THESIS

DEAD TREES DO TELL TALES: INVESTIGATIONS INTO THE ROLE OF FIRES ON THE LOCATION AND RECOGNITION OF ARCHAEOLOGICAL SITES IN THE PINEY CREEK DRAINAGE OF THE GREATER YELLOWSTONE ECOSYSTEM

Submitted by

Abraham Kvale Thompson

Department of Anthropology

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Master's Committee:

Advisor: Lawrence C. Todd

Jason M. LaBelle
Jason S. Sibold
Peter M. Brown
Robert O. Coleman

ABSTRACT

DEAD TREES DO TELL TALES: INVESTIGATIONS INTO THE ROLE OF FIRES ON THE LOCATION AND RECOGNITION OF ARCHAEOLOGICAL SITES IN THE PINEY CREEK DRAINAGE OF THE GREATER YELLOWSTONE ECOSYSTEM

The discovery and documentation of an archaeological site is dependent on three conditions. First, that people in the past left something behind; second, that those materials preserved; finally, that location is observed and documented by a researcher. Fires impact all three. Past fires would have interacted with available resources and caused changes to local and regional geomorphologic processes (conditions one and two). Perishable artifacts can be burned and destroyed in the heat of a fire. Even durable items such as projectile points can be modified by heat fracturing, spalling, and potlidding (condition two). Modern fires substantially increase the efficiency of the discovery and surface documentation of this material (condition three).

During the summer of 2006, a large stand replacing fire, the Little Venus Fire (LVF), burned 14,164 ha acres of the Greybull River Drainage in Northwestern Wyoming. Under the burn were hundreds of archaeological sites that had been recorded before the LVF burned. After the fire, most of the reexamined sites revealed a wealth of new cultural material and added a previously undocumented Protohistoric record to this region.

Fire scars on the whitebark pines in the Piney Creek Drainage in the Shoshone National Forest of Northwestern Wyoming show evidence of past fires. Crossdating these fire scars to tree ring samples from this drainage showed when this drainage burned in the past. Multiple fire scars dated to 1648. Temporally diagnostic artifacts including obsidian tri-notched projectile points, metal arrow points, and trade beads, as well as radiocarbon samples taken from processed bison bone, suggest that humans were present in this drainage in the years surrounding this fire. This research examines impacts of fires on both the resources available to prehistoric humans, and to research conducted by present-day archaeologists.

ACKNOWLEDGMENTS

Top three slots on my thank you list include; Larry Todd, thermal spalls, and lime flavored gin. Together, these three pulled me toward archaeology. Together these three have been my mentors, adventurers, and friends. They’ve all taught me much and it was honestly a test of their combined wills to pull me through the thesis process. Through knowledge diffusion during my time with Larry in the mountains of the Upper Greybull, I learned some of his knowledge on how to turn modern patterns in the physical world into digestible datasets. Early in my career I was diagnosed with what experts (Larry Todd) have called “Academic ADD.” Archaeology was prescribed because of the broad spectrum of potential interconnected research projects. Interpreting the past is a detective story and all patterns surrounding archaeological material have absorbing stories to tell. Larry taught me how to turn my easily excitable distractibility into a passion for asking interdisciplinary questions. All his carful edits, thoughts and comments helped mold this thesis into a readable document.

Larry Todd and Becky Thomas gave me a home though many field seasons, between field seasons, winters, and summers. Over the course of my academic career, their friendship is responsible for my love of the Upper Greybull and my tolerance and of spicy foods. I can’t thank them enough.

Sarah Millonig. Words can’t express how I came to love the words “you need to just finish the damn thing.” They’re still music to my ears. In all seriousness, I wouldn’t have finished this without you. When I was unsure or couldn’t see the end, you were there for me. You pushed when I questioned myself, and comforted when I drove myself. Your patience, kindness, edits, and support have been tremendous. You've watched me struggle, un-focus, falter, refocus, push, and eventually succeed.

Jason LaBelle, I cannot thank enough for attempting to keep me on topic. For years now I've been rushing into his office mumbling some tangentially grand idea about this thesis. His response is simply to remind me there was a thing such as graduation and I should eventually start to think about it. Jason kept me realistic. Without his guidance I would still be trying to connect tree ring patterns and the urgency for interstellar space travel.

I could not have learned dendrochronology without the help of Peter Brown. Lab, field, class, home, Peter has been welcoming with supplies, answers, jokes, and information. Jason Sibold introduced me to the spatial analyst tool bar. My life hasn't been the same since. Thanks to Rocky Coleman for being easy to talk to and interested in this research. I appreciate all theirs thoughtful comments, support, and guidance provided by my committee.

As with most things in my life, I lucked out. I have a job where I get to do archaeology and I have the privilege to work with great people. My boss, Nicole Branton deserves special thanks. Not all employees have sick days, vacation days, and thesis days. She also wrote Appendix D with me and guided me through how to make archaeology a career. Additionally, she helped me to recognize when additional words are not needed. I'm still working on removing them. Marcy Reiser has been my academic sibling and her support and enthusiasm about my research has been invaluable.

When I had question about research, needed to borrow a microscope for a weekend (or many months), she was always more than happy to help.

My family (including my surrogate brothers Clay Hunt and Chris Organ) deserves more than a “thanks” for standing with me; they deserve my adoration. For years I’ve been out of cell phone range, distracted during visits, too tired to talk long, missing on holidays, forgetful of birthdays, and broke from student loans. Whenever I have had the chance to float back to the world for a home meal my family has always welcomed me with a hug and a smile. Chris has spent hours with me chatting about research, statistics, and writing. His support has been invaluable. Clay is my best friend and partner in crime. He’s helped me find the best distractions. Bike tours, road trips, weddings, gaming, and taekwondo are included in the list of adventures that have kept us from finishing degrees. However, his faith in me has never faltered.

Finally, I apologize for not being able to name them all, but each “Toddler” who has ever marked a waypoint deserves my gratitude and respect.

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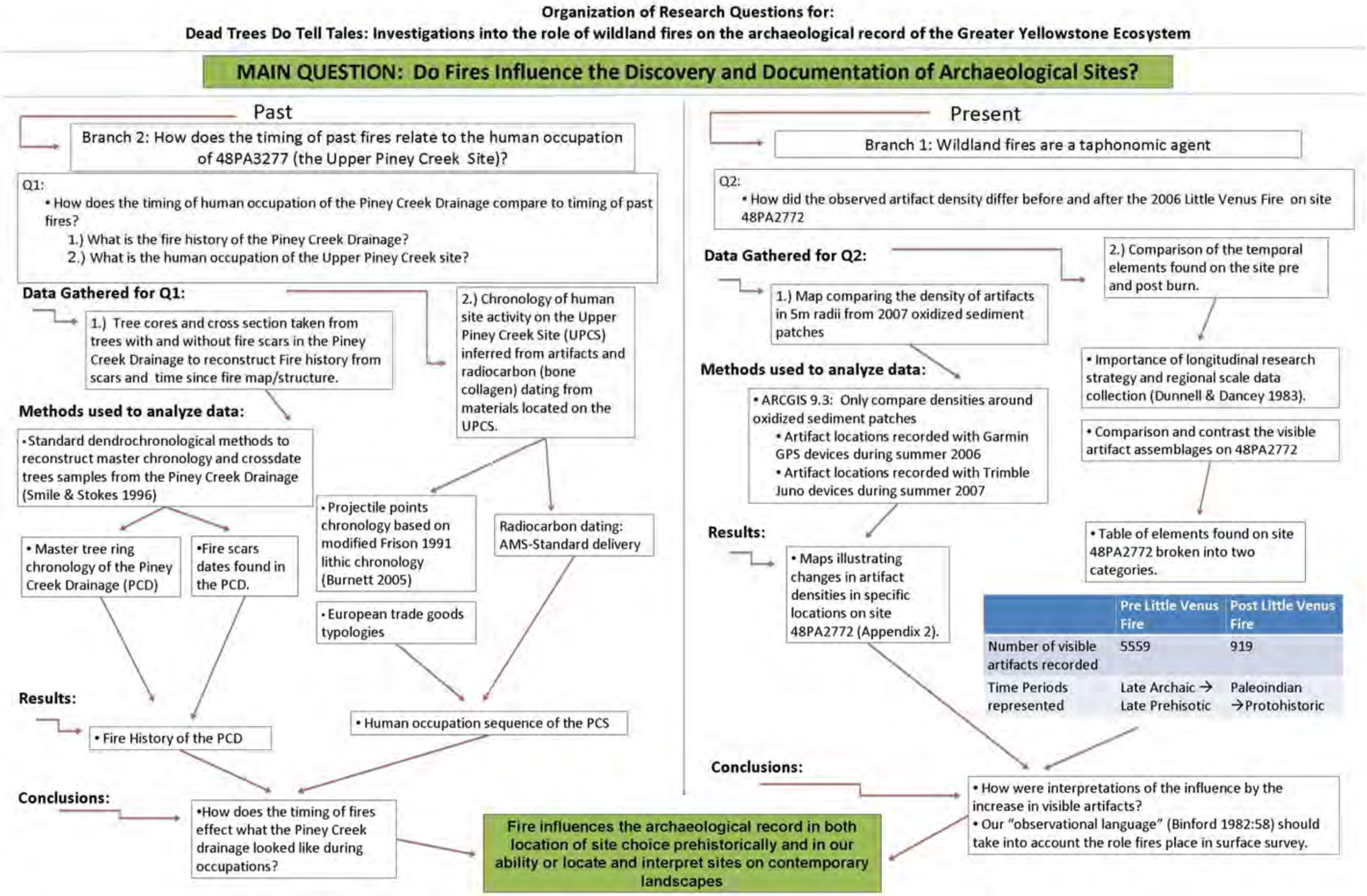
CHAPTER 1: TWO THINGS WE LEARN FROM FIRE

This thesis asks one question, “Do fires influence the discovery and documentation of archaeological sites?” The simple answer is yes. The complicated answer comprises the body of this thesis.

How Fires Affect Archaeological Site Location and Recognition

There are three ways in which fires affect the formation and finding of archaeological sites. The impacts of fire not only affected past people, but they also influence what we document in the present. For prehistoric people living across a landscape, fires and the aftermath of fires would have affected local resources. Fires would influence resources available to past humans and in turn how those people positioned themselves across the landscape. In this respect, fire plays a role in forming the archaeological record. For archaeologists, fire affects our capacity to find and record cultural material across a landscape. Modern fires can play a key role in our ability to recognize and document the archaeological record.

Figure 1.1 is a model of the main question asked by this research. This figure serves as a framework for both basic research and interpretations. As stated, this topic is a simple yes or no question. Yet the breadth it could encompass is overwhelming and exciting. Like most intellectual curiosities, there is the dangerous potential of quickly compounded complexity. However, this research tried to take this topic and narrow it to something simple and digestible. Figure 1.1 not only describes the research, but it also focuses (and more importantly limits) the main question into two branches. These branches represent the impacts of fire in the past (Branch 1) and how fires interact with the archaeological record on modern landscapes (Branch 2). Both of these branches examine the environmental conditions surrounding fires at the two temporal extremes in the life of an artifact.



Organization of Research Questions for:
Dead Trees Do Tell Tales: Investigations into the role of wildland fires on the archaeological record of the Greater Yellowstone Ecosystem

MAIN QUESTION: Do Fires Influence the Discovery and Documentation of Archaeological Sites?

Past

Branch 2: How does the timing of past fires relate to the human occupation of 48PA3277 (the Upper Piney Creek Site)?

Q1:
- How does the timing of human occupation of the Piney Creek Drainage compare to timing of past fires?
  1.) What is the fire history of the Piney Creek Drainage?
  2.) What is the human occupation of the Upper Piney Creek site?

Data Gathered for Q1:

1.) Tree cores and cross section taken from trees with and without fire scars in the Piney Creek Drainage to reconstruct Fire history from scars and time since fire map/structure.

2.) Chronology of human site activity on the Upper Piney Creek Site (UPCS) inferred from artifacts and radiocarbon (bone collagen) dating from materials located on the UPCS.

Methods used to analyze data:

- Standard dendrochronological methods to reconstruct master chronology and crossdate trees samples from the Piney Creek Drainage (Smile & Stokes 1996)

- Projectile points chronology based on modified Frison 1991 lithic chronology (Burnett 2005)
- European trade goods typologies

Radiocarbon dating: AMS-Standard delivery

- Master tree ring chronology of the Piney Creek Drainage (PCD)
- Fire scars dates found in the PCD.

Results:

- Fire History of the PCD
- Human occupation sequence of the PCS

Conclusions:

- How does the timing of fires effect what the Piney Creek drainage looked like during occupations?

Present

Branch 1: Wildland fires are a taphonomic agent

Q2:
- How did the observed artifact density differ before and after the 2006 Little Venus Fire on site 48PA2772

Data Gathered for Q2:

1.) Map comparing the density of artifacts in 5m radii from 2007 oxidized sediment patches

2.) Comparison of the temporal elements found on the site pre and post burn.

Methods used to analyze data:

- ARCGIS 9.3: Only compare densities around oxidized sediment patches
  - Artifact locations recorded with Garmin GPS devices during summer 2006
  - Artifact locations recorded with Trimble Juno devices during summer 2007

- Importance of longitudinal research strategy and regional scale data collection (Dunnell & Dancey 1983).
- Comparison and contrast the visible artifact assemblages on 48PA2772

Results:

- Maps illustrating changes in artifact densities in specific locations on site 48PA2772 (Appendix 2).

- Table of elements found on site 48PA2772 broken into two categories.

	Pre Little Venus Fire	Post Little Venus Fire
Number of visible artifacts recorded	5559	919
Time Periods represented	Late Archaic → Late Prehisotic	Paleoindian →Protohistoric

Conclusions:

- How were interpretations of the influence by the increase in visible artifacts?
- Our "observational language" (Binford 1982:58) should take into account the role fires place in surface survey.

Fire influences the archaeological record in both location of site choice prehistorically and in our ability or locate and interpret sites on contemporary landscapes

Figure 1.1. Model of research questions and design.

Branch 1 follows the right side of Figure 1.1 and deals with the present. Because artifacts are part of the modern landscapes, the present (modern) fires are interacting with those landscapes and affecting the archaeological materials. For landscapes and artifacts, fire is a taphonomic process. Taphonomy is the “science and laws of embedding” (Efremov 1940:93). One main focus of taphonomic research, is to study processes that deposit materials “from the biosphere to the lithosphere or geological record,” (Lyman 1994:1). In basic terms, taphonomic processes are ever changing depositional forces that affect how materials came to reside in their current locations. These processes can act on the small-scale (roots interacting with the orientation of small flakes) to large-scales (landscape scale events including stand replacing fires, mass wasting events, or glaciers).

Fire, for example, affects how landscapes change through time and, in turn, how archaeologists come to view the materials within that setting. Since there are many examples of sites impacted by fire in the GRSLE project area, Q2 asks how fire influenced one site (48PA2772) using two sources of information: (1) artifact densities; did they change after the site burned? (2) Temporally diagnostic artifacts; were there proportionately more temporally diagnostic artifacts found after the fire than before the fire? The methods and results for Q2 are simple comparisons using locational data gathered for the material on the site. The goal of Branch 2 is to develop conclusions about whether there was a meaningful difference after the fire and what that difference could mean for finding, documenting, and interpreting archaeological sites.

