our discipline is to tell the whole story of these early Americans. I argue that this can only be done with the use of digital and three dimensional technologies, as this will expose new information and further preserve the integrity of the sites and collections we study.
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Introduction

The field of archaeology has a long standing set of traditional excavation and analysis methods. We seek to understand past cultures by analyzing what they left behind, but by nature, this process is destructive as archaeologists excavate and take artifacts out of their original context. This process allows us to study these artifacts, but limits the amount of information we can gain from the entire site as a whole. The field of archaeology has seemed to be hesitant when adopting new technologically advanced methodologies when the age of technology has been knocking at the threshold of our discipline for years. There are current projects today that have embraced this technological transition and utilize technologies that have provided new avenues for preserving and analyzing archaeology sites. One of these technologically advanced projects is taking place at the Cooper’s Ferry site located on the Lower Salmon River in Western Idaho (see Figure 1). This project under the direction of Dr. Loren Davis and Oregon State University aims to discover new information about Western Stemmed Tradition peoples that thrived in the Great Basin and Pacific Northwest around 13,000 years ago. This paper draws from my experience...
as a field school student who joined this project in the summer of 2015. For eight weeks, I was able to experience and work with some of the newer technologies that have been adopted. In this thesis, I will demonstrate how new digital methods of replication and recordation improve Pacific Northwest Paleo Indian research by providing detailed examples of how these technologies work and how they are utilized at the Cooper’s Ferry project.

**Pacific Northwest Paleo Indian Sites**

The Pacific Northwest of North America contains an archaeological record that can be considered an incomplete puzzle whose pieces are just starting to fall in place. As our knowledge progresses in the sciences, we seek to understand who the first Americans were, and how these early Paleo Indian peoples migrated into North America. To answer these key questions, there has been a considerable amount of excavation and analysis done at significant sites around the northwest including the Paisley Caves, Rimrock Draw Rock shelter, Buhl Burial Site, Weies Rock shelter, and Cooper’s Ferry Site in the Lower Salmon River Canyon. These sites lend support to understanding migrational and occupational behaviors, as well as expanding the length of time humans have existed in America.

**Paisley Caves**

Located in the Summer Lake Basin of Southern Oregon, the Paisley Caves site yields some of the oldest radiocarbon dates that support a long history of human occupation. The Paisley Caves sit on what was once the shore of the Summer Lake basin. These caves created great shelters for early peoples due to their close proximity to food and water. After a long occupation at the Paisley Caves, aeolian and colluvial deposits buried the evidence of human
presence thus creating a dry environment, perfect for preserving organic material that was left by the early inhabitants (Gilbert et al. 2008:786). Since 2002 the University of Oregon field school, led by Dr. Dennis Jenkins, has been excavating the site. In the years between 2002 and 2011, 190 radiocarbon dates were taken from plant remains, coprolites, and faunal remains to solidify an accurate radiocarbon date range. These radiocarbon dates place human occupation at the Paisley Caves site between 12,450 and 2,295 radiocarbon years (Jenkins et al. 2012:223-224).

The Paisley Caves have yielded two very key sets of artifacts. Projectile points that belong to a style called the Western Stemmed Tradition have been found at the site. Human coprolites have also been found at the site. Together, both provide a significant amount of evidence for early occupation at the site. Four Western Stemmed projectile points have been found, along with hundreds of pieces of debitage within the first three lithostratigraphic layers. These projectile points and debitage are associated with radiocarbon dates that fall between 11,070 and 11,340 radiocarbon years (Jenkins et al. 2012:223). There is no evidence of the Clovis tradition at the Paisley Caves, which adds support to the argument that Western Stemmed culture was an independent indigenous culture that coexisted with Clovis.

A unique data set from the Paisley Caves are the 65 coprolites that have been radiocarbon dated and DNA tested. In most archaeological settings, organic materials such as coprolites do not fossilize and are lost to the forces of time. The dry nature of this cave system has fortunately preserved these artifacts. In the first lithostratigraphic level, 14 fossilized coprolites were found that appeared to be of human origin. The use of DNA screening showed that all specimens contained human mitochondrial DNA. It is believed that eight of these
samples might have been contaminated by the excavation team. Six of the samples, on the other hand, tested positive to having mitochondrial DNA consistent to indigenous Native tribes. To ensure that these results were accurate, all members of the research team submitted a DNA sample to check for contamination. Using radiocarbon dates from bone collagen found in the remains of an early camel, three of the oldest coprolites from the first lithostratigraphic layer date to 12,300 radiocarbon years (Gilbert et al. 2008:787-789). The coprolites and projectile points found at the Paisley Caves provide significant support to the idea of early humans bearing the Western Stemmed Tradition occupied the Pacific Northwest around 12,300 radiocarbon years ago (Jenkins et al. 2012:223).