The left side of Figure 1.1 (Branch 2) shows how dates where derived for when past fires burned across the Piney Creek Drainage and compares those dates to when people were using the Upper Piney Creek Site (UPCS). Since trees and humans are two separate species, they need separate dating methods. The two questions in the Q1 box speak to two types of dating scales. First, dating past fires with fire scars needs to begin with using the trees to build a chronology. Comparing fire scars to this chronology allows researchers to know the year a fire burned. Second, radiocarbon dating processed bison bone associated with the archaeological material on the UPCS provides a date range for the use of this site. In other words, trees provide dates at the annual scale and radiocarbon samples at the decadal to century scale. The conclusions and interpretations at the bottom of the model bring together these two scales of information to answer whether fires would have affected the available resources for past people, and how modern fires can help archaeologists make present-day interpretations about past actions.

When conducting archaeological survey, it is logical to assume that there is greater visibility on ground surfaces after the vegetation burns. It is, however, more complicated finding methods to explain and represent the types of information present-day archaeologists can record. For example, there may have been costs (increase runoff in streams, decrease in edible plant material, breathing increased levels of dust and ash, etc.) and benefits (increased ungulate grazing, cleared viewsheds, open trails for travel, etc.) to prehistoric populations living in either a pre or postfire environment. Those interpretations are very hard to surmise from artifacts alone. Fire history, however can help analyze the environmental conditions before or after a fire and aid archaeologists in reconstructing what resources would have been available. According to Williams (2000) Native Americans would use fire as a hunting practice to drive game such as deer and elk. Also, Williams (2000) notes burning a landscape will often promote the growth of grasses and other vegetation. This technique would have been a prehistoric “Range

Management" strategy that increased game predictability. However, there are obvious disadvantages to living in an environment while it is burning. The behavior of the Little Venus Fire, in terms of damages caused and unpredictability of the burn even to trained firefighting personnel (Petrili 2006), are examples of the hazards of large fires.

The types of fires that typify environments can vary. These different fires impact the local environment in various ways. It is important to keep in mind the variability in the behavior of modern fires when comparing them to past fires. Variation in fires (such as seasonal timing, size, severity, and spread) impacts the local and region landscapes differently. Each influences the resources available to humans. Large-scale fires can cause increases in erosion (Wondzell and King 2003) and link to mass wasting events and other large geomorphic processes (Meyers et al. 1995; Ollie 2008). These unstable landscapes, created immediately following large stand replacing fires, would have posed a greater risk to people traveling in this area. However, at a broader temporal scale, they can create ponds, open areas to different types of vegetation, and increase overall biotic diversity across a landscape (Ollie 2008:111).

Further, understanding where and how intense fires will burn increases the knowledge potential to archaeological research in predicting the most efficient "bang for your buck" survey areas (Burnett and Todd 2009). Burning away the surface vegetation increases the efficiency during surface documentation of archaeological material (Burnett and Todd 2009; Todd et al. 2009). More material exposed on the surface means more data archaeologists have to interpret the patterns left by past humans at the landscape scale. Before further discussion of these influences, an important definition needs to be made about exactly how this thesis will view fires and how important they have been throughout the course of human prehistory.

The Role of Fire in Human Evolution

Humans and fire share a relationship that reaches deep into the human evolutionary past (Alperson 2008; Conedera et al. 2009:555; Pausas and Keeley 2009; Wiener et al. 1998). No part of our lives is exempt from the benefits provided by the warmth and energy released from a flame. Regretfully, it is beyond the scope of this investigation to discuss the breadth and depth of this relationship. However, a significant point needs to be kept in mind to contextualize the important role fire has played; fire has been at the center of human evolution (Burton 2009; Wrangham 2009; Wrangham et al. 1999, James 1989). Whether the result was an increase in the melatonin in the brain of hominids that helped initial human socialization (Burton 2009) or providing protection and digestion ease on the ground and out of the trees (Wrangham 2009), fire has burned alongside the human evolutionary past. However, fire has not been a driving force, nor has it been a mechanism for natural selection. Rather, for the past million and a half years (Pause and Keeley 2009) humans have warmed themselves with the benefits fire has provided. Fire gave humans an opportunity to change their diet and the benefits of that change influenced the evolution of our body structures (Wrangham et al. 1999). Fire also helped create an atmosphere conducive to our social evolution (Burton 2009; Pause and Keeley 2009:597). Early on (in terms of human evolution), the fire’s versatility secured it as one of “the most important extrasomatic technologies” (James 1989:1). This tool helped to open cold environments to the influx of human migrations (Sauer 1950). The earliest human economies are, what Carl O. Sauer (1950) refers to as, fire economies.

Later (in terms of human evolution) humans and fire have maintained this relationship up to and throughout the Holocene (Sauer 1950). Humans, in a way, were one of the main sources of ecological evolution and used fire as a tool to bring about "deep and lasting modifications in what we call 'natural vegetation'" (Sauer 1950:19). Examples of this come from pre-Columbian Native American populations in California (Keeley 2002). Here, fire was used to maintain shrublands and maximize their resource output (Keeley 2002:311). Further, Native Americans of the southern Appalachians implemented management strategies to burn selected areas while excluding others (Delcourt and Delcourt 1997:1013; Delcourt et al. 1998:276). Humans have used fires at small scales (light, cooking, security) and humans have used fires on large scales (slash and burn agriculture, forest management, warfare; Sauer 1950).

From an archaeological perspective, understanding the impact of fires across a landscape helps to understand what the impact or benefit would have been for the past people whom shared that landscape. This thesis will focus on one example of how fire would have impacted a prehistoric population of humans (the Mountain Shoshone) living in Northwestern Wyoming. However, this thesis will not examine the impact of fire on human evolution. Nor will it seek to understand the role of humans within historical fire regimes. Rather, this investigation will examine how one past fire might have influenced the resource availability of whitebark pine nuts, bison (*Bison bison),* and big horn sheep (*Ovis canadensis*) to Native Americans living in what is now known as the Piney Creek drainage during the Late Prehistoric and Protohistoric.

The large Protohistoric site (48PA3277, the Upper Piney Creek Site) lies within the Piney Creek Drainage (PCD). At this site are a diversity of artifacts, features, and faunal remains. In 2006, this site was burned by the Little Venus Fire. That fire, combined with the archaeological fieldwork in this area, created an exciting chance to integrate research between archaeological questions and dendroecological methods. This situation opened the door to understand how the Little Venus Fire related to the historical fire regime for the Piney Creek Drainage and how fires would have impacted past plant, animal, and human communities.

Perfect Research Setting

Fires are landscape phenomenon (Baker 2009:1; Bowman et al. 2009; Falk et al. 2011). This thesis will not examine the influence of individual features and hearths at a specific archaeological site. Rather I seek to address themes of the Greybull River Sustainable Landscape Ecology Project (GRSLE) and treat this process (fire) as a large scale, landscape event. Keeping with the theme of *landscape taphonomy* defined by Todd et al. (2004) as a “complex, evolving, and integrated set of cultural, biological, climatological, chemical and geological processes,” I examine the impact of fires as being part of this system of processes.

Since 2002, the GRSLE project has conducted archaeological research the Upper Greybull Watershed (Reiser 2010). This area is one of the most remote areas of the Greater Yellowstone Ecosystem (GYE) (Burnett 2005; Todd 2008). Figure 1.2 shows the location of this research area.

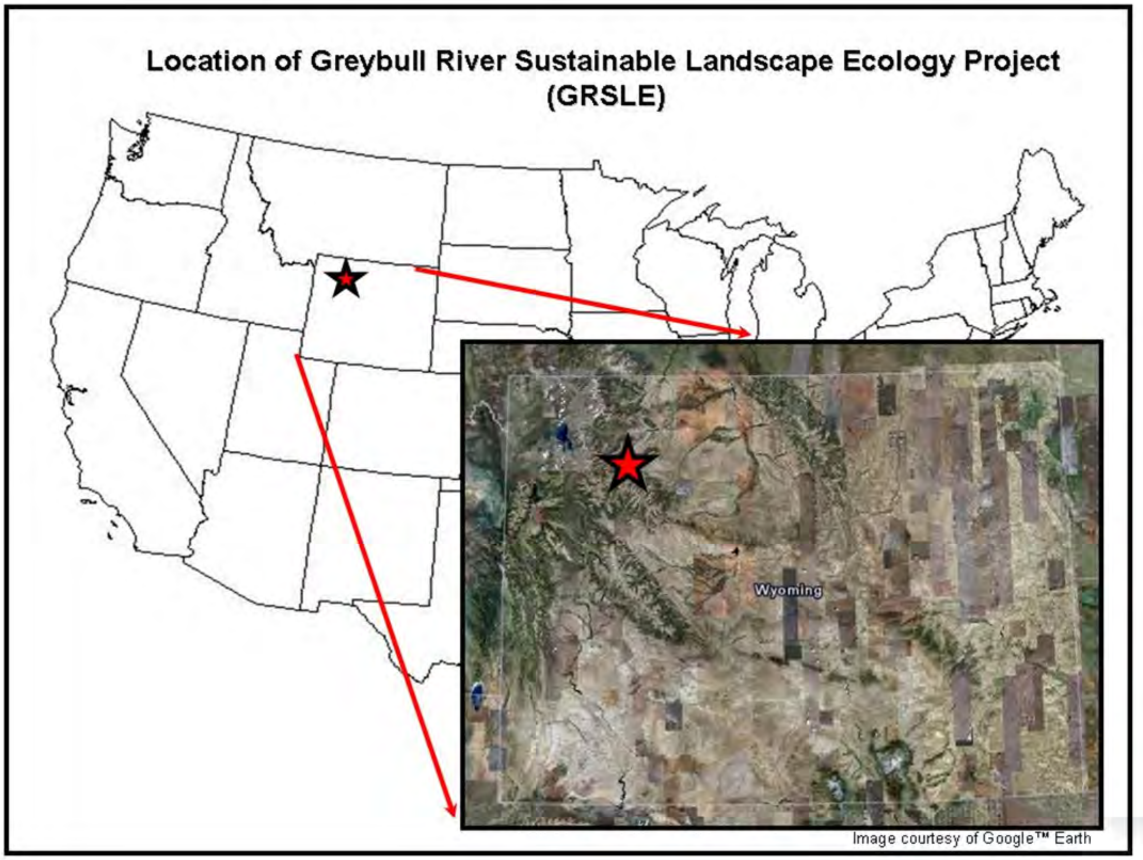


Figure 1.2. GRLSE (Greybull River Sustainable Landscape Ecology) project area located near the northwest corner of Wyoming. Image courtesy of Google™ Earth.

Over the past 9 years (2002-2011), the GRSLE project, (see www.greybull.org) has recorded over 400 archaeological sites ranging from 2190 to 3382 meters above sea level in the Shoshone, Owl Creek, Wind River, and Greybull River drainages of central western Wyoming (Reiser 2010; Todd 2008). The mean elevation for chipped stone artifacts recorded is slightly above 2800 (Todd 2008). This places the majority of the GRSLE sites within the subalpine zone. Within the larger Greybull River drainage, the trees sampled to construct the fire history for the Piney Creek Drainage fall within 2500 to 2800m in elevation. Both the trees and the artifacts from this area are sources of data that help identify past events in this region. Archaeologists can never go back in time. They can never see through the eyes of people that lived during the past. They can, however, reconstruct what was happening in an ecosystem when the past people where living there. Dendrochronological methods serve to reconstruct how past patterns and processes affected tree growth and development (Parish et al. 1999; Schweingruber 1993). At the same time, dendrochronology can be used to reconstruct those same patterns and processes that were acting and interacting with humans. The trees of the Piney Creek Drainage used for this analysis were five needle pine species, whitebark pine (*Pinus albicaulis)* and limber pine (*Pinus flexilis).* Many of those samples extend back several hundred years, and the oldest tree sampled dates back to 1493CE. Fortuitously, the archaeological record for this area exhibits sites with occupations from the later Late Prehistoric and Protohistoric periods. Using these two forms of proxy data (archaeological dating techniques and fire history methods) allowed for a multidisciplinary examination of the relationship between humans and fires in the Piney Creek Drainage.

Setting the Stage: The Little Venus Fire

In the summer of 2006, the high intensity, high severity Little Venus Fire (LVF) consumed nearly 14164 ha in the Greybull River Drainage on the east side of the Shoshone National Forest in northwestern Wyoming (Todd et al. 2009). It is important to understand the role the LVF played in this ecosystem. If fires today are to be used as examples of past events, they have to be first understood in modern contexts. Questions such as; “what are the factors promoting fires today?” and “Do fires today act differently than past fires?” have to be kept in mind.

When interpreting the connections between archaeological research and fire histories (as with any other type of multidisciplinary study) variability and complexity in both pattern and process must be understood before inferences can be made discerning interactions between processes. Human behaviors are very complex; environmental and social forces are often intricately woven into cultural processes and are often seemingly impossible to separate. With trees, and the fires that burn them, processes can be somewhat simpler to tease apart.

Fire in many ecosystems has served as a keystone ecological and evolutionary process (Falk 2006; Mutch 1970; Schwilk and Ackerly 2001; Whitlock et al. 2003). Fire, as a disturbance, varies in its effects to certain ecosystems. In lower elevation stands, such as those dominated by ponderosa pine (*Pinus ponderosa*), anthropogenic factors including practices of suppression and grazing have altered the fuel compositions for these forests and introduced a crown fire regime to a system previously dominated by a surface fire regime (Allen et al. 2002; Brown et al. 1999; Keane et al. 2007). Surface fire regimes are typified by a high frequency of low intensity fires (Swetnam 1993). Evidence for these types of fire regimes often comes from low elevation stands exhibiting a “large number of trees with multiple fire scars” (Falk 2006:143). Further evidence from ethnographic accounts illustrates that Native Americans frequently set fires for a variety of reasons (Anderson and Moratto 1996). In areas such as costal redwood forest, fires were controlled and cultivated by humans. Their burning practices were an integral part of the ecology of those forests (Brown and Baxter 2003). Together, these types of data support the idea that lower elevation forests were typified by frequent, low intensity surface fires. Two factors have contributed to decline in fire frequency in lower elevation forests (Sherriff et al. 2001). First, fire suppression has caused changes to the fuel compositions by not allowing understory vegetation to burn; thereby creating dense, fuel choked forests. Second, in some areas, the lack of Native American burning practices has taken away a potentially vital, frequent ignition source (Sherriff et al. 2001).