*Rimrock Draw Rock Shelter*

In southeast Oregon near the town of Riley, archaeologists from the United States Bureau of Land Management, with help from the University of Oregon, have been excavating the Rimrock Draw Rock Shelter, which has also demonstrated a considerable intensity of human occupation. In 2011, the BLM and members of the Oregon Archaeological Society found 26 projectile points and a fluted biface, prompting further investigation of the site. After auguring and finding obsidian debitage, three test pits were dug at the site, revealing a hearth and ground stone. In 2012, the University of Oregon hosted a field school to continue researching early human occupation at the site (Provost et al. 2015).

The site yielded tooth enamel fragments believed to belong to a species of camel that went extinct around 13,000 years ago. The stemmed points and fluted bifaces date to around 13,000 years. One of the most exciting finds came in 2012. An orange agate scraper was found
beneath a layer of volcanic ash that, through chemical analysis, matches ash from a known Mt. St. Helens eruption that occurred 15,800 years ago. That would mean this scraper would be older than 15,800 years. If this holds true, the Rimrock Draw Rock Shelter would be the oldest known human occupation site on the west coast. The University of Oregon and the BLM will be continuing excavations at this site in the next few years seeking more evidence that this site sheltered humans over 15,800 years ago (Bureau of Land Management 2015).

*The Buhl Burial Site*

The Pacific Northwest contains significant evidence for early human occupation. At the Paisley Caves and Rimrock Draw Rock Shelter, stone tools, faunal remains, plant material, and coprolites signal a human presence. These artifacts are analyzed to determine the length of occupation, and what resources people were utilizing in the region. In 1989 archaeologists from the Herrett Center and the Idaho State Historical Society excavated the most complete and oldest Paleo Indian remains that have been found thus far in Idaho.

A full skeleton was found in a grave in a highway district gravel quarry. This quarry lies just north of the town of Buhl, which is located in south-central Idaho. The burial site was covered by alluvium from the Bonneville flood and dry windblown dust that preserved the majority of the remains in situ. The skeleton exhibits very minimal post mortem damage. Based on radiocarbon dates from bone collagen, it is estimated that the remains are 10,675 ±95 years BP. Based on the fused cranial sutures and the occlusal eruption of the third molars, it is estimated that the individual was between 17 and 21 years old. The remains are believed to be of a woman who, based on craniofacial features, resembled American Indian and East Asian
peoples. Also found in situ, five artifacts were associated with the remains: one complete pressure flaked obsidian biface, resembling the Western Stemmed Tradition, a portion of a bone needle, two fragments of a bone awl, and a badger baculum, thought to have been a funeral offering as there were no more badger remains found near the site (Green et al. 1998: 437-489).

*The Lower Salmon River Canyon*

The Lower Salmon River Canyon, the traditional lands of the Nez Perce tribe, contains much of the tribe's prehistory. The archaeological record confirms that the Lower Salmon River Canyon has a very long history of human occupation. One of these sites is the Weis Rock Shelter located in the basalt walls of the Lower Salmon River Canyon. The rock shelter, located just above the river, provides access to a variety of food resources. This site was excavated from 1961 and 1963 by University of Idaho archaeologist B. Robert Butler. Excavations revealed that the rock shelter had been occupied from around 8,000 years BP to as recent as 600 years BP (National Park Service 2015).

Another Lower Salmon River Canyon site that has produced evidence of a long paleo-Indian occupation is the Cooper's Ferry Site. Between 1961 and 1964 B. Robert Butler excavated at the Cooper's Ferry site above the banks of the Lower Salmon River. This excavation employed the use of heavy machinery, and was only dug in one elongated trench. Artifacts found during Butler's excavation thus lost contextual evidence, but did give an idea of how old the site could be. Large stemmed and lanceolate projectile points were found associated with sediment dating to the late Pleistocene and early Holocene (Davis 2001: 231).
The Cooper's Ferry Site was reinvestigated in 1997, when Dr. Loren Davis opened a test pit on the site to expand on B. Robert Butler's research. This two by two meter test pit, Unit A, was placed just west of Butler's original trench. Unit A contained evidence of extended human occupation in all lithostratigraphic levels. Two key pieces of evidence are the two pit features that were found. Pit Feature One contained stained sediments that showed evidence of oxidation from being fired. This appears to have been part of a hearth. Pit Feature Two contains much more physical evidence. Located much deeper in the lithostratigraphic layers, Pit Feature Two showed signs of a poorly sorted sediment when the surrounding nature of the lithostratigraphic layers was a consistent loamy sand. This suggests a purposefully dug pit made by early Hunter Gatherers. The poor assortment of sand and gravel suggest that the pit was refilled. Once Pit Feature Two was fully excavated it was found to contain a cache of stone tools (Davis and Schweger 2004: 696-698). These included 13 total tools that consisted of four Western Stemmed projectile points, two cryptocrystalline silicate unifaces, one large basalt core, three Western Stemmed blades made from cryptocrystalline silicates, two modified flakes made from cryptocrystalline silicates, and one quartzite hammer stone (Davis et al. 2014: 11-13). This feature appears to resemble a tool kit that a hunter stored away, planning to retrieve at a later time. Wood charcoal associated with the sediment matrix of Pit Feature Two yielded an age of 11,410±130 radiocarbon years (Davis and Schweger 2004: 698-699). This date and the presence of Western Stemmed Projectile points suggests that a separate culture possibly predates and coexisted with early peoples bearing the Clovis tradition.
Background