In contrast, low frequency, high severity fire regimes kill trees by burning through the canopy and reaching the tree tops (or crowns), or by spreading high intensity fires across the ground surface. Large fires such as these are referred to as stand replacing events (Schoennagel et al. 2004). High elevation stands have been adapted to a high intensity, crown fire regime (Allen et al. 2002; Schoennagel et al. 2004; Sherriff et al. 2001). Unlike lower elevation forests, such as those dominated by ponderosa pine and giant sequoias, crown fire regimes are within the historic range of variability for these types of stands (Sherriff et al. 2001). The fact that suppression activities have not played as large a role in altering the fire regimes in subalpine settings does not mean human activities do not have the potential to cause an impact. Fires in high elevation, subalpine forests, are more often driven by climate than the accumulation of fuels from recent fire suppression efforts. Modern anthropogenic emissions are continuing to alter the climate on a global scale to what will fall outside the historic range of variability for these ecosystems (Flannigan et al. 2000; Gillett et al. 2004). The changes caused by global warming are impacting forest disturbance regimes, including fires (Dale et al. 2001). Due to the recent severity and extent of the Mountains Pine Beetle epidemic, the forests of North American and Canada may have very limited potential to offset anthropogenic CO_2

emissions (Kurz et al. 2008). Alterations to global climatic patterns have the potential to expose subalpine forests to climatic changes outside their historic environmental averages (Amiro et al. 2001). Future climate change models predict that Canadian Boreal forests could see average temperatures increase by as much as 5˚C and precipitation, in western area of the forest, could decrease by an average of 20% (Amiro et al. 2001: 408). These factors will create an area highly conducive to large scale fire disturbance events that have the potential to create a positive feedback loop with anthropogenically induced global climate change and carbon levels (Amiro et al. 2001). The initial large scale burns will release carbon dioxide adding to the temperature induced increases in fire conditions while decreasing the availability of forests to act as a carbon sinks (Amiro et al. 2001).

Climate can be shown to effect fire on smaller, more specific regions (Westerling et al. 2006), but synchrony of fires can occur across broader temporal and spatial scales (Kitzberger et al. 2007). Increased droughts and temperatures lengthen the fire season in western U.S. forests, specifically in the Northern Rockies (Westerling et al. 2006). Forests of the Northern Rockies are generally located in mid to high elevations and their fire regimes have not been fundamentally altered by fire suppression efforts (Westerling et al. 2006). However, in the years 1987-2003, areas of the Northern Rockies experienced an increase in average temperatures by 0.87˚C when compared to the average temperatures from 1970-1986 (Westerling et al. 2006: 940-941). Fire frequency in these areas during the 1987-2003 was four times greater than the average for 1970-1986 (Westerling et al. 2006). The relatively small increase in temperature [when compared to the 5˚C increase described by Amiro et al. (2001)] was enough to increase the fire frequency in areas of the Northern Rockies hitting hardest in those areas centered around 2130 meters in elevation (Westerling et al. 2006). This elevation falls within the elevational spectra of the GRSLE project sites.

The LVF was ignited by a lightning strike on June 19, 2006 at 1736 and discovered on June 23rd after burning its first estimated 40 ha (Petrili 2006:36). According to the Case Review, *Little Venus Fire Shoshone National Forest WY-SHF-09* (CRLVF 2006), burning and smoldering continued until the fire was declared out on October 31, 2006. The course of the fire spread through the summer can be seen in Figure 1.3.

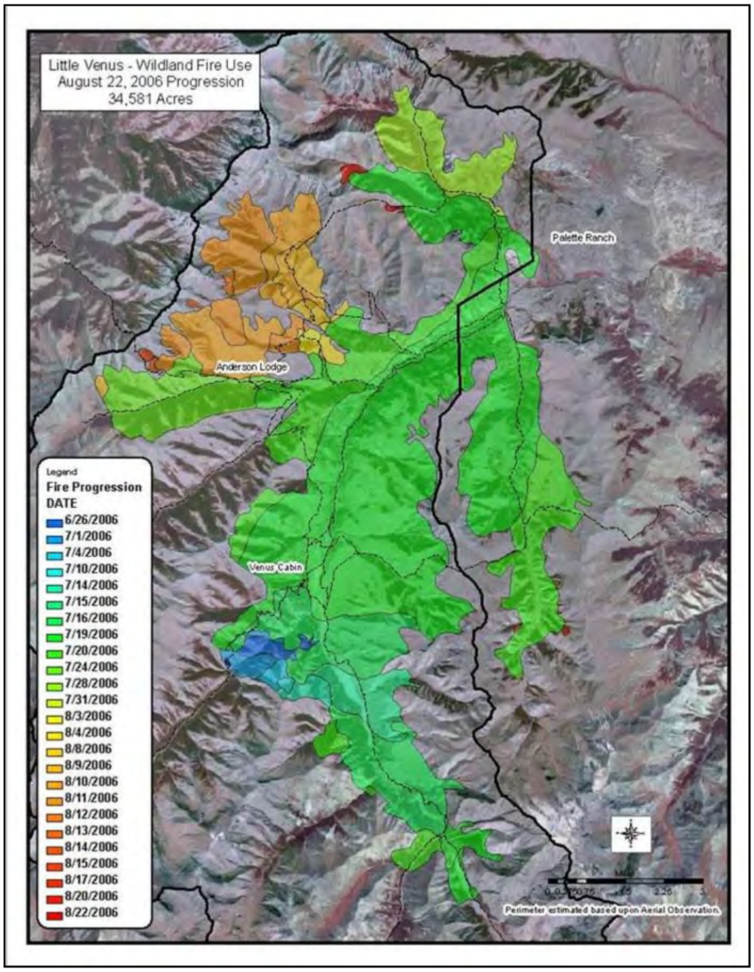


Figure 1.3. Spread of the Little Venus Fire (LVF) through the summer of 2006. This Image was adopted from the 2006 Case Review, Little Venus Fire Shoshone National Forest WY-SHF-09.

Through the course of the summer, the LVF was a high elevation stand replacing event. Many factors contributed to the spread and intensity of this fire. During the early weeks of July 2006 periodic rains and light winds had kept the rate of fire spread low. However, beginning on July 13th, dryer weather helped the LVF increase in size and severity (Petrili 2006:7). Though weather forecasts predicted the return of cooler and wetter conditions in the 3-5 days following July 13th, the opposite happened when the humidity decreased and the temperature increased (Petrili 2006:9).

GRSLE crews were conducting field research until they were advised to leave camp on July 17th. On July 18th, difficulties with radio communication between fire personnel and a shift in the wind lead to the entrapment of 10 firefighters while en route to de-brief and alternate crews (Petrili 2006:3-4). The weather report for July 18th issued a red flag warning because of a cool pressure system approaching. This pressure system was to bring strong winds to this area (CRLVF 2006; Petrili 2006:10-11). Those 10 firefighters were forced to deploy fire shelters and shown in Figure 1.4

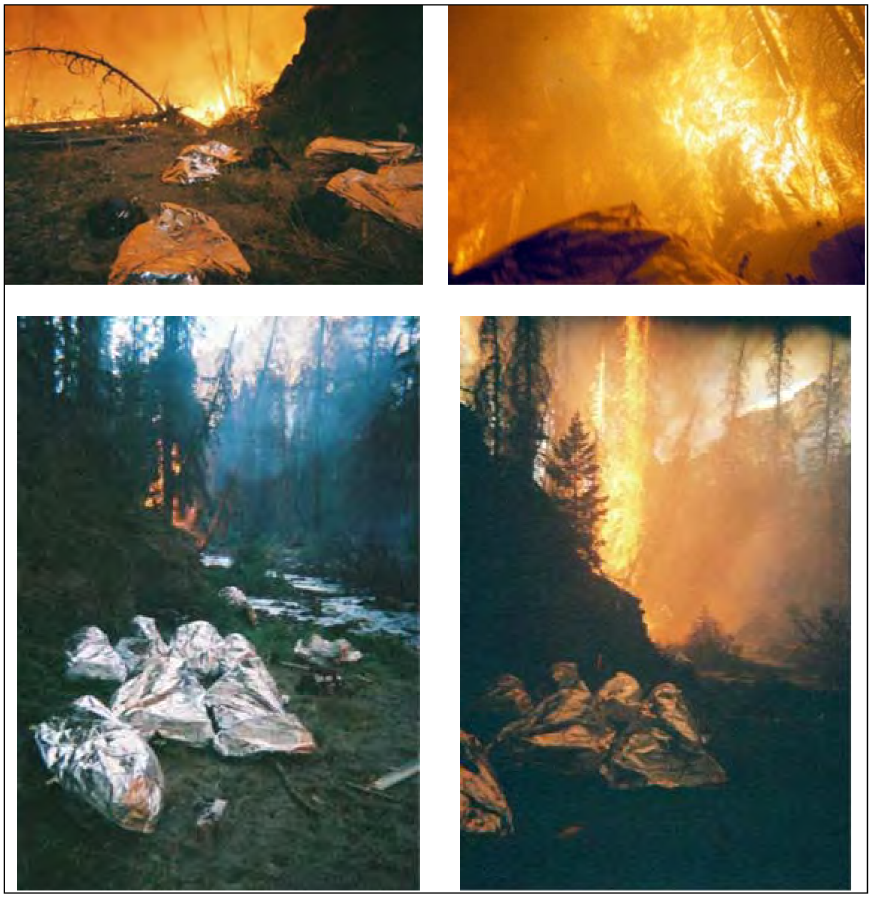


Figure 1.4. Deployment of fire shelters by firefighters during the LVF. Images taken from the 2006 Peer reviewed report, Little Venus Fire Shelter Deployment.

By the 19th of July the weather conditions helped the fire spread to 8350 ha (CRLVF 2006). Through the remaining weeks of summer the spread of the LVF slowed and the perimeter of the fire is began to be maintained with a combination of bucket drops and “natural outs” in the sage/grass areas (CRLVF 2006; Petrili 2006:18). An initial post-fire archaeological reconnaissance to assess the impacts of the LVF to the archaeological resources was completed in September (Todd 2006). The burning and smoldering continued though August and into October. On October 31, 2006, the fire was declared out (CRLVF 2006).

Since both the Washakie Wilderness is an area approved for wildland fire use (WFU) and the LVF was a naturally ignited event, the fire was managed as a WFU (Petrili 2006:5-6). WFU was first supported in National Park Service policy in 1968 (Kilgore 2007:102). Today, WFU is used in areas (including the Washakie Wilderness) where fire is recognized to play a natural role in that ecosystem. One of the main practices within WFU areas is to let the fire burn in hopes of promoting the healthy relations between fires and those ecosystems that thrive with fires. (http://www.nifc.gov/fuels/overview/fireTreatment.html, accessed April 14, 2011). Some of the strategies to protect both the public and their property included the application of fire protective material to several cabins within the Greybull River Drainage (Figure 1.5). There were, however, at least five historic cabins and one wickiup group destroyed during the fire (Lawrence Todd, Personal Communication). Of the nearly 14000 ha burned, only 162 of those were on non United States Forest Service Land (CRLVF 2006).

Figure 1.5. Example of one of the management strategies. The crew seen above is protecting the Venus Cabin from the LVF. This building survived. This image was adopted from the 2006 Case Review, Little Venus Fire Shoshone National Forest WY-SHF-09.

According to CRLVF, the LVF burned through a mixed conifer environment. The area fuels for this fire were increased by trees that had been killed by the Mountain

Pine Beetle epidemic. The majority of the beetle killed trees were Engelmann spruce, but other trees that were impacted and present were lodgepole pine, whitebark pine, and Douglas fir (CRLVF 2006). Beetle infestation in this area had resulted in approximately 50% mortality during 2001-2006 (Petrili 2006:39). The number of beetle killed trees is thought to have increased the fuel loads for this fire (Petrili 2006:39). While these fuel loads made prediction models for the LVF inaccurate (Petrili 2006:39) the historical range of variability for this type of subalpine environment is typified by high intensity stand replacing fire events (Allen et al. 2002; Larson et al 2009; Romme and Turner 2004; Schoennagel et al. 2004; Sherriff et al. 2001; Turner et al. 1994; Walsh 2005). However, the probability is high that the beetle infestation impacted the intensity and severity of the LVF.

While this thesis is not directly examining the role the beetles played in the severity of the LVF it is an interesting side in terms of fire behavior. Further, in using modern fire for a comparison of previous fire, it is important to take into account all of the potential influences to modern fire. Figure 1.6 shows the beetle infected trees (identified by the distinctive bluestain found in beetle killed trees) in relation to those sampled for this thesis research. Whether or not beetle killed trees increased the severity of the LVF, has yet to be determined.

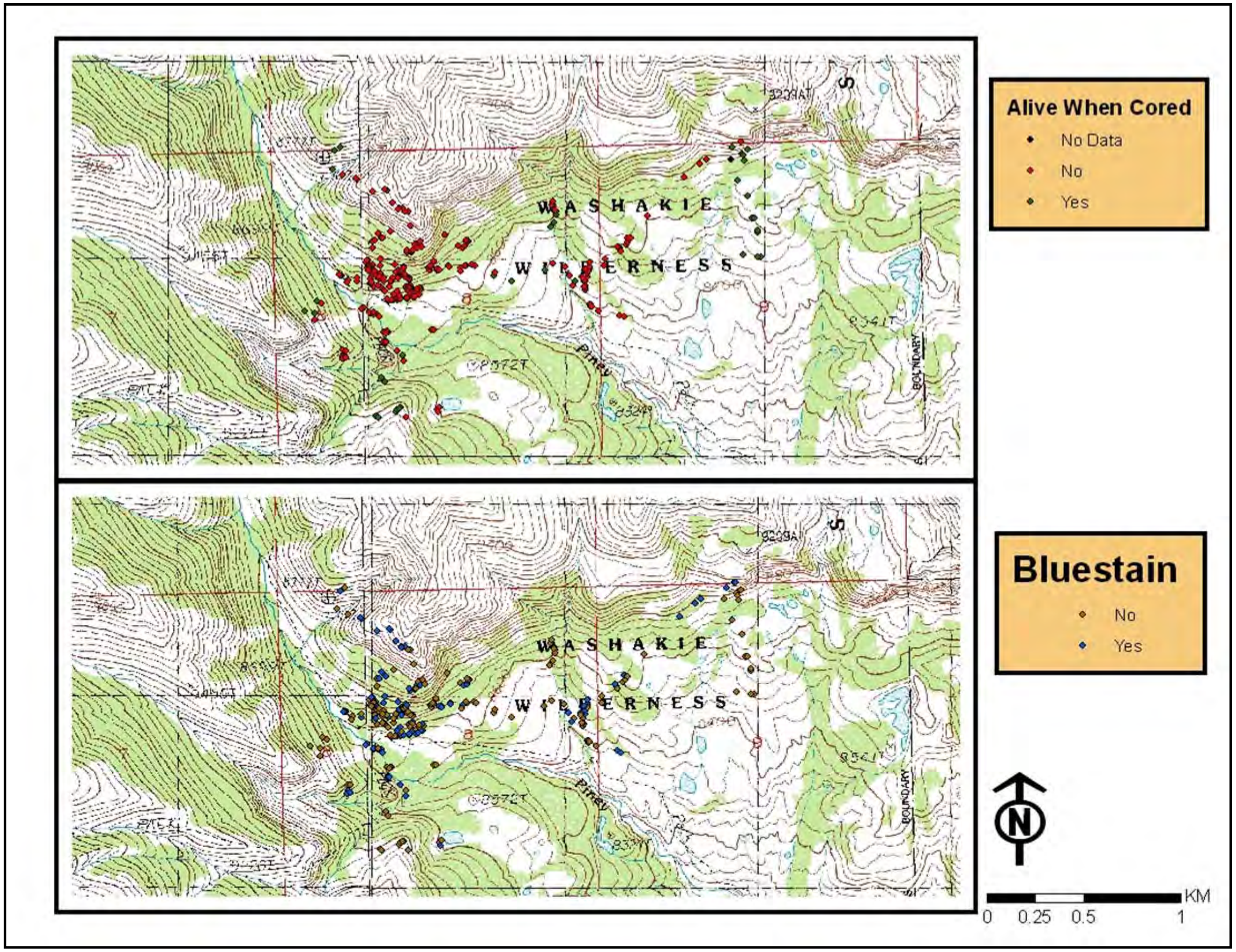


Figure 1.6. Location of all the trees sampled to reconstruct the fire history of the Piney Creek Drainage. Bluestain refers the beetle introduced fungus (*Grosmannia clavigera*) that killed the trees. The green dots represent the trees that still had green needles when sampled. These live specimens were to be used to anchor the tree ring chronology.

Beetles and other factors, such as the blister rust, are decimating a very large portion of the remaining whitebark pine communities (Kendall and Keane 2001; Larson et al. 2009; McDonald and Hoff 2001; Tomback et al. 1993; Walsh 2005). Blister rust, a disease caused by the fungus *Cronartium ribicola,* was first observed in Western North American in 1921 (McDonald and Hoff 2001:198). Identified by the cankers on the trunks and branches, blister rust kills large numbers of whitebark pines. Promoting the relationships between whitebark pine and organisms (specifically Clark's Nutcracker) that help them regenerate is one management strategy that has been suggested to help deal with the impacts of blister rust (Kendall and Keane 2001:237). In areas where blister rust is killing whitebark pines faster than they can regenerate, fire in those stands would burn the infected pines and open the environments into those "suitable for nutcracker caches," (Kendall and Keane 2001:237).

Five needle pines, such as whitebark pines and limber pines, are long lived tree species that, some researchers have postulated, can live and reproduce successfully with a low severity, surface fire regime (Moody 1998:6). However, as a species, whitebark pines thrive with stand replacing fire events. Unlike other types of trees that reproductively benefit from fires, the cones of five needle pines are not serotinous. Rather, the five needle pines rely on other organisms, such as Clark's Nutcracker, to cache and distribute seeds in areas where surface vegetation has been cleared by fire (Tomback et al. 2001:94). This strategy aids the regeneration of whitebark pine after a large stand replacing event (Walsh 2005:4). The Clark's nutcracker prefers to cash nuts in open, burned areas (Lanner 1996; Tomback and Linhart 1990:191; Walsh 2005:4). This corroborates the previously stated ideas that the elevation range of whitebark pine is typified by infrequent high severity fires. Because of these and other reasons, whitebark pine communities are thought to be "one of several fire-dependant forest types," (Arno 2001:84).

The behavior of the LVF was in many ways typical for the type of stand replacing fires that are part of the historic regime for subalpine settings. The spread, severity, and impact of the LVF may have been slightly outside of the historic range of variability for fires in many environments because of factors such as the bark beetle and global climate, but the fires of the past would have been similar in many ways for Shoshone living within the UPC drainage several hundred years ago. Since the mid summer weather and the late autumn snowfall were the driving forces in promoting and eventually ending the fire in 2006, even with the aid of modern suppression efforts, it can be assumed that those would have also been drivers for the fire behavior to past stand replacing fires in this area.

Evidence for Human Occupations Punctuated by Fires

The GRSLE project has extensive evidence to support that people have occupied the Greybull River drainage the past 11,000 radiocarbon years (Burnet 2005:29). Also, there is strong evidence that large fires have burned across this region in the past, and that they have done so within the UPC drainage. The evidence for those past fires comes from the sedimentation of the UPC drainage (Ollie 2008:52). Fires and other disturbances are part of the cycle of landscape change that typifies this region (Knight 1994; Meyer et al. 1995; Ollie 2008). Another site documented by the GRSLE project (48PA2811) was used as the main focus of Ollie's (2008) research. The results of that research linked increase in debris flow to disturbances and landscape phase changes. These phases of landscape change were punctuated by fire events that set the stage for short term mass-wasting events and sedimentation in the areas immediately surrounding the Piney Creek drainage and the site 48PA2811 (Ollie 2008:88-94). During these Panarchial cycles of landscape change, humans were also present and may have witnessed some of them over the course multiple human generations (Berkes and Folke 2002; Ollie 2008:19).

Many of the periods of increased sedimentation in similar areas of Yellowstone have been linked to fire because of the increase in fire debris intermixed in the deposition (Meyer et al. 1995; Ollie 2008). In the Piney Creek drainage, Ollie 2008 found evidence of fire in the debris flows within the cut banks of Piney Creek, near site 48PA2811. These fires happened over the last several thousand years (Ollie 2008:89-92). Also, based on the Late Archaic projectile points found on the site and the Late Prehistoric dates recovered from radiocarbon dates [identified from the charcoal of *Picea engelmannii* in the sediments surrounding the hearth features eroding from the cut bank above Piney Creek (Ollie 2008:72-74)], people too have been occupying this drainage for the past several thousand years.

The research conducted by Ollie (2008) is an example of placing humans in the long term cycle of landscape change through geologic time. Based on the evidence in her research, both humans and fires were part of the landscape history of the Piney Creek drainage. Ollie's broad scale approach helps to understand the interaction between humans and landscapes through the Holocene. My research narrows in on a smaller window of time to understand what the environmental conditions would have been like in the few decades surrounding fire a single disturbance.

Archaeological Spandrel of the Little Venus Fire

Archaeological research has an inherent dualism imbedded in its research methods. We study not only the by-products and proxies of human activity (the faunal, material, and other types of tangible remains left behind), but we also have to understand the range of natural processes that have acted on, moved, and altered those remains (Burger et al. 2008; Behrensmeyer et al. 2000; Lyman 1994; Schiffer 1983; Todd 1983). Often these remains are objects representing activities performed in the past and exist as part of modern landscapes (Todd 2008). From this, archaeologists must understand the range of processes those materials have undergone and survived and the artifact patterns those processes have created (Burger et al. 2008:206; Schiffer 1983:675-676). Archaeology is not only the study of the past, but it is the study of the present. The archaeological records, those data from which we glimpse into the past reside on, in, and as part of components of contemporary landscapes and the contemporary world (Binford 1972:118; Todd 2008). This interaction between the past and present creates a dualism for all archaeological research. Not only do we have to understand the past, but we have to understand the past in the context of the present and how it may have changed through time (Binford 1972).

Gould and Lewontin (1979) introduced the architectural term “spandrels” to evolutionary thought. Spandrels (in architecture) are necessary byproducts of dome and archway construction but serve no architectural function (Gould and Lewontin

1979:147). They are however easels for many great works of art. As murals, their "function" has nothing to do with their construction. Gould and Lewontin (1979) used this idea as a counterpoint to the adaptionist idea that every morphological traits evolved with a function. This thesis views the interaction of fires and humans in very much the same way. The byproducts of fires across landscape have many advantages to the people living in those environments. The role of humans in the ignition, promotion, and management does not have to be functionally understood when interpreting the benefits of fire adapted environments.

One of the byproducts of the LVF was the opportunity to bring the wealth of archeological knowledge (Todd 2008) together with the historical fire regime. The LFV dramatically increased the visibility of surface artifacts throughout the GRSLE project area (Burnett and Todd 2009). Figure 1.7 shows the location of all the GRSLE sites in relation to the boundary the LVF.

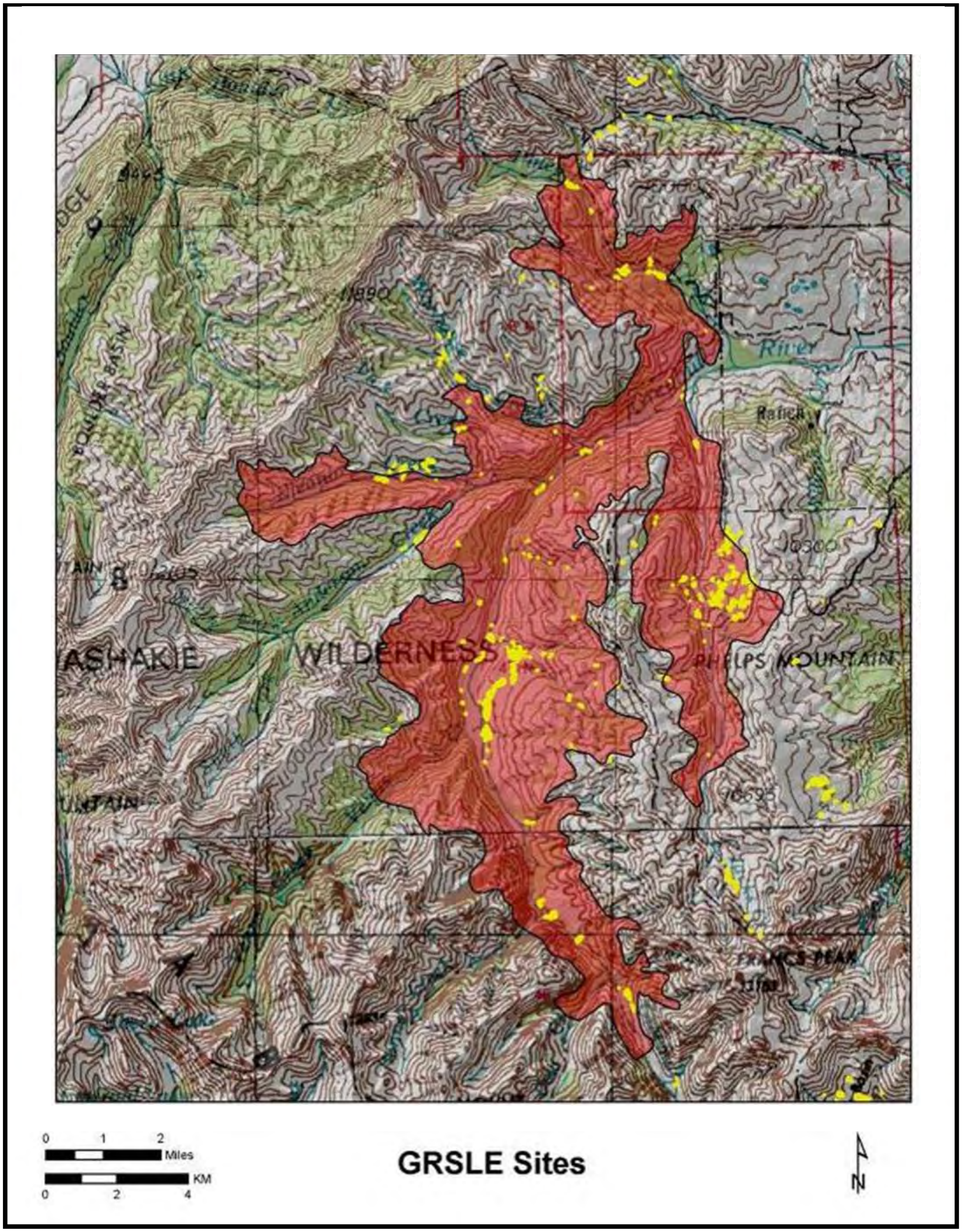


Figure 1.7. Location of the sites documented by the GRSLE project. Yellow, solid shapes are the archaeological sites (representing time periods spanning from the Paleoindian period to the Protohistoric). Red, semi-transparent area is the boundary of the LVF.

Archaeological sites are subject to natural and cultural processes (Burnett and Todd 2009; Derr 2006; Todd et al. 2004). From the initial knapping of a flake, to the measurement of that flake between the calipers a field tech, archaeologists seek to understand the range of processes that took place between initial deposition and site observation. The culmination of these processes is known as the taphonomic record (Burger et al. 2008; Lyman 1994; Schiffer 1983). Within the GRSLE project, Todd and Burnett (2009) compared the pre and post visible assemblages of six sites and found that the number of artifacts observed increased by an average of 1592%. Further, not only did the quantity of material increase but the area of the sites increased by an average of 652% (Reiser 2010:8; Todd 2009). Fire is a taphonomic agent (Derr 2006:71). Given the right set of environmental conditions, a fire can burn through areas, scorching off all vegetative cover, and leave behind an area free from visibility limiting surface vegetation (Todd 2008). This newly uncovered environment drastically increases the amount of information that can be observed during the surface survey and recording of archaeological sites (Burnett and Todd 2009).

Discussion

This chapter discussed how fire will be defined and examined. Fire as a landscape phenomenon interacts with the people that live and have lived on larger landscapes. The benefits of fire have been used by prehistoric humans, but fire can also benefit archaeologists attempting to interpret the record of those prehistoric lives. Fires provide archaeologists with chances to better find archaeology on the modern ground surface. Also fire histories help reconstruct the resources available (whitebark pine nuts, bison, and big horn sheep) to Mountain Shoshone during their occupation of the Upper Piney Creek Site. The following chapters will demonstrate how fires influence the location of archaeological sites in both prehistoric and modern contexts. The LVF and the longitudinal research (studying archaeological sites over multiple seasons) of the GRSLE project serve as the example to examine the interaction of both past and modern fires on the archaeological record.

CHAPTER 2: METHODS OF "HOW ARCHAEOLOGISTS LISTEN TO TREES"

Again, this thesis is asking the question, "Do fires impact the discovery and documentation an archaeological site?" This main question has been broken into two branches to evaluate a specific location:

Branch 1) **How can understanding modern wildfires influence how we interpret archeological sites?**

Branch 2) **How does the timing of past fires relate to the human occupation of 48PA3277 (the Upper Piney Creek Site)?**

This chapter will discuss the methods used in those two branches. Branch 1 relies on a simple comparison using data collected and analyzed through geographic information systems (Arcmap 9.3). The methods for Branch 2 are a combination of general archaeological methods and dendrochronology. For both of these branches, it cannot be overstated how important the GRSLE project's longitudinal research was in gathering these data. Data collected for Branch 1 could not have been gathered during a single field season. Time was invested at the site 48PA277 in the summers, before and after, the fire collecting these data. This branch could not have been evaluated if this site hadn't been documented both pre and post fire. How the site information changed depended on the timings of both recordings. The research presented here only scratches the surface of the wealth of information documented by the GRSLE project.

Interdisciplinary Methods

The "hallmark trait" of archaeological research is the interdisciplinary nature of archaeological investigation (Burger et al. 2008:227; Redman 2005:70). Research conducted as part of the GSRSLE project has sought kept with that theme (Reiser 2010:3). My research sought to capitalize on archaeology's interdisciplinary nature by using tools, methods, and concepts from the fields of archaeology, fire ecology, dendrochronology, and geographic information systems. Because of this, there will be three sets of methods discussed. Those are the general archaeological methods used to describe the occupation of the Upper Piney Creek Site, the GIS and data collection methods used to illustrate how the Little Venus Fire changed the visibility and interpretation of 48PA2772, and the dendrochronological methods used to construct the fire history and fire ecology in the Piney Creek drainage.