Prior to the excavations at Paisley Caves, Rim Rock Draw, Buhl burial and at Cooper's Ferry, it was believed that peoples bearing the Clovis tradition were the first peoples to enter the Americas. Now these sites have provided evidence that suggests that peoples bearing the Western Stemmed Tradition either predated or were contemporaneous with Clovis peoples (Beck and Jones 2010:81). That is why archaeology sites containing evidence of the Western Stemmed Tradition are important to the cultural chronology of the Pacific Northwest. My research focuses on how digital technology can improve Paleoindian research. In the following section, I evaluate three topics, which includes Clovis and Western Stemmed technologies, the culture history model of the Lower Salmon River area, and an understanding of one well-known archaeology site that is using 3D technologies to assist in excavation and analysis.

Clovis and Western Stemmed

To understand the relationship between Clovis and Western Stemmed Traditions, Charlotte Beck and George T. Jones's 2010 paper “Clovis and Western Stemmed: Population Migration and the Meeting of Two Technologies in the Intermountain West” gives a good summary of the current knowledge base on these traditions. Beck and Jones describe both the ice free corridor and coastal migration theories that contest the Clovis first hypothesis, thus opening the door for the Western Stemmed Tradition. The article explains that even though we have a large sample of Clovis data, some of the earliest radiocarbon dates come from Western Stemmed sites. The record of known Clovis sites is also presented, demonstrating that Clovis technology has a very wide distribution across North America, but is somewhat absent in the
Great Basin. Instead, evidence of the Western Stemmed Tradition is most prevalent within the Great Basin. With such variability between Clovis and Western Stemmed along with a wide distribution of radiocarbon dates, Beck and Jones agree that Clovis and Western Stemmed Traditions were contemporaneous and further research is needed to fully understand where both of these cultures originated from (Beck and Jones 2010).

Lower Salmon River Culture History Model

The next topic that I will focus on is the culture history model of the Lower Salmon River Canyon. My research, which focuses on the excavations at the Cooper’s Ferry site located on the Lower Salmon River which represents many phases in cultural chronology. B. Robert Butler initially developed a culture history model for the Lower Salmon River, but was recently updated in Dr. Loren Davis’s paper “Lower Salmon River Cultural Chronology: A Revised and Expanded Model.” This model details the various cultural phases that are present in the Lower Salmon River Canyon and are supported by evidence of lithic technology. Davis details the original cultural phases that Butler described while proposing two new cultural phases that predate what Butler had originally developed. These two new phases include the Cooper’s Ferry Phase one and two. Cooper’s Ferry Phase one is distinguished by stemmed points most closely associated with the Lind Coulee type of stemmed points. This phase is also represented by multidirectional flake cores and modified flakes. This phase has radiocarbon dates that ranges from 11,500-11,000 BP. Cooper’s Ferry Phase two is represented by stemmed and lancelot points which resemble the Windust style. This phase is also defined by hearth features with high artifact concentrations that suggest people were using the Salmon River more than
the previous phase. Cooper’s Ferry Phase two has radiocarbon dates that range from 11,000-8,400 BP (Davis 2001).

_Digital Technology in Archaeology_

Digital technology is relatively new to the field of archaeology and is slowly making its way into sites around the world. One of the most famous technologically advanced sites is the Neolithic site, Çatalhöyük, located in the Anatolia region of Turkey. This site has been using digital methods for the last 20 years. Åsa Berggren and colleagues describe the use of digital methods at Çatalhöyük in their paper “Revisiting Reflexive Archaeology at Çatalhöyük: Integrating Digital and 3D Technologies at the Trowel’s Edge.” This paper provides a great case study of how digital technologies are improving archaeology. Berggren and colleagues describe the 3D technologies and techniques that have been developed to enhance preservation and the immersive experience for researchers. Some of these technologies include the use of 3D scanning, image based 3D modeling, photogrammetry, GIS, and the use of tablets. The research team at Çatalhöyük have strived to record in micro detail every single level and lithostratigraphic layer. This includes taking many digital geospatial measurements, and consistently taking 3D laser scans and digital photographs. All of this information can then be downloaded into GIS which can create a compiled digital model. These models can then be constructed into an immersive program that allows researchers to digitally excavate the site level by level in an accessible computer program. This provides the research team with instantaneous analysis. Artifact distribution can be seen in a visual model at the site instead of at the lab. Project members are also equipped with tablets that allow for instantaneous cataloging that expedites the cataloging process. The use of all of these technologies have
created a user friendly work environment that is both affordable and efficient (Berggren et al. 2015).