Archaeology, dendrochronology, and fire ecology all rely on data sources that develop proximately to the processes they are examining. In other words, they study the remains a given process left behind. All three of these fields seek to answer questions about processes that are difficult or even impossible to directly measure. Dendrochronology for example, examines patterns in growth rings of trees. Those patterns are used to reconstruct when those trees grew (Stokes and Smiley 1968). Growth rings are dependent on outside environmental influences. Trees respond to harsh years (such as drought, injury, or competition) by limiting the amount they grow (Stokes and Smiley 1968). In tough times, the growth rings of the trees will be smaller than average. In years with favorable conditions to growth, the trees respond with larger than average growth rings. Understanding how the growth of a tree varied through time, allows researchers to use patterns of growth rings as stored information about environmental conditions or other outside influences.

A.E. Douglass developed dendrochronology as an indirect or proxy data source to study solar flare activity (Nash 1999:19). This method of dating was immediately recognized by archaeologists (specifically Clark Wissler) as a means to assign calendar dates to sites across the American Southwest (Nash 1999:20). Tree ring patterns have been used by archaeologists in a wide variety of situations to provide indirect dates to archaeological material. This thesis uses of dendrochronology and fire ecology to reconstruct how past fires affected some of the resources for the Mountain Shoshone (the Sheep Eaters).

"Catch and Release Archaeology"

This research could not have been completed without the longitudinal research of the GRSLE project. One of the goals of the GRSLE project is to understand the interactions between the archaeology and the landscapes in a way that keeps the archaeology on that landscape (Todd 2008). The GRSLE project employs a type of archaeological "catch and release," that leaves most artifacts in place (Todd and Burnett 2003). When artifacts are found or relocated in the GRSLE project, locational data are taken for each individual artifact along with an infield analysis. After the infield recording, the artifacts are returned to place. This data collection procedure has been practice by the GRSLE since 2002 (Bechberger 2010; Bohn 2007; Burnett 2005; Derr 2006; Mueller 2007; Reitze 2004; Ollie 2008; Todd and Burnett 2003; Todd 2008). Longitudinal data collection has helped understand the archaeology of this region, across the entire landscape, over time. My research took some of those archaeological data and compared them to the dendrochronological data and placed the human record alongside the fire history record.

Branch 1: Benefits of "Catch and Release Archaeology" to 48PA2772

This section illustrated the benefits of the "catch and releases archaeology." The summer of 2007 was not the first time 48PA2772 was documented by the GRSLE project. In the previous summers (2003-2006), researchers documented the 5538 pieces of chipped stone and several unique items such as a steatite bead and pendent.

After the LFV, the landscape was a patchwork of areas that had been differentially burned (Todd 2006:4). Variables leading to this mosaic pattern of burning (including fuel loads, hill slopes, ground moisture, wind speeds, and other factors) caused the intensity of the LVF to vary in many locations. For example, in certain areas, dense, homogenous fuel loads heavily stoked the fire and allowed it to intensively burn in large sections. The fire would burn across the entire ground surface and all of the vegetative content was completely removed. In areas where the fuel loads were patchy rather than homogenous, the fire either spread above the ground surface through the tree canopies or followed fuels (or the lack thereof) in other directions, and left islands of unburned ground and understory vegetation. Fuel loads, winds, rivers, and hillslopes acted as natural fire breaks and some areas within the larger boundary of the LFV were unburned. This differential burning created a mosaic of burned and unburned ground surfaces (Todd 2006). The ground surface of 48PA2772 was an example of a mosaic ground surface.

Another product of this patchwork of burning was the creation of discrete oxidized sediment patches. These patches were produced as a piece of fuel (such as a stump or fallen log) smoldered for a sufficient amount of time to reach a temperature hot enough to rust (or oxidize) the surrounding sediments. Figure 2.1 is OX112 (oxidized sediment patch 112) that was recorded on 48PA2772.

Figure 2.1. Oxidized sediment patch OX112 from site 48PA2772. Sediment patch was created by the LVF during the summer of 2006. Photograph was taken and the patch was mapped in using GPS technology during CSU’s 2007 archaeological field school. Photo taken by Larry Todd.

These patches are important to archaeological investigations for several reasons. Past analyses have revealed that cultural materials having undergone thermal alteration have not always been the result of direct human activity (Buenger 2003). Thermal alteration not only extends to artifacts that are found on archaeological sites, but discrete patches of oxidized sediment scatter the landscape in post high intensity fire environments; researchers refer to these as "phantom hearths," (Alperson-Afil 2007) or "faux features," (Conner et al. 1989; Johnson 2004). Hypothetically, future depositional events due to increased erosional episodes that follow stand replacing fires could cover these features and, if subsequently excavated, emulate cultural features (Johnson 2004). Figure 2.2 shows the distribution of oxidized sediment patches on sites 48PA2772 and 48PA2776 in relation to all of the artifacts that have been observed on the sites. Both sites where documented before the LVF and both were reexamined after the fire. The 2007 surveys recorded the presence of oxidized sediment patches that had been created by the LVF. If Johnson's (2003) hypothetical depositional events preserve these "phantom hearths" future researchers will have to separate these features from those humanly-created.

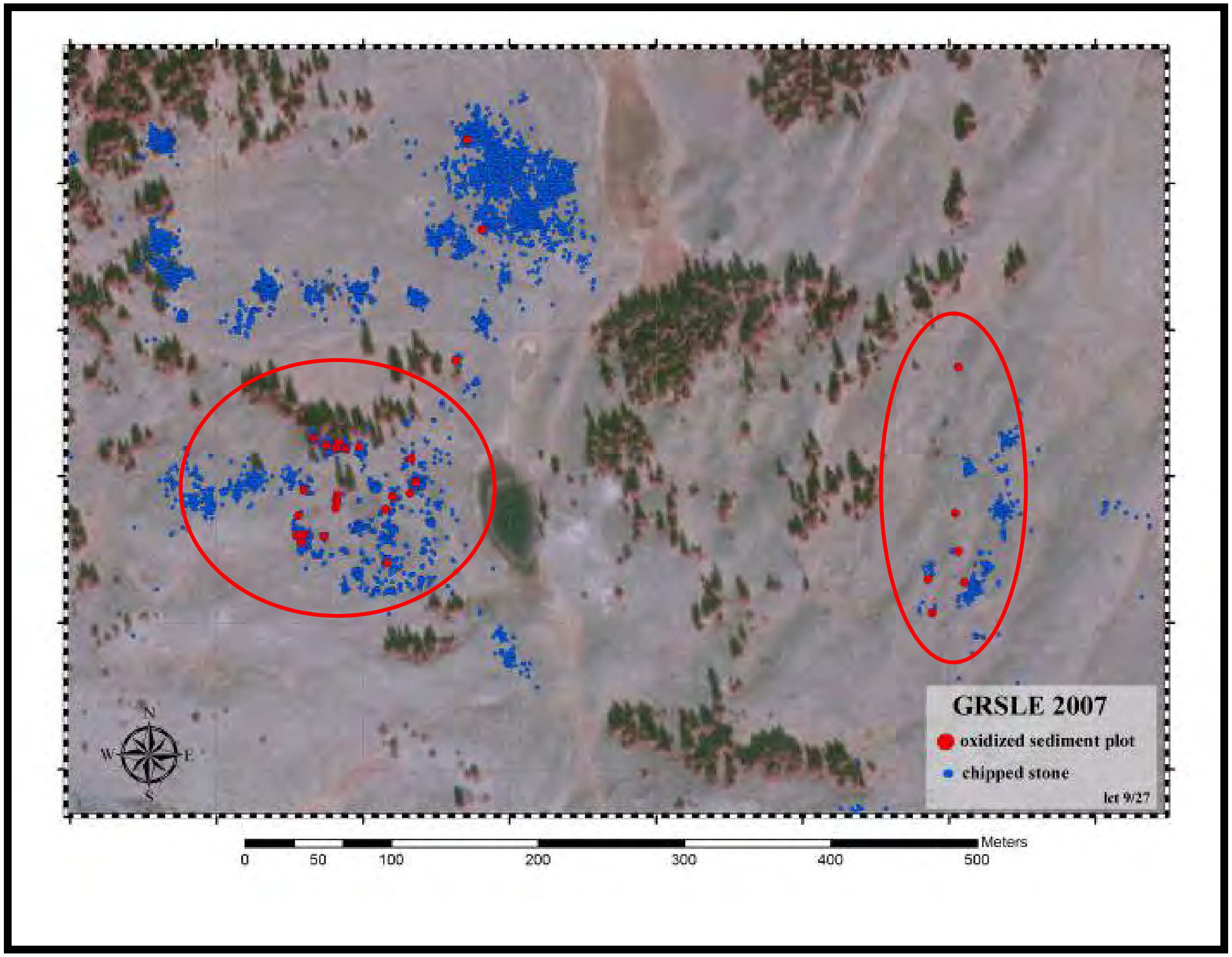


Figure 2.2. Occurrence of oxidized sediment patches on sites 48PA2772 (Left) and 48PA2776 (Right). Data gathered by Colorado State University's archaeological field school during the summer of 2007. Patches were created by the 2006 LVF. Image courtesy of Larry Todd.

Again, holistically understanding the history of an environment will aid in reconstructing interactions between archaeological materials (including features) and past fires in an environment. Hearths can reach temperatures of nearly 600˚C (Bellomo 1993:533) These “phantom hearth” features can be created when sediments are exposed to temperatures above 500˚C (Connor et al. 1989). Areas typified by low, moist fuel loads do not often promote the necessary temperatures. However, as evidenced by the LVF, heat generated during a high intensity, stand replacing fires often reaches these temperatures. Different types of fires have either more or less potential to create these features. By examining what types of fire typify environments; archaeologists can better interpret large fires as a taphonomic agent (Koepsell 2007).

These discrete areas of oxidized sediments also created a unique opportunity to document how a high intensity fire impacts the interpretation of a previously recorded archaeological site (Koepsell 2007; Todd 2008). In 2007, researchers on 48PA2772 used Trimble™ JunoST devices for the infield documentation of artifacts that were within two and five meters of each oxidized sediment patch. Circular areas with the radii of two and five meters were flagged around each patch. Since locational data were recorded on each artifact observed on the surface of the site in 2006, the area within these radii could be used to compare the increase in artifact exposure in the most severely burned areas. Figure 2.3 shows the location of artifacts pre and post LVF, and the distribution of oxidized sediment patches across 48PA2772. These values were used to extrapolate what new information was added to the site as a result of the increase in surface visibility, and how those data changed the interpretation of the site assemblage.

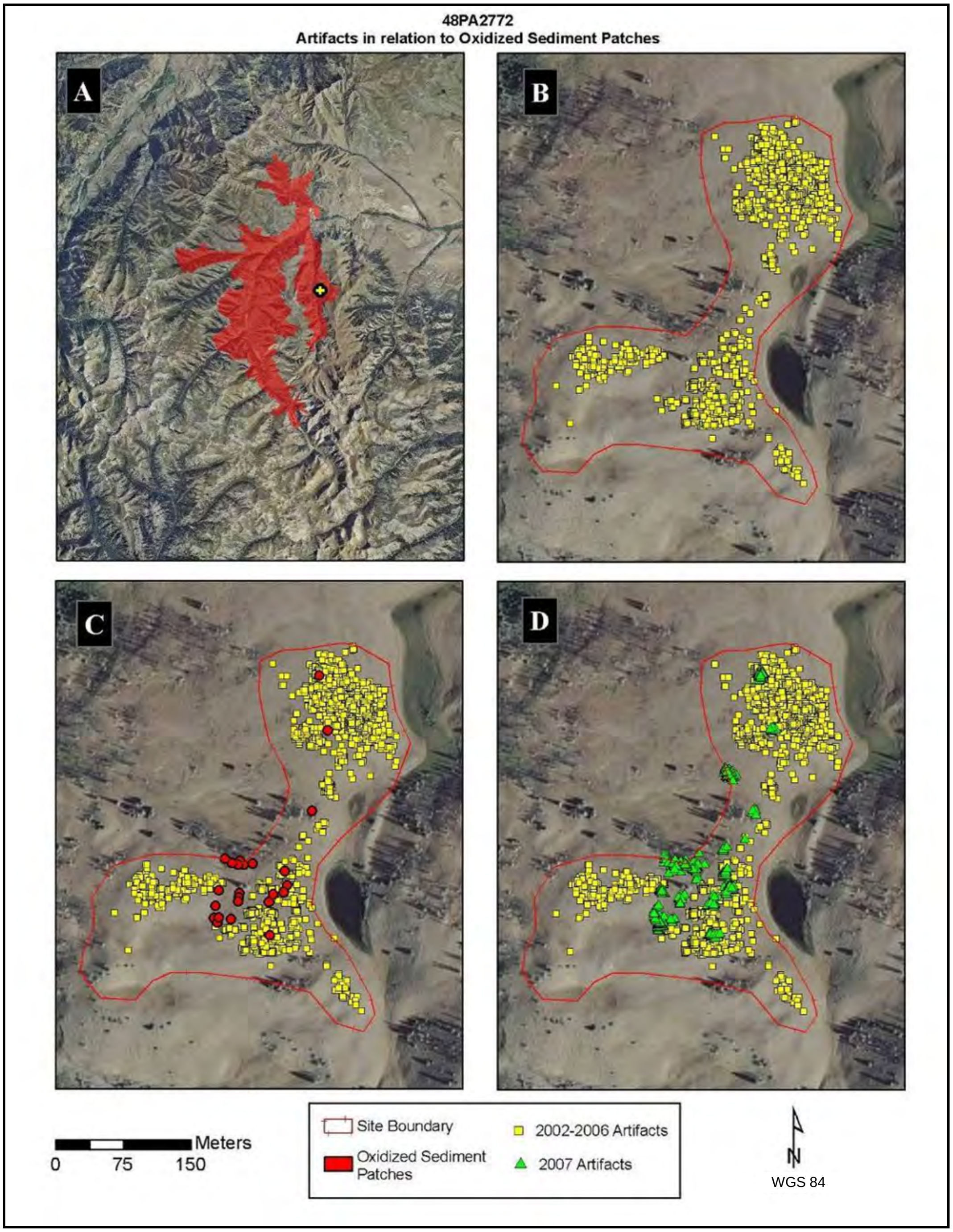


Figure 2.3. Site map of 48PA2772. **(A)** location of 48PA2772 in relation to the area burned in the LVF. **(B)** location of the all artifacts found in the years 2002-2005. **(C)** distribution of oxidized sediments patches across the site. **(D)** Distribution of all the artifacts recorded in 2007 showing the increase in artifacts observed as a result on the increase in surface visibility.

Data sets from the previous seasons (2003-2006) were compared to data documented in the summer of 2007. The 2007 crews did not document the entire site. They focused on those intensely burned area surrounding the oxidized sediment patches (OX). For each OX locational point, a five meter buffer was created in ArcGIS 9.3 and the clip tool was used for each of the pre and post datasets to extract only the materials that were inside the area of the buffer. Since the Trimble™ Juno devices can give sub-meter accuracy and the OX# was recorded by each of the crews, there was a high degree of accuracy in assigning each material to a specific OX patch. However, many of the buffers surrounding the patches overlapped. For this reason, each patch was treated as a separate event and the clip tool extracted those materials within the area of each buffer so that each patch could be treated as an individual datum point uninfluenced by the surrounding patches. A Locus GPS device was used in the previous field seasons to record each artifact found. Since these devices give sub-centimeter accuracy, the buffer could be overlaid on these data sets and used to clip only those artifacts that were within the area of the five meter buffers before the LVF. Figure 2.4, OX120, is an example of the figure created from each OX patch. Additional OX figures and the sizes of each oxidized patch are in Appendix B.

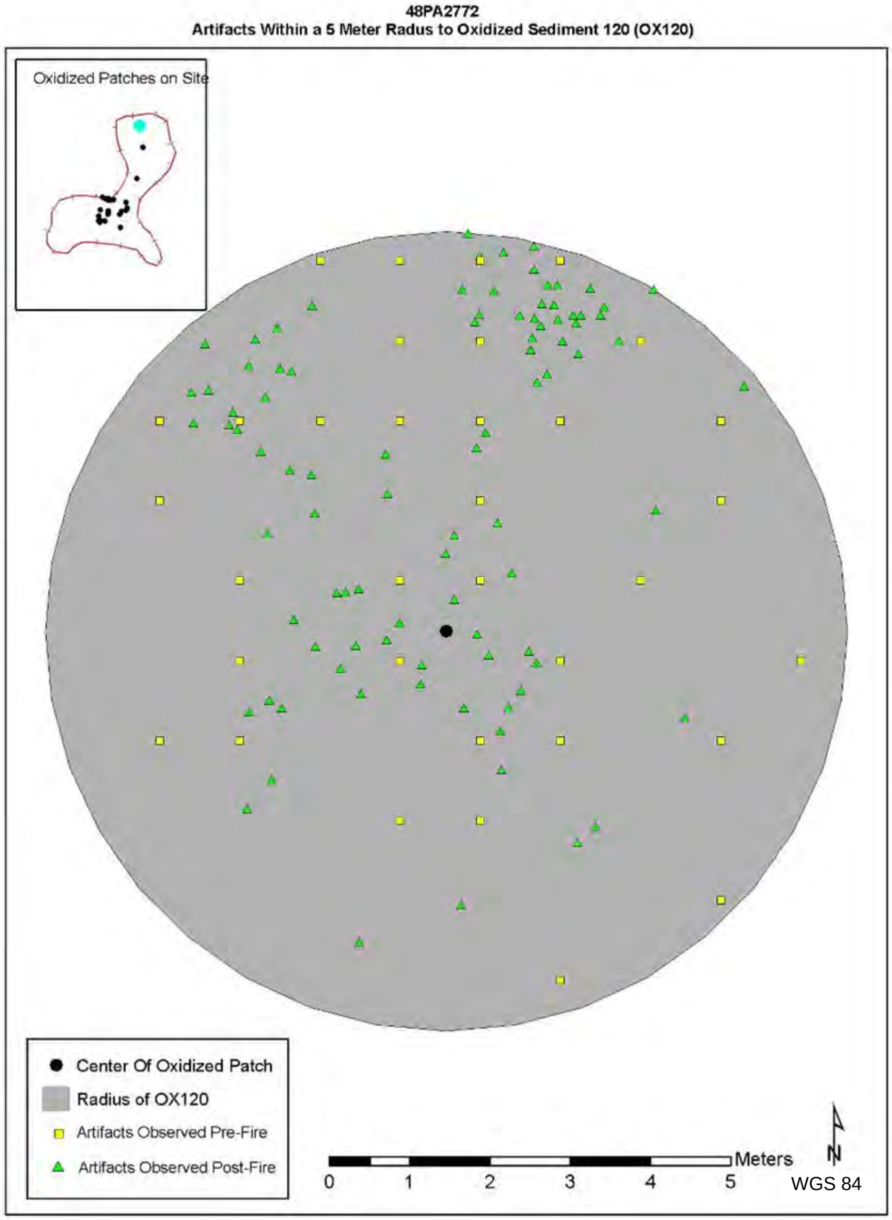


Figure 2.4. OX120 and associated artifacts. The central dot is the center of the oxidized sediment patch. The size of the patch was 1.8m x 0.5m. The yellow squares are those artifacts that were recorded before the LVF in the 2003-2006 field seasons. Green Triangles represent those artifacts documented after the LVF (2007).

Materials documented in the area defined by each five meter radii were then separated into types and classes so each separate source of information could be individually classified. When asking how the change in visibility affects the interpretation of a site, a change in the number of faunal material cannot directly compare to the change in the number of chipped stone. In other words, those basic quantity changes are not equivalent. For example, suppose one longbone and one flake was documented in one of the buffered areas before the fire. Then during the fire the longbone fractures and splinters. The flake, on the other hand, does not fracture or spall and remains intact. After the fire, cattle trample through the burned area distributing the fragmented pieces of longbone. Later, the archaeologist returns and documents each of the longbone fragments separately and still records the one flake. In this scenario the increase in the number of longbone fragments does not mean there were more faunal materials than there were before. Rather it means the bone was more susceptible to damage from the fire. Comparing these datasets separately then combining the results helps to better limit the introduction of formational uncertainty. When treated as data, a single glass trade bead, scraper, awl, or projectile point represents more information than does a single flake. For example, materials such as trades beads and projectile points bring information about when a site was occupied. Awl or scrapers on a site are indicative of certain types of activities. A single flake, though informative in many ways, does not yield the same type of either functional or temporal information as other types of formal tools.

Branch 2: Human Occupation compared to the Fire History

This section relates to the left side of Figure 1.1 under the “Past” heading. There are two sets of methods and both are listed under question one (Q1) of Branch 1. The first is the general archaeological methods that were used to document the Upper Piney

Creek Site (48PA3277). The second is the dendrochronological and fire history methods used to date of the fire scarred trees sampled in the Piney Creek drainage.

Archaeological Methods

Initially found and preliminarily documented in 2007, site 48PA3277 is located on the Piney Creek floodplain and was exposed by the 2006 LVF. During the summer of 2008, the site was recorded in greater detail. Surface visibility was high and the site was noodle surveyed (unsystematically walking across the site and pin flagging all material) and recorded using an EDM (electromagnetic distance measurement) total station (Sokkia®Set 4BII®). Trimble™ GPS devices were used to record a small percent of the total site assemblages. A total station was also used for data collection on many of the diagnostic artifacts and features. Lithic materials, such as debitage and other non-diagnostic material were documented and left in situ as part of the GRSLE project's overall longitudinal research design. Other diagnostic elements were collected if they could yield greater information by laboratory analysis (such as obsidian sourcing or radiocarbon dating), or were at high risk of being looted. The LVF increased the risk of having the record leave in the pockets of uneducated backcountry tourists. More evidence for how fire influences visibility of sites, artifact densities, and analysis will be discussed in Chapter 3.

Data Collection on the Upper Piney Creek Site (48PA3277)

The 2006 LVF and the subsequent wind deflation of the loose sediments, removed much of the taphonomically active zone (TAZ). This exposed many of the artifacts that had been previously underneath that layer of active vegetation (Todd 2008). Afforded a greater degree of surface visibility on the site, the removal of the TAZ and the exposure of the artifacts allowed the site to be documented as though the Mountain Shoshone who lived there had just left (Todd 2008). The entire camp area was exposed. Bones, beads, flakes, projectile points, hearths, other materials, and their spatial relationships were all uncovered. Because of this increased visibility, a total station was used to gather more accurate locational data on each artifact. A combination of Trimble™ devices (both Juno and GeoXT) and EDM (Electromagnetic Distance Measurement) total stations (Sokkia®Set 4BII®) was used to gather locational data as UTM (Universal Transverse Mercator) coordinates (Zone 12N WGS 84) on each artifact and faunal material observed on the Upper Piney Creek site (UPCS).

Two types of dating standards were used at UPCS. First, the projectile points and trade goods (such as glass trade beads and metal artifacts) were used to give the general time periods of occupation on the site. The prehistoric chronology for the GRSLE projectile point sequence is a modified version of a framework developed by Frison (Burnett 2005: 29). Glass trade beads (like those on the UPCS) are one of the most common types of protohistoric artifacts (Brooke 1990:29). The second set of dates for this site is based on radiocarbon analysis of samples recovered human modified faunal material. Remains from both bison and bighorn sheep were present on this site and samples of butchered bison bone were analyzed by Beta Analytic.

Dendrochronological Methods

Dendrochronology is “the study of tree time” (Douglass 1929; Nash 1999:1). This method of dating assigns calendar dates to the growth rings of trees (Stokes and Smiley 1968). For roughly 90 years, dendrochronology has contributed to archaeological investigations (Nash 1999). From A.E. Douglass’s early dating of southwest structures to the timing of culturally pealed tree bark (Nash 1999), dendrochronology has served as a method for assigning dates to wooden remains and hearths left by humans. Dendrochronological analyses also document ecological patterns across landscapes (Reiser 2010:41). These include climate, disturbance regimes, and fluctuations in stand compositions over long periods of time. To archaeologists, the trees provide data on the aspects of the ecosystem during past human occupations.

Since each tree responds to the immediately surrounding environmental conditions, there can be a great deal of variation in the tree-ring patterns. The trees sampled for this research came from a variety of settings within the Piney Creek Drainage. While some trees lived on steep slopes of hillsides, others lived on the drainage floor or near a permanent water source. Each of these settings impacted how the trees responded to the larger climatic conditions. For example, during a drought year, the growth of a tree in proximity to Piney Creek would not be limited by a lack of water. In contrast, a tree living on a talus slope during the same drought would be very limited in the amount of annual growth. Though these trees survived the same drought, the tree near Piney Creek would not record the stress the other trees weathered that season. In other words, the unstressed tree would be complacent to the environmental conditions as it grew. This complacency, or other factors that affect tree growth, lead to very different patterns across a landscape. Comparing this pattern across tree samples is known as crossdating (Speer and Hanson-Speer 2007:90-91).

Dendrochronologists use these patterns and associate calendar dates to the tree rings through crossdating (Speer and Hanson-Speer 2007). Dendrochronology is more complicated than simply “counting” rings (Peter Brown Personal Communication). Rather than counting, dendrochronologists crossdate the variation exhibited between growth rings of certain types of trees (Shepard 2002). This allows them to assign dates to wooden samples found in archaeological assemblages (such as structures). Figure 2.5 is an example of a prepared core, and the variation of its growth rings has been mapped on what dendrochronologists call a skeleton plot.

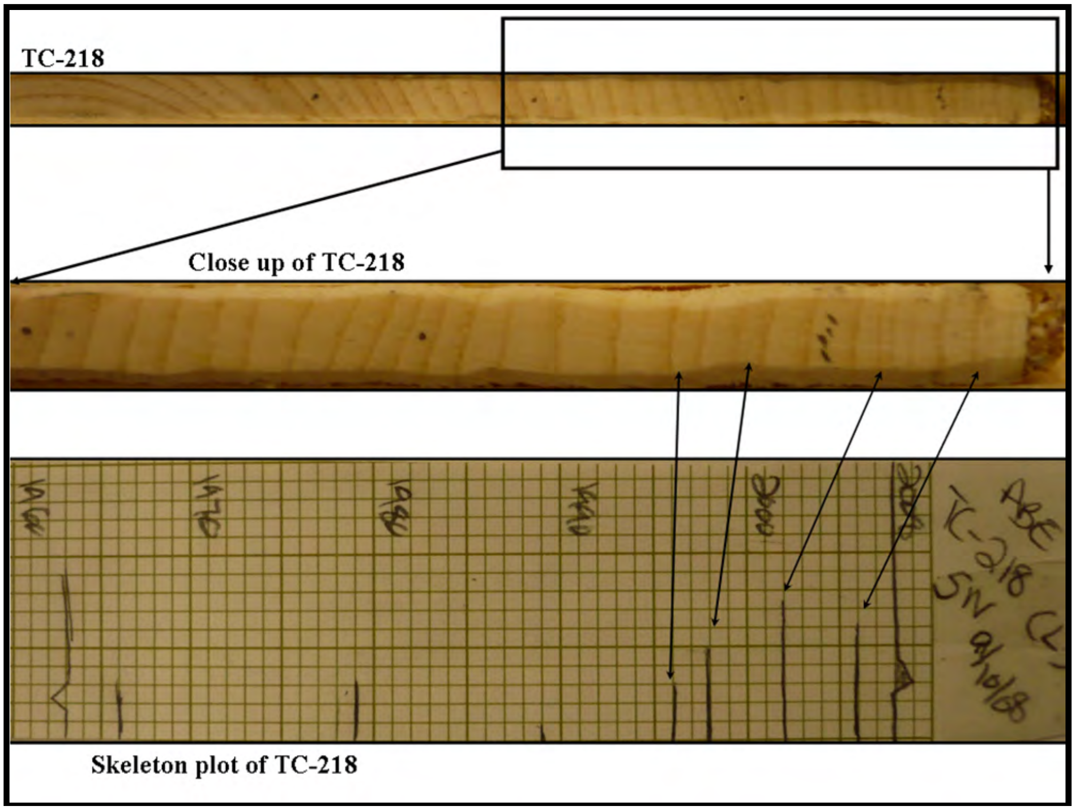


Figure 2.5. Close up of a skeleton plot for TC-218. The image on top is illustrated the sanded down core sample. Dots (as seen in the images) are place every 10 years so the sample can be skimmed over quickly and the dates and patterns can be easily recognized. The single dote represents a decade, two denotes 50 years, three a century, and four dotes are used to mark a millennia. The four dotes in the above image represents the year 2000. The lowest image is the skeleton plot that maps the variation between the growth rings on this core sample and the arrows point to the calendar dates those rings represent.

A skeleton plot is a way to visually graph the variation between individual growth rings. To clearly see the cells that comprise each growth ring, the cores must be mounted and sanded. Each core is essentially cross sectioned with progressively finer grades of sand paper until the surface of the sample is smooth and blemish free. Starting with course grade sandpaper (60 grit), the sample is prepared and smoothed. Finer grades (up to 400 grit) are used to finish the surface of the sample. Finished samples are then viewed through a low powered microscope (7x-35x). Each growth ring is then compared to its nearest neighbors starting at the outside (right end) of the sample. It is important to begin the skeleton plot with the outside ring to ensure consistency. The differences between the growth rings are recorded on a small sheet of graph paper. This graph paper is the skeleton plot. For example, on sample TC-218 (Figure 2.5) the sanded sample is shown above the graph paper (skeleton plot). From right to left, the smaller growth rings represent the years 2006, 2002, 1998, and 1996. These rings are smaller than the rings of their immediate neighbors. The lines on the graph paper represent the approximate differences. After each skeleton plot is completed, it is compared to the skeleton plots of other samples. If the patterns in growth rings match between samples, these samples can be crossdated.