After examining the Clovis and Western Stemmed Tradition, the culture history model of the Lower Salmon River Canyon, and Çatalhöyük, an archaeology site that has been known for its longstanding use of digital technology, I would like to demonstrate the need for using digital technology in paleo Indian archaeology sites. In the Pacific Northwest, we need more research and new methods in order to answer what cultural tradition first subsisted in the Pacific Northwest. Even when we look at a specific area such as the Lower Salmon River Canyon, we need to use new digital methods to accurately analyze lithic technology and correctly place these technological traditions in the proper chronological order. Çatalhöyük, which has used digital methods in their excavation and analysis is a great example of how using digital methods can efficiently improve how we learn about early peoples.

**Theoretical Framework**

Archaeology requires a well thought out plan in the excavation and analysis process. This plan is heavily influenced by a theoretical framework that develops a method for interpretation and execution. Oregon State University uses more of a technological and scientific approach in the interpretation of archaeological data at Cooper’s Ferry. That is why for this thesis I have chosen to use both processual and behavioral theories to guide my methodologies and interpretation.

Processual archaeology was pioneered by Lewis Binford in the early 1960’s. This theory stated that the research goals of archaeology should be the same as anthropology. The field of
archaeology should try to answer holistic questions about the complex systems of cultures. To do this, the scientific methods along with a wide variety of other scientific disciplines are implemented into archaeological research. Binford has said “we cannot dig up a social system or ideology” (218). What archaeologists can dig up are artifacts that become key clues to answering social system and ideological questions (Binford 1962:218-224). Culture-Historical theory examines artifacts at face value that only allows us to place the artifact in space and time (Trigger 2006: 205-206). By splitting artifacts into the functional classes of technomic, sociotechnic, and ideotechnic, archaeologists can reconstruct the ideology of past cultures (Binford 1962:218). This supports the need for implementing such theories as behavioral archaeology and environmental archaeology.

Behavioral archaeology studies the relationship between artifacts and human behavior. This can be seen in the context of artifacts in the archaeological record. Behavioral archaeology seeks to explain the evolution of human societies. This includes the changes in the technology and social structure (Schiffer 2004:579-580). At Cooper’s Ferry, Unit A yielded pit feature two, which contained 13 stone tools. This suggests that someone purposefully placed a tool kit of sorts with the intention of returning. The context of these artifacts in this case can tell us as much about early peoples than the actual artifacts can.

Processual theory guides Oregon State University and the Cooper's Ferry Project. The Cooper’s Ferry Projects seeks to explain the environmental and behavioral factors that have led to a long occupation of Western Stem tradition Paleo Indians in the Lower Salmon River Canyon around 13,000 years ago. The Cooper's Ferry site has a major emphasis on geology as the site contains well stratified sediment layers that reveal effects the local geology has had on the
development of the site itself. Oregon State University is a consistent leader in the sciences and has developed the Pacific Slope Archaeology laboratory which houses a wide variety of digital three dimensional technologies that assist in the analysis of archaeology sites. The Cooper's Ferry project is also partially funded by the Bureau of Land Management, which has a focus on public engagement in archaeology. The uses of newer three dimensional technologies along with the constant release of YouTube videos documenting the project, engage the public and increase interest in archaeology.

The use of digital technology at Cooper’s Ferry creates a detailed record of all artifacts, artifact context and the site as a whole. By digitally collecting and compiling this information, archaeologists can recreate three dimensional models of artifacts and specific units. These three dimensional digital models help provide an accurate model of what the site looked like when it was inhabited by humans. When artifacts are laser scanned and 3D printed, it allows archaeologists to looks in micro detail which can expose new information regarding behavioral use and function. Oregon State University's dedication to using new three dimensional recordation and replication technologies for the Cooper's Ferry project makes the use of processual theory logical for this thesis. As I seek to answer how implementing three dimensional technologies can improve Paleo Indian research, I will be using a processual archaeology approach to support my argument.
Methods

In order to adequately answer my question of how new digital methods of recordation and replication will help us understand early prehistoric sites, I conducted extensive research and field work at the Cooper's Ferry site in Western Idaho. My field work was completed over the course of eight weeks in the hot desert canyon of the lower Salmon River. This project was conducted in 2015 under the direction of Dr. Loren Davis of Oregon State University and in accordance with the Bureau of Land Management and the Nez Perce tribe.

Prior to attending this field project, I explored the findings from past field seasons at Cooper's Ferry. I also found it necessary to examine the regional prehistory of human occupation in the Pacific Northwest to understand cultural and behavioral similarities. The Cooper's Ferry Archaeology Project is one of a few sites to implement new digital methods such as 3D printers, scanners, Total Stations, and on site cataloging equipment that aid in excavation and artifact analysis. During this project, I was able to use some of these digital methods, so it was imperative that I understood how they worked and how they can be applied to a working archaeology site. Oregon State University uses 3D laser scanners and 3D printers to better examine the projectile points and bifaces found at the site. By scanning an artifact into a computer, the user is able to zoom in to see percussion marks to better understand how the artifact was made. The 3D printer will then create a replica of the projectile point that anyone will be able to handle and possibly identify how early people’s might have used it. Oregon State also uses 3D scanning cameras that create a topographical 3D model of the ground, and macro photography that shows in detail cross sections of lithostratigraphy to preserve the context of the artifact. This essentially preserves the site as I found it even though further excavation has destroyed the artifacts’ original context. The
use of 3D technology enables the ability to preserve and share the site with other researchers who have not visited the site.

In the field, over the course of eight weeks, I excavated a two by two meter unit in Area A. I used skim shoveling techniques to excavate certain areas down to the goal level. I also used toweling techniques to excavate around krotovina and artifacts in a more precise manner. During the excavation process when I unearthed an artifact or map krotovina, I used a Total Station to record precise coordinates that were later entered into the Geographic Information System program. I also used the Total Station to take elevations and create reading numbers. To further record artifacts, sediment samples, and krotovina, I used ARCHIE, a wireless cataloging system that was developed specifically for the Cooper's Ferry Project. This system connects with GIS to digitally recreate the original context of each level. Archie also gives each artifact and soil sample a unique QR code that automatically links smart phones to the artifact catalog. I also used digital cameras to record artifacts and krotovina in their original context along with recording the end of a level. At the end of the level, I processed the sediment from the level through both a 1/8th and 1/16th inch metal screen. This was to ensure that all cultural material was collected. Throughout the project, I used multiple tools to aid in excavation. These included trowels, shovels, sediment sifters, wheelbarrows, sculpting tools, paint brushes, digital camera, laptops and the Total Station. All of these tools and methods aided in the safe recovery of important Paleo Indian tools and refuse.

During my experience living in a very historic region of western Idaho, I also conducted research about the regional geology and Nez Perce cultural history. I visited the Nez Perce Cultural Center and participated in setting up a traditional Nez Perce teepee and observed other artifacts found in the local region. I heard many oral histories from the tribe and of the area we were
excavating. Dr. Loren Davis provided me with an opportunity to conduct experimental archaeology with throwing atlatls and stone knapping during down time. I deemed it very important to understand how early people hunted in this area. I made my own atlatl out of wood, Salmon River green stone, and sinew. I also learned how early humans in the area knapped Western Stemmed projectile points out of local materials such as crypto-crystalline silicates and basalt. While living in the canyon, I read some of Dr. Davis's past work on the Cooper's Ferry Site and of other sites in the Salmon River canyon. These included an updated culture history model (Davis 2001), an analysis of occupation and migration patterns (Davis et al. 2012), and the use of oxygen isotopes in river muscle shells to determine past climate conditions (Davis and Muehlenbachs 2001). I wanted to fully understand the cultural, behavioral and environmental conditions that led to the occupation of Cooper's Ferry, thus many forms of research were essential.

**Digital Technology**

New digital technology not only serves to preserve archaeological sites, but will hopefully shed new light, and answer new questions that were previously unanswerable due to technological constraints. In this section, I will provide a detailed description of each form of digital technology being used to preserve and analyze at the Cooper's Ferry site. This includes describing what the technology is, how it works, and how it is benefiting the research project.

**3D Laser Scanning**

Three dimensional lasers scanners have the ability to digitally map and record lithic, organic, and faunal artifacts. When artifacts are completely excavated and cataloged, they are put in a three dimensional laser scanner (Oregonstate.edu 2016). A series of laser beams is
projected on the artifact, which is on a rotating pedestal. As the beams play over the artifact, the light is reflected back into a sensor that records the elevations of each detail (see Figure 2). Once the artifact completes several revolutions, a full three dimensional model is created in a computer. These models can be rotated in the computer to view every detail of the artifact (see Figure 3) (Boehler et al. 2002). This data can be sent to a 3D printer that will create a physical replica out of plastic. Oregon State University uses a NextEngine 3D scanner. According the NextEngine web site, their laser scanner costs $2,295 with the option for various software programs costing more. Although costly, three dimensional laser scanners provide the best way to preserve artifacts by way of a digital media. The NextEngine Scanner is accurate to 0.0025 inches (NextEngine.com 2016). Viewing a digital scan of an artifact, archaeologists can study artifacts in fine detail with the option to zoom in. This

Figure 2. NextEngine laser scanner scanning a biface (Oregonstate.edu)

Figure 3. Left is a 3D computer generated model created by a 3D scanner of the projectile point which is located on the right (Tang 2016).
reduces the amount of time researchers physically handle the real artifact thus preserving it for museums or further research. Scanning artifacts also allows additional research to be done by archaeologists in other geographical locations around the globe.