When those growth patterns are compared, the similarities exhibited illustrate shared stresses acting on the growth of those trees. Once variation between trees for a localized area, or stand, has been compared, a master chronology for the study area can be created. This master chronology serves as a reference point to compare and assign dates to events recorded by the tree ring variation (such as wood taken from structures, fire scars, or cultural peels).

However, before the tress can be crossdated they must first be sampled. To construct a tree ring chronology for the Piney Creek Drainage, 381 samples were taken from the 304 trees. Figure 2.6 shows where those samples were taken in relation to the LVF boundary and the Upper Piney Creek Site.

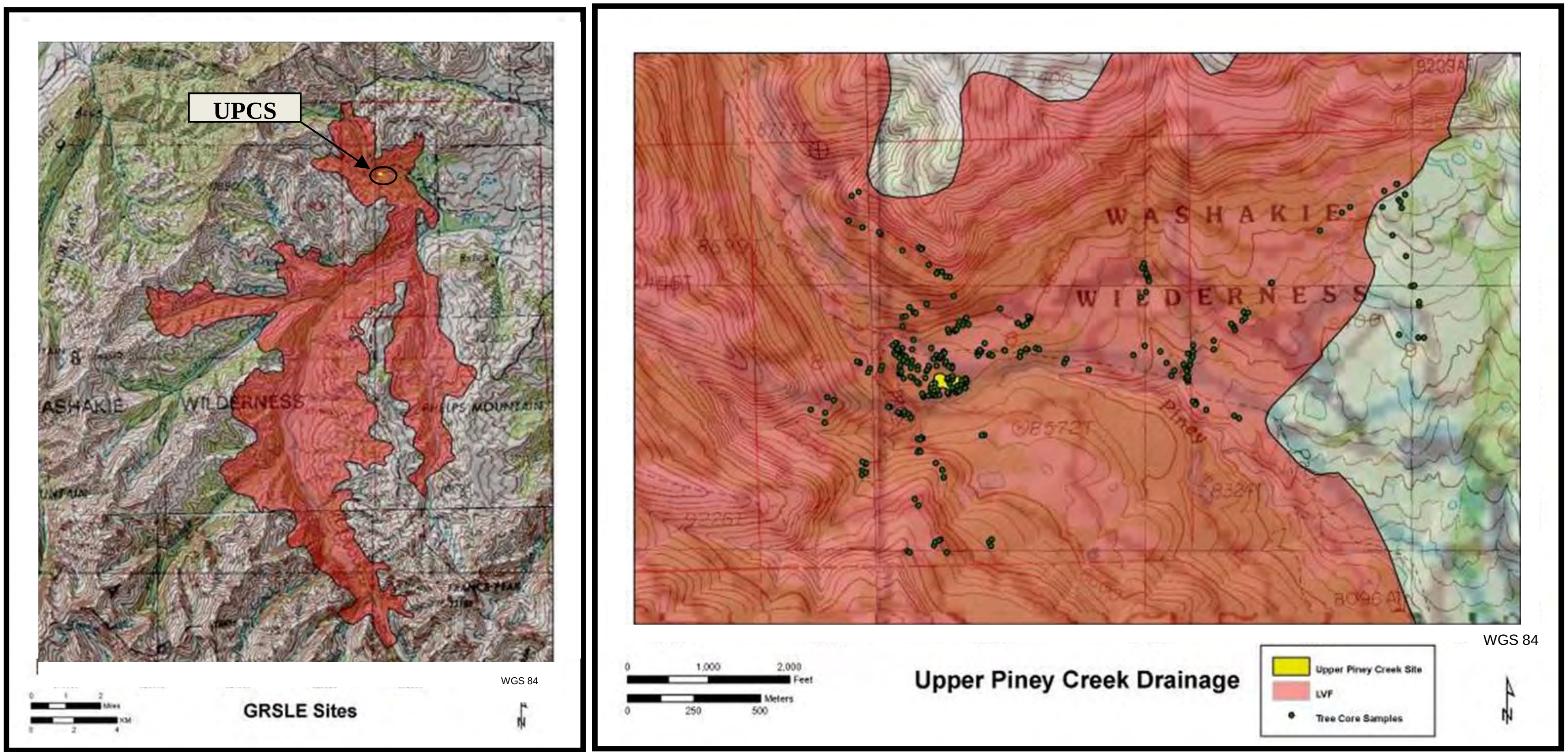


Figure 2.6. Location of the UPCS. **(Left)** Location of the UPCS in relation to the spread of the LVF. **(Right)** Close up map of the Pine Creek Drainage illustrating the relationship between the LVF, the UPCS, and the trees sample to build the fire history and master tree ring chronology for this area.

Samples included cores and cross sections. Cores were extracted from 55 trees that still had green needles and 325 samples were from dead trees (no needle data was recorded on one of the samples). The extraction (or core sampling) used Haglof 50.8cm (20in) 3-thread increment borer, 4.3mm diameter to core the trees and either a small hand saw or two handed “misery whip” cross cut saw to remove cross sections from fire scarred trees. Multiple cores were taken from some of the sampled trees as low to ground surface as possible (under 30cm). This was done to obtain pith ages as close to germination ages as possible. Many trees were severely burned in the 2006 LVF and in some cases much of the sap wood had burned away. Taking multiple, low to the ground samples also ensured that at least one of the samples gathered from that tree would section the apical marrow stem (or pith). Growth rings near the pith curve are often difficult to crossdate. Sampling the pith provides a relatively straight sample that can be more easily and accurately measured. Also, sampling the pith gives the earliest date for that tree. In some cases, cores were taken higher when rot was found in the lower trunk of the tree. Cross sections were often taken of fire scarred trees by sawing wedge cuts into trees. The majority of the cross sectioned trees had died in the fire, had been killed by beetles, or had suffered from severe blister rust.

Past fires are recorded in the trees and dates for those fires can be assigned through examination of fire scars. Fire scars form on a growth surface (cambium) of the tree when fires damaged a portion of that tree. It the tree survives during subsequent seasons, the tree grows over that damaged area. Figure 2.7 is an example of a cross sectioned fire scar and describes the formation and preservation of the fire scar. Crossdating multiple scars serves as the best method for assigning calendar dates to past fires (McBride 1983:57). However, fires burn trees. A tree that survives one fire may not survive a subsequent one. Each time a new fire burns through an area, it burns through the record of pervious fires. If a tree survives a fire and it is able to grow over the burned section, a fire scar is created and researchers are able to crossdate that fire scar with other locally scarred trees and assign calendar dates to each fire scar (Gill 1974:198). The cross sections are meant to capture the scar and the surrounding rings so it may be crossdated with other specimens.

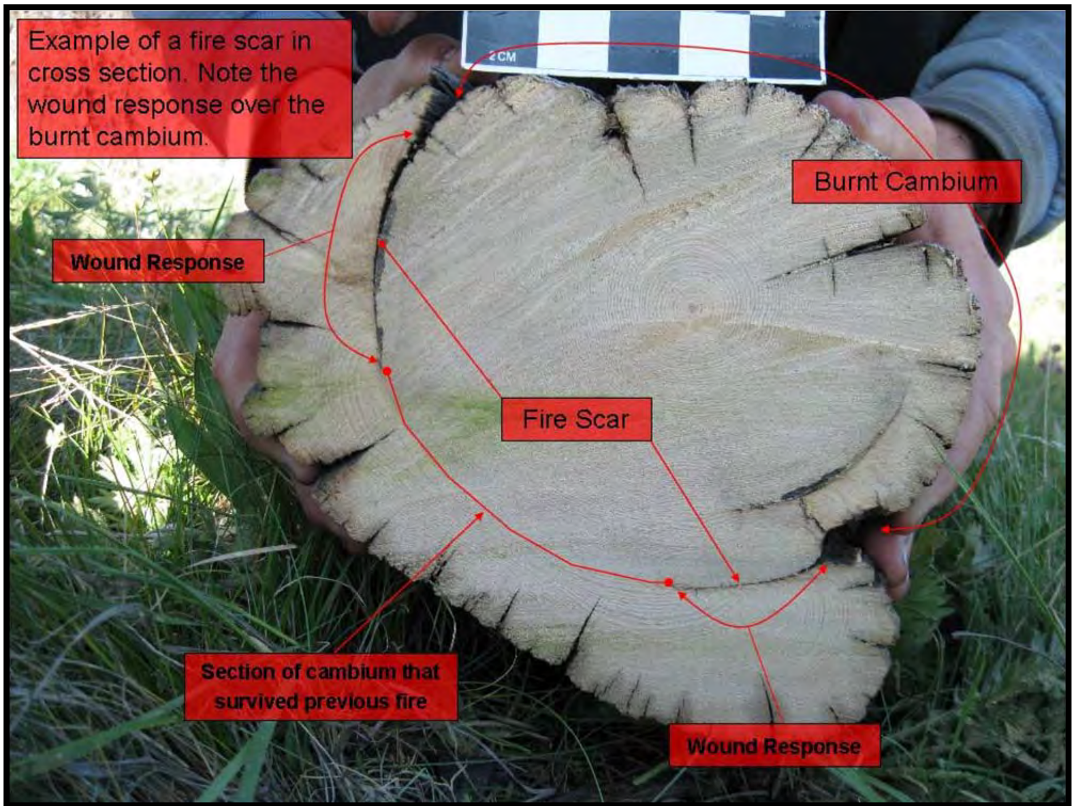


Figure 2.7. Cross section of a fire scar TC-400. Previous fire burnt the majority of the cambium (the growth surface of the tress) leaving only a small section of the tree alive. The wound response of the tree grew over portions of the fire scarred cambium. The growth sequence on the unburned portion of the tree continued well after the previous fire burned through this area. The growth ring that was developing during the fire has been preserved by the wound response of the tree.

The ability of trees to grow over their damaged areas proves to be one of the most accurate methods for reconstructing when past fires burned through an area over the past several hundred years (Gill 1974). Unlike other techniques, such as charcoal lake sediment cores (Millspaugh and Whitlock 1995), or sediment flow rates related to disturbance events (Ollie 2008) that give broad date ranges for past fires, crossdating fire scars gives the exact year a fire burned. However, when conducting a fire history based on fire scars, it is important to keep in mind that fires are not the only events that scar trees. In fact, one of the main problems with using fire scars to reconstruct a fire history comes from having scars on trees that were not caused by fires (McBride 1983:55). This process of regeneration did not evolve solely in response to injuries suffered through fire exposure.

Non-lethal levels of cambium removal, regardless of origin, will cause a tree to re-grow over and injured area. The North American porcupine is one example of an animal that removes the cambium of trees. Porcupines have been documented to eat the inner bark of trees as a staple in the winter months (Harder 1980: 13). The tree responds to this feeding injury in the same way it responds to any other injury by re-growing over that injured portion (Klvana et al. 2004: 284). Figure 2.8, is an illustration of a porcupine scar found during the summer of 2008 compared to some of the fire scars sampled. In comparison to fire scars, porcupine scars do not typically extend up from the ground surface. Since North American porcupines are semi arboreal, the scars they create are usually higher up the tree and form oval shaped scars (Klvana et al. 2004). Other events that can remove cambium include falling trees hitting living trees, vehicles hitting trees along the side of roads, animals rubbings (bear claws, moose, and elk antlers), historic fencing girdling a tree, and other bark peeling activities.

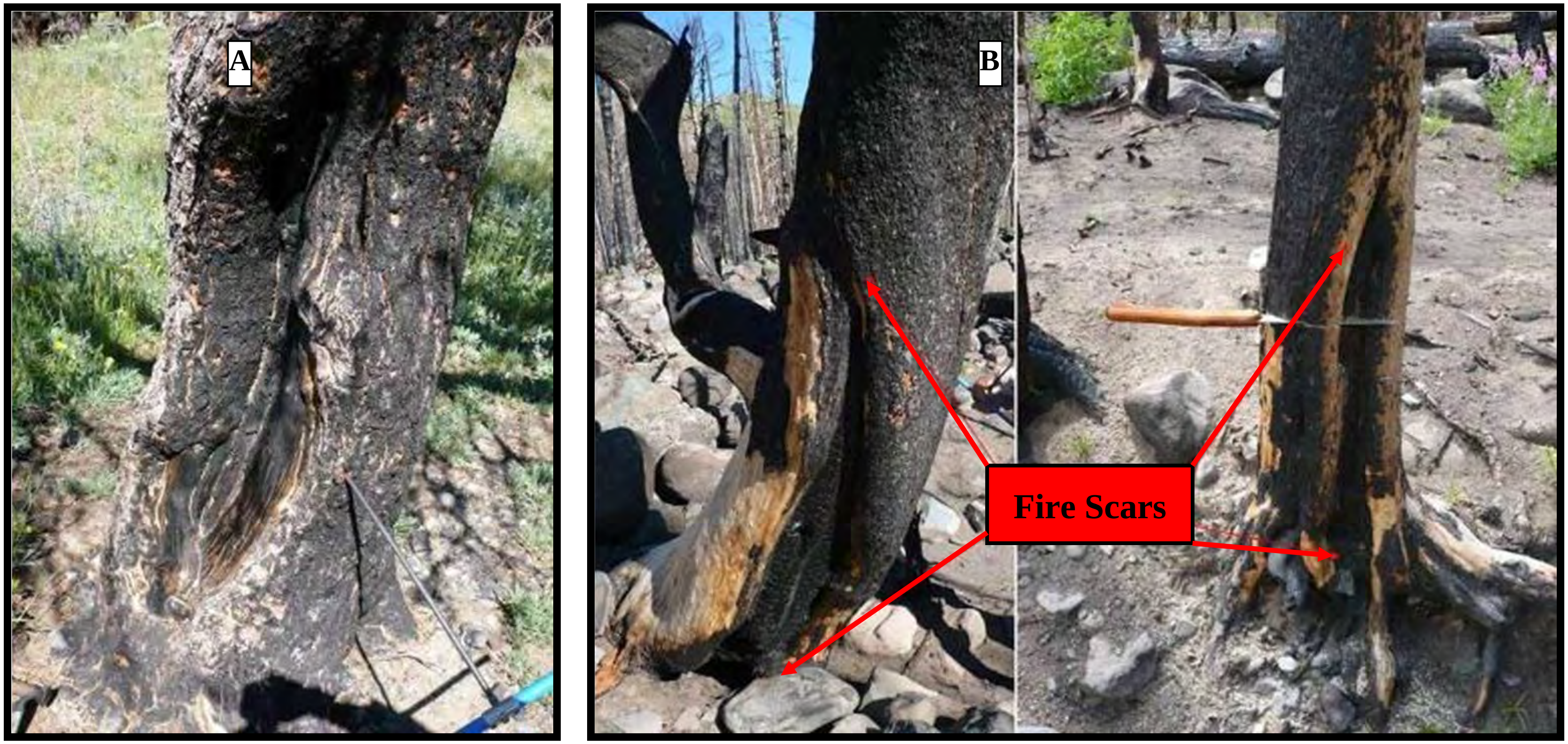
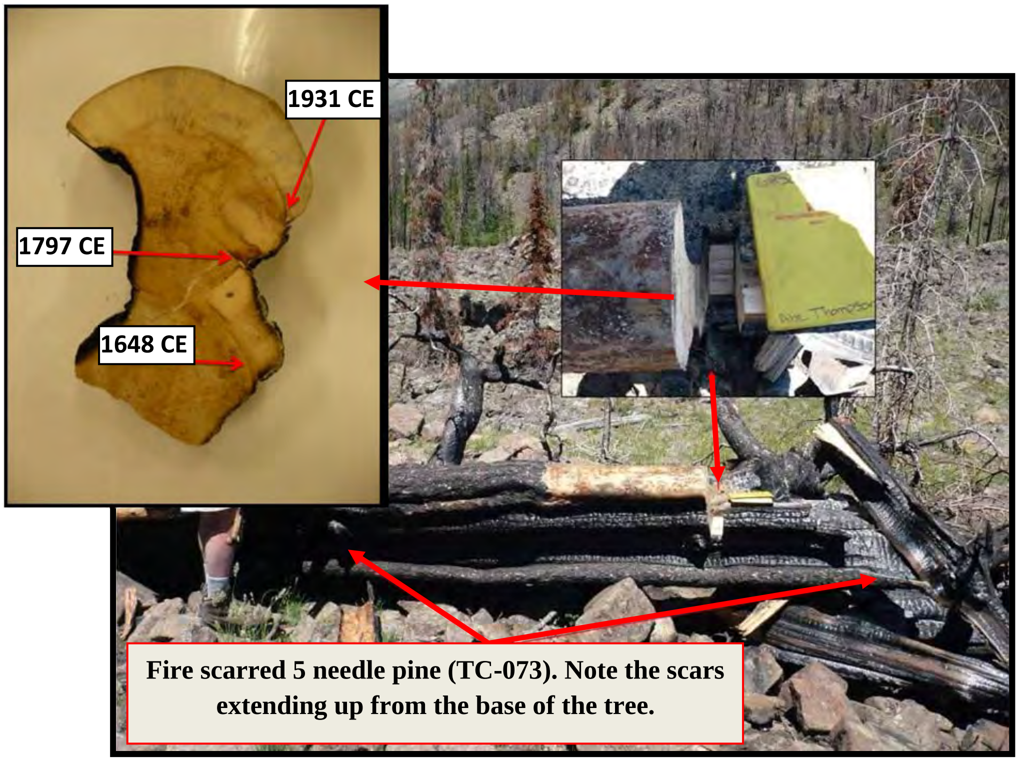