3D Printing

Three dimensional printing has been around since 1986 but commercial use has not become available till very recently (Lipson and Kurman 2013:38). Three dimensional printing uses a 3D laser scan and creates a physical object using a ductile material such as heated plastic or metal. An injector extrudes a filament of the desired material in a layered fashion, constructing millimeter thin layers one at a time (see Figure 4) (Lipson and Kurman 2013:11). This process is repeated till an object is completely finished. Oregon State University uses a Maker Bot Replicator 2 that according to the Maker Bot Company costs $2,889 (MakerBot.com 2016). This technology allows archaeologists to make accurate, museum quality replicas of artifacts. In fact many museums, such as the Metropolitan Museum of Art, are using 3D printers to print artifacts and art pieces for patrons to touch and experience (Undeen 2013). These replicas allow archaeologists to analyze artifacts without risk of damaging the artifact. Although artifact curation is a cautious process, artifacts can still become damaged from consistent handling. One of the best ways of understanding lithic tools and how they were used is to pick them up and examine how they feel in the hand. Also, archaeology is a collective effort. The
insights of multiple archaeologists can provide new, invaluable analysis of one specific site or artifact. After a site's collection is stored away or displayed in a museum, access to that artifact is fairly limited. With 3D laser scanning technology and 3D printing, archaeologists can print and physically handle the artifact without having access to a site's collection or be geographically nearby the site. Archaeologists now can study a site's artifacts from anywhere in the world.

Total Station

The Total Station is a digital theodolite that measures geographical distance in X, Y, and Z planes. Total Stations have replaced the theodolite telescope and line level for recording the location of an artifact, feature, or krotovina. The Total Station uses an electronic distance meter that discharges a laser at a retro reflector posted on top of a staff placed in the location of an artifact, feature, or krotovina. The laser beam is reflected back to the Total Station where the sensor determines depth, distance, and horizontal position in geographical space. Once the Total Station has recorded the measurements, it can generate a recall number that will assist in the cataloging process. The Total Station contains a memory that records all measurement points taken; these are downloaded into a program known as geographic information system and mapped. Prior to the emergence of the Total Station, the theodolite telescope and line level were used to measure key objects. That process relied heavily on human knowledge and, consequently was vulnerable to human error. The Total Station is accurate to the millimeter and allows for more efficient measurement and recording (McPherron 2005: 1004-1006).
GIS

Geographic information system is a digital system designed to compile, store, and analyze spatial geographical data (Esri.com 2016 A). GIS allows archaeologists to see patterns in artifact distribution as well as create a rudimentary three dimensional model of a site or unit. GIS was developed for plotting geographic data in Canada (Wheatley and Gillings 2002). Now GIS is used all over the world to compile data for many different fields. For Archaeology, GIS records and plots locations of artifacts and features. Recently, GIS has been applied to analysis of the artifacts themselves. Loren Davis and colleagues at the Pacific Slope Archaeology Laboratory have started to make 3D scans of artifacts and input the scans into GIS. This process, called GIS-based Lithic Morphometric Research (GlîMR), uses the 3D scan from a biface and treats the biface as an island land mass (see Figure 5). Any stone knapped into a biface has characteristics that resemble those of a land mass. Flake scars resemble drainage basins from mountains or hills. The sharpened edge of a biface resembles an island shore line. GlîMR uses algorithms and elevation data from the projectile point to distinguish each and every flake scar present on the biface. The 3D scan and GIS allows archaeologists to see trends in the biface manufacture process by examining the angle and shape of
these flake scars. These trends can be compared among other known bifaces, and can determine if one artifact has any connection with other known artifacts based on how the artifact was made (Davis et al. 2015 A: 200-203).

**Digital Artifact Cataloging**

The traditional method for cataloging artifacts, screening material, and sediment samples in the field typically involves filling out a series of cataloging forms which are entered into a computer program at a later date. Through some ingenuity and advanced computer systems, OSU has developed a way to digitally catalog artifacts at the site, thus removing the need for tedious paper work. At Cooper's Ferry, Oregon State University uses a system entitled ARCHIE, which creates a wireless network that is transmitted from one central computer. This enables the use of laptops that can access the ARCHIE cataloging website. Once an artifact is completely excavated and mapped with the Total Station, that artifact can then be cataloged using the ARCHIE system. This system uses a series of drop down windows that accurately describe the artifact. The recall number from the Total Station is used as an artifact ID and enables its location to be synced into the system. The digital photographs of the artifact can also be instantaneously uploaded at the time of cataloging. The cataloging process ends with the printing of a QR code that travels with the artifact. This QR code allows students and staff the ability to immediately bring up all information documented on that object by the use of a smart phone camera (Nyers and Vollmer 2016).

Using the Archie System, artifacts, krotovina, sediment samples, and screening materials are cataloged at the site shortly after they are excavated. This limits the amount of
error that can occur because the same team excavates and inputs the data. Errors are caught quickly and corrected. This would be less likely if cataloging was to take place outside the excavation site and input by students or staff not involved with the excavation process. The ARCHIE system also compiles all of the information found at the site. Using a digital open source cataloging system like ARHIE compiles not only data collected from artifacts and levels, but also multimedia such as photographs, three dimensional scans, and video production.

*Videography*

Archaeology can use a whole array of digital technology to analyze and preserve the site along with the artifacts found there, but these same technologies that I have listed above fail to capture the excavation process and experience. The Cooper's Ferry research project has introduced an answer to this dilemma. Along with archaeology students and professionals, this project employs a full time videography staff that documents the excavation through video production. They conduct interviews, capture the day to day excavation activities, and develop informative and interesting videos that are posted online for public viewing. These videos capture the excavation experience and allow the public to gain a broader knowledge of archaeology as a whole as well as understanding the importance of the research being conducted. The videography team is also responsible for documenting the excavation process through a series of *GoPro* cameras. These cameras are placed above the site and take pictures every 10 seconds (Wilcox and Kmiecik 2015). This enables a time lapse to be constructed and allows archaeologists to review the photographs from when an important artifact or feature is found.
Cost

Although the technology I have discussed is exciting and adds valuable opportunities for advancing research, it also comes at a cost. I have included a breakdown of costs (see Figure 6) that describes the general price ranges for the technologies being used at the Cooper’s Ferry project. It is easy to see that by implementing these technologies the cost adds up quickly. For projects that may not have abundant monetary resources, it is important to fully understand the benefits these pieces of technology can bring. The key question is why should projects spend this much money to implement these technologies into their excavation and analysis? In the next section I will outline the benefits of each piece of technology in more detail.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Next Engine 3D scanner (NextEngine 3D Laser Scanner 2016)</td>
<td>$2,295</td>
</tr>
<tr>
<td>MakerBot 2 Replicator (MakerBot.com 2016)</td>
<td>$2,289</td>
</tr>
<tr>
<td>Total Station (Allen Precision Equipment 2016)</td>
<td>$2,000-$6,000</td>
</tr>
<tr>
<td>GIS (Esri.com 2016 B)</td>
<td>$2000-$7000</td>
</tr>
<tr>
<td>GoPro Cameras (GoPro.com)</td>
<td>$399</td>
</tr>
<tr>
<td>Videographers</td>
<td>Paid Position</td>
</tr>
<tr>
<td>ARCHIE (Nyers and Vollmer 2016)</td>
<td>Free</td>
</tr>
</tbody>
</table>

*Figure 6. A cost break down of technology used at the Cooper’s Ferry project*
Results

As archaeologists and scientists, we have an ethical responsibility to understand the most we can about the early peoples we study. The Cooper's Ferry site, which seeks to explain the cultural and behavioral factors that led to the long standing occupation of Western Stemmed culture in the Lower Salmon River Canyon, demonstrates the need for implementing new digital technology (Davis 2001:241-242). Using digital replication and recordation methods will improve what we know about the behavioral conditions of Western Stemmed peoples as well as improving the entire excavation and preservation process.

The Cooper's Ferry site dates to around 11,410 B.P, earlier than any of written record, and creates a challenge in understanding the behavior of early peoples (Davis and Schweger 2004:702). The Nez Perce who possibly descend from Western Stem people have provided some insights from their oral histories, but another way to fully understand the behavior of these early Americans is to examine the artifacts they left behind. Three dimensional laser scanning permits us to examine artifacts in great detail. One of the best identifiers of a culture is to examine the technology they used and their construction methods for how they were made. Because tool making is a behavior that is passed on from generation, to generation, it is important for archaeologists to study the lithic artifacts found at Paleo Indian sites like Cooper's Ferry. Laser scans produce accurate digital models of artifacts allowing the analyst to zoom in on percussion marks and pressure flake scars. We can also measure the angle at which the flake was removed. These scans can be run through editing programs such as *Mesh lab* or *Adobe Illustrator* to highlight and distinguish flake scars, percussion platforms, and other key elements of lithic technology. These measurements accurate within 0.0025 of an inch and are more
accurate than the traditional analog method of using calipers (NextEngine 3D Laser Scanner 2016). This process of 3D scanning can also be used on faunal remains to look for human modification elements. By using 3D scans to examine flake scars and percussion marks, identifying human modification features can be easily seen in the computer rendering (Davis et al. 2014). Laser scans can also be put into GIS such as the GLiMR program. Using GIS can measure the individual elevations of lithic tools and can compare the lithic tool against a data base of similar tools. Potentially, this technology can help us identify lithic artifacts that were made by the same person or same groups of people (Davis et al. 2015: 200-203 A).

Laser scans and GIS allow archaeologists to see a virtual, detailed model of an artifact. For the sake of preservation, research cannot always use the artifact for analysis due to the danger of the artifact becoming damaged. Three dimensional printing I believe can provide a solution to this problem. Although a 3D printer cannot print in the same material as lithic artifacts, it can produce an exceptionally accurate copy. These replicas can be used in place of the real artifact and can be handled without the danger of artifact damage. Three dimensional printers also have the ability to print objects at an enlarged size. This can emphasize flake scars and striking platforms which can educate archaeologists how the lithic artifact was made. A common find at sites like Cooper’s Ferry is debitage that is created during the stone knapping process. Most of these flakes have little importance because they lack further human modification, but there are larger flakes that exhibit use or modification. In the field it is very difficult to differentiate between large pieces of debitage and flakes that have been modified or utilized. By laser scanning and printing these large flakes we can enlarge the possible beveled edge or use marks.
3D laser scanning and 3D printing offer a new advantage in that they make artifacts more accessible to more people. By scanning artifacts, we create a digital version of that artifact which can then be sent anywhere in the world via the internet. A digital catalog of 3D scanned artifacts can be looked at in detail by researchers who would not normally be able visit the site or the artifact collection. Access to a 3D scan also means that anyone can create a 3D artifact replica if they have a 3D printer. The ability to send artifacts around the world digitally allows more people to study and provide different interpretations to archaeology sites, hopefully building a larger knowledge base about a specific culture or archaeology site.

3D laser scanning and printing is a great tool for analyzing artifacts. The Cooper’s Ferry project uses several other pieces of digital technology that help us preserve and analyze the site itself such as the Total Station. The Total Station is accurate up to about two to three millimeters to 1 kilometer (Nikon 2016). Its use of lasers and its on board computer can process geospatial information instantaneously. This makes recording geospatial data of artifact locations, and mapping features much easier and faster. The geospatial data recorded by the Total Station can be automatically uploaded to GIS, which can display the data visually. GIS can visually show artifact distributions on X, Y, and Z planes as well as the mapped features like krotovina, and pit features. This creates an accurate 3D model of the entire site that preserves the original context of each level.

The use of the ARCHIE cataloging system has streamlined the cataloging process for the Cooper’s Ferry project. By digitally cataloging artifacts shortly after they are excavated, the chance for cataloging error goes down due to the lack of tedious cataloging forms as well as the cataloging being present at the site. During my experience at the project, there were many
times where we were able to correct a cataloging error by checking the level or the artifact right at the site. The ARCHIE system also creates a user friendly experience by compiling all data in one digital program. All of the geospatial data, pictures, videos, and sediment samples’ data are all in one space where all information can be accessed at once. All artifacts and sediment samples are also given QR codes which can be scanned from any smart phone. These features all make this type of cataloging program ideal for large scale archaeology projects that contain large artifact assemblages.

In conclusion, these replication and recordation technologies have an immense positive impact on Paleo Indian archaeology sites. In my analysis of all of these technologies, I have developed five key answers to why current and future Paleo Indian archaeology sites should implement these newer replication and recordation technologies. First, these new technologies preserve the integrity of all artifacts and levels of the site. Archaeology is a destructive science and by using digital technology we are preserving the site as a whole forever on a digital format, which allows archaeologists to visit the digital site when the project concludes. Second, by using such technologies as the 3D scanner and printer, archaeologists can examine artifacts from around the world without actually traveling to the site or the institutions where the artifact collection is held. This allows more archaeologists and students to study sites that would not normally be available to them. Third, these technologies are more accurate than their analog counterparts. 3D laser scans and the use of a Total Station almost eliminate the chance for human error when taking measurements. Fourth, Advancements in these technologies have enabled us to gain a better understanding of human behavior. 3D printing allows us to physically handle artifacts much like the creator of the artifact did when it was
made. The new development of GLiMR allows us to digitally reconstruct and destruct bifaces, which can shed new information on how the artifact was made and by what groups of people. Lastly, I believe that archaeologists are indeed scientists who have an ethical responsibility to learn as much as we can about the people we study. Our ancestors have the right to have their story told, and for others to learn about them. By adopting some of these new replication and recordation methods, we are not only better preserving history but we are actually able to learn more as well.

Conclusion

Archaeologists will continue to study the past, but that does not mean that our methods should remain in the past as well. The field of archaeology should be on the cutting edge of the future. In this thesis, I have described the Cooper’s Ferry project, the advanced replication and recordation technologies used at the site, and provided detailed explanations of how these new technologies improve the preservation and analysis of Paleo Indian archaeology sites. These results, I believe, give a compelling argument that technology is not a hindrance to archaeology but a benefit to research. By examining sites like the Cooper’s Ferry project, it is easily seen how the addition of replication and recordation technologies can not only improve the excavation, preservation, and analysis process, but allow archaeologists to learn information that was previously inaccessible. Although these technologies have a high monetary cost associated with them, the benefits they can provide are priceless. This paper is written as a call to action for the field of archaeology. Archaeology as a scientific discipline should embrace new developments in technology as they are developed, and experiment with how they can be used to improve our traditional methods. I believe that by incorporating newer digital technologies
into our methodology, archaeologists can become better story tellers who can transcend history for present and future generations.
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