Figure 2.8. Comparing a porcupine scar to fire scars. **(A)** probable porcupine scar (TC-036). **(B)** fire scars (TC-53B and TC-174A), respectively). Notice the oval shape of this porcupine scar compared to the triangular shape of the fire scars.

Because of the danger of misidentifying scars on trees, multiple sources of evidence were used before determining whether or not the injury that produced the scar could be associated with a fire. Pictures are an important tool of the field scientist. For this research, photographs were taken for many of the scars to provide a visual confirmation of the distinguishing traits that are more often associated with fire scars. For example, the height and placement of the scar helps to identify if it was fire that created the scar. If the tree survives this fire, the scar can be seen to extend from the ground surface up the trunk of the tree (Baker 2009:153). The effect is a triangular scar with the ground surface as the base. Figure 2.9 is an example of a fire scared tree (TC-073).



Fire scarred 5 needle pine (TC-073). Note the scars extending up from the base of the tree.

Figure 2.9. Multiple fire scars on TC-073.The scar on this tree can be seen extending from the base of the tree up the trunk. This tree exhibits multiple scars all extending up the base of the tree. The portions of the burnt cambium from the previous fires are exposed in the foreground of this image. The cross section of this sample is also shown to give the dates and illustrate the “cat face” created by the scar and the wound wood.

Tree cores and cross sections were gathered during the summer field season 2008, by Colorado State University's archaeological field school using increment bores and hand saws. UTM locations were recorded on handheld GPS units. 304 trees were sampled in the Piney Creek Drainage of the Shoshone National Forest. To increase chances of obtaining a useable sample from each tree and crossdate fire scars, multiple cores were often taken from individual trees yielding a total of 381 samples. Table 2.1 lists the trees sampled and the abbreviations assigned to different tree species.

Code	**Scientific Name**	**Common Names**	**# of Samples**
5N	*Pinus flexilis* + *Pinus albicaulis Engelm*	Limber pine +Whitbark pine	269
PIEN	*Picea engelmannii*	Engelmann spruce	43
ABLA	*Abies lasiocarpa*	Subalpine fir	5
PSMEG	*Pseudotsuga menziesii* (var. *glauca* (Beissn.) Franco)	Douglas-fir	13
Aspen	*Populus tremuloides*	Aspen	5
999	No Data	No Data/ Unrecognizable	46

Table 2.1. Codes used for identifying trees, the tree species cored, and the number of core samples gathered from the Piney Creek Drainage in the area surrounding the Upper Piney Creek Site.

The methods for dating the tree core and cross sections were standard dendrochronological techniques (Stokes and Smiley 1968). The samples were visually crossdated by plotting ring variation on graph paper (skeleton plotting) and comparing the variation that exists between ring growths to a master skeleton plot (showing years with similar variation across all samples).

The trees sampled in the drainage were dominated by two five needle pine species, whitebark pine and limber pine (N=269). No distinction was made between whitebark pine and limber pine during sampling because the LVF burned away diagnostic elements (needles, bark, and cones) that would have allowed field differentiation between the two species. Tree branches were used to differentiate five needle pines from spruces and firs. Five needle pines have upsweeping branches and, at higher elevations, spread out to create a shrub-like appearance. Also, five needle pines can exhibit a multi-trunk architecture (Walsh 2005:63) that differs from spruce and fir. Microscope identification is possible for differentiating five needle pines and other tree species sampled, but was not undertaken for this project. To date the fire scars, only the five needles pines were used to construct the chronology and compare the fire history to the timing of the human occupations at the UPS. Five needles where chosen to represent the fire history because of the relationship between whitebark pine and fire and the preference of whitebark pine nuts exhibited by both the Clark’s Nutcracker and prehistoric humans (Adams 2010).

The majority of the trees in the Piney Creek drainage were burned in 2006 when the LVF consumed nearly 14,164 ha of the Greater Yellowstone Ecosystem. Many of the trees were subject to a severe beetle epidemic prior to the fire, evidenced by the amount of bluestain fungus. Beetle epidemics may act as a factor increasing the intensity, and extent of wildland fires (McCullough et al. 1998:108). Bluestain fungus can serve as a source of proxy data for past beetle outbreaks, and can help identify the impact of past pine beetles on historical fire regimes (Brown and Schoettle 2008:342). Unfortunately, no past beetle outbreaks were recorded by the trees of the Piney Creek drainage.

Accuracy Testing of the Tree Ring Variation

There are several methods that can be used to check the accuracy of a tree ring chronology. Tree rings widths of six samples were measured and entered into the program COFECHA. This program checks the chronology by statistically assessing and comparing the variation in the tree ring sequence with the measurements of the ring widths (Grissino-Mayer 2001:205). Using a Velmex micrometer and Measure J2X software, the samples from the live trees were first measured to give anchor dates to the "series" of ring measurements. Not all core and crosssections were measured because of complacency and other issues (none-readable core, un-crossdateable patterns, etc.). A more detailed description of how COFECHA builds a master tree ring chronology can be found in Reiser 2010.

Summary

Both branches (Figure 1.1) used methods for separate analysis about very different patterns. These methods came together when sequencing the human occupation and timing that sequence with the fire history. Methods for Branch 1 (present) focused on the large dataset gathered from longitudinal research in the Upper Greybull. Examples for this branch were assembled from a variety of sites documented and rerecorded during the 2007 field season. 48PA2772 was analyzed in greater detail. On this site, near experimental conditions were created by the LVF. Discrete patches of oxidized sediments gave direct before and after comparisons of a subset of the total site area. Branch 1 used standard dendrochronological methods to build a tree ring chronology and crossdate the fire scarred samples. Coupling this with the radiocarbon dates from the UPSC faunal material gives a date range for the use of this site. These two sources of data will be compared in the next chapter.

The longitudinal research strategies of the GRSLE project allowed for sites be revisited and rerecorded. This aids in understand the archaeology as part of a dynamic landscape. After the LFV, a new process of change was introduced to the understanding of the human record of this region. Because of the fire, new sites were uncovered and those in turn brought additional questions about how past people interacted with large scale fires. That event called for new tools and methods from difference disciplines (dendrochronology and fire ecology) to be used and integrated into this ever growing research conversation.

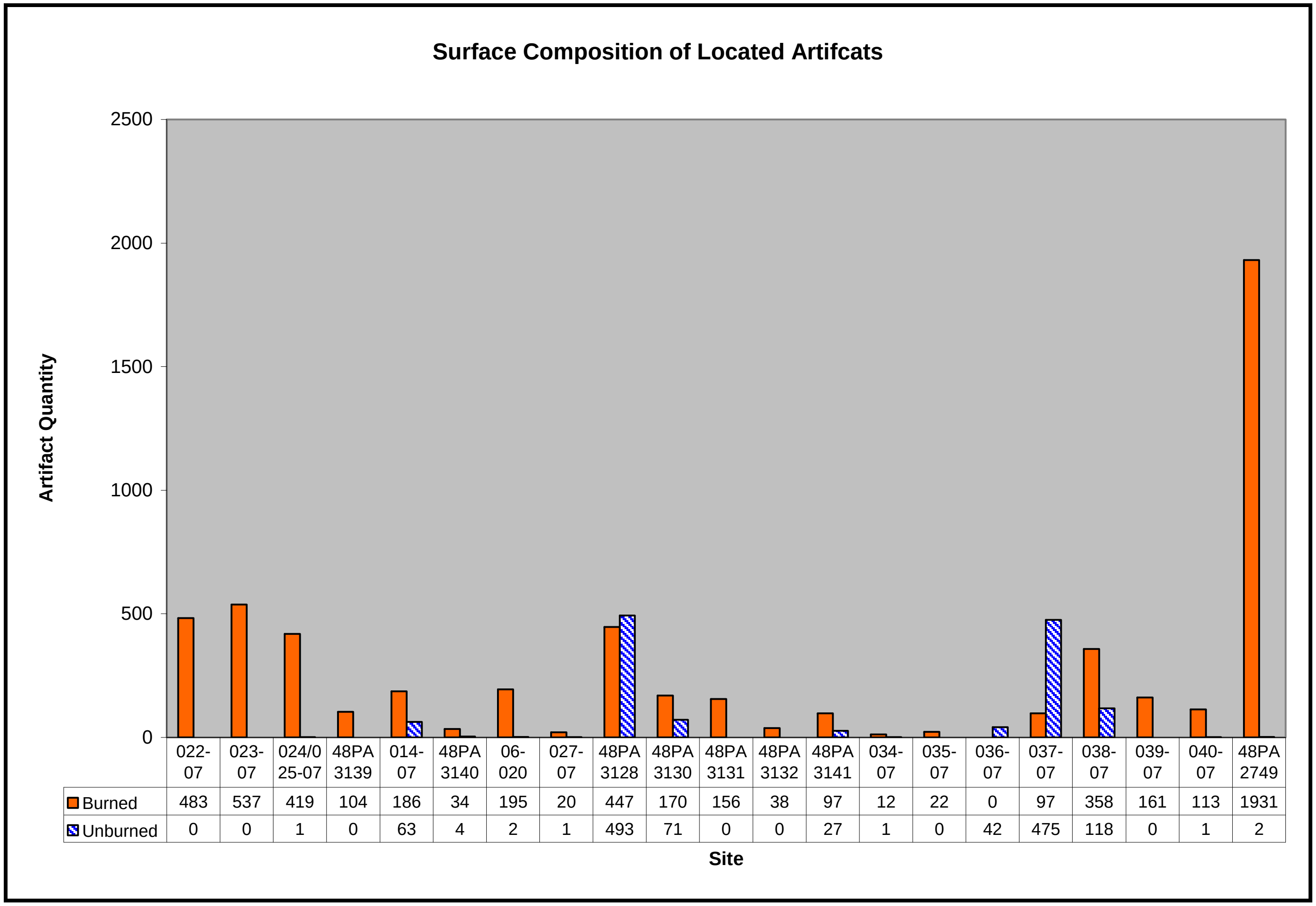
CHAPTER 3: RESULTS

This chapter will discuss the evidence that provides clues about the aspects of the main question found in Figure 1.1. The beginning section focuses on the right side (Branch 1) and addresses the evidence for past fires and past human occupations within the Piney Creek drainage. Disturbances, such as fires, have played an integral role in the landscape evolution of the Piney Creek Drainage (Ollie 2008). The archaeological materials and the tree ring record indicate that humans were occupying this drainage in the years surrounding past fires. This chapter is prefaced with a discussion of the archaeological evidence for the human occupation for 48PA3277 (the Upper Piney Creek Site) during the Late Prehistoric and Protohistoric periods. The evidence for these occupations comes from both radiocarbon dates gathered from bone collagen and from the temporally diagnostic artifacts observed on the surface of the site.

The second part of this chapter focuses on the left side of Figure 1.1 (Branch 2) and will examine how much information can be gained by recording surface artifacts in a post fire environment. The evidence was gathered from sites across the GRSLE project area. General artifacts counts from a subset of the sites documented in 2007 will be used to examine how the disturbance event (the LVF) influenced the archaeological information over the project area. On a smaller scale, the archaeological material documented on 48PA2772 before and after the Little Venus Fire will be examined to address the question of how the increase in visibility of surface artifacts impacted the archaeological potential.

Branch 1: Surface Visibility and Artifact Densities

Referring back to the main questions of this thesis, “Do fires affect the discovery and documentation of archaeological sites?” the following section addresses the relationship between fire and surface artifact visibility. Fire clears vegetation and increases surface visibility of archaeological remains (Burnett and Todd 2009; Johnson 2004). Not surprisingly, data gathered from Colorado State University’s archaeological field school summer 2007 illustrates that more artifacts can be found in areas that have recently burned than in areas surveyed with surface vegetation (Todd and Burnett 2009). The LVF was an example of a high intensity, stand replacing crown fire in a subalpine setting. Because of the longitudinal research conducted in this area through the GRSLE project, many sites that were recorded before the fire could be reexamine after the LVF. To briefly illustrate how much can be found with the increase visibility in a post-fire environment, attention can be turned to data collected during survey in the summer of 2007. These data are presented in Figures 3.1 and 3.2 and Tables 3.1 and 3.2. Some of the sites have been designated by Smithsonian numbers; others have yet to receive those designations and are listed by their temporary site numbers.



	022-07	023-07	024/025-07	48PA3139	014-07	48PA3140	06-020	027-07	48PA3128	48PA3130	48PA3131	48PA3132	48PA3141	034-07	035-07	036-07	037-07	038-07	039-07	040-07	48PA2749
■ Burned	483	537	419	104	186	34	195	20	447	170	156	38	97	12	22	0	97	358	161	113	1931
▨ Unburned	0	0	1	0	63	4	2	1	493	71	0	0	27	1	0	42	475	118	0	1	2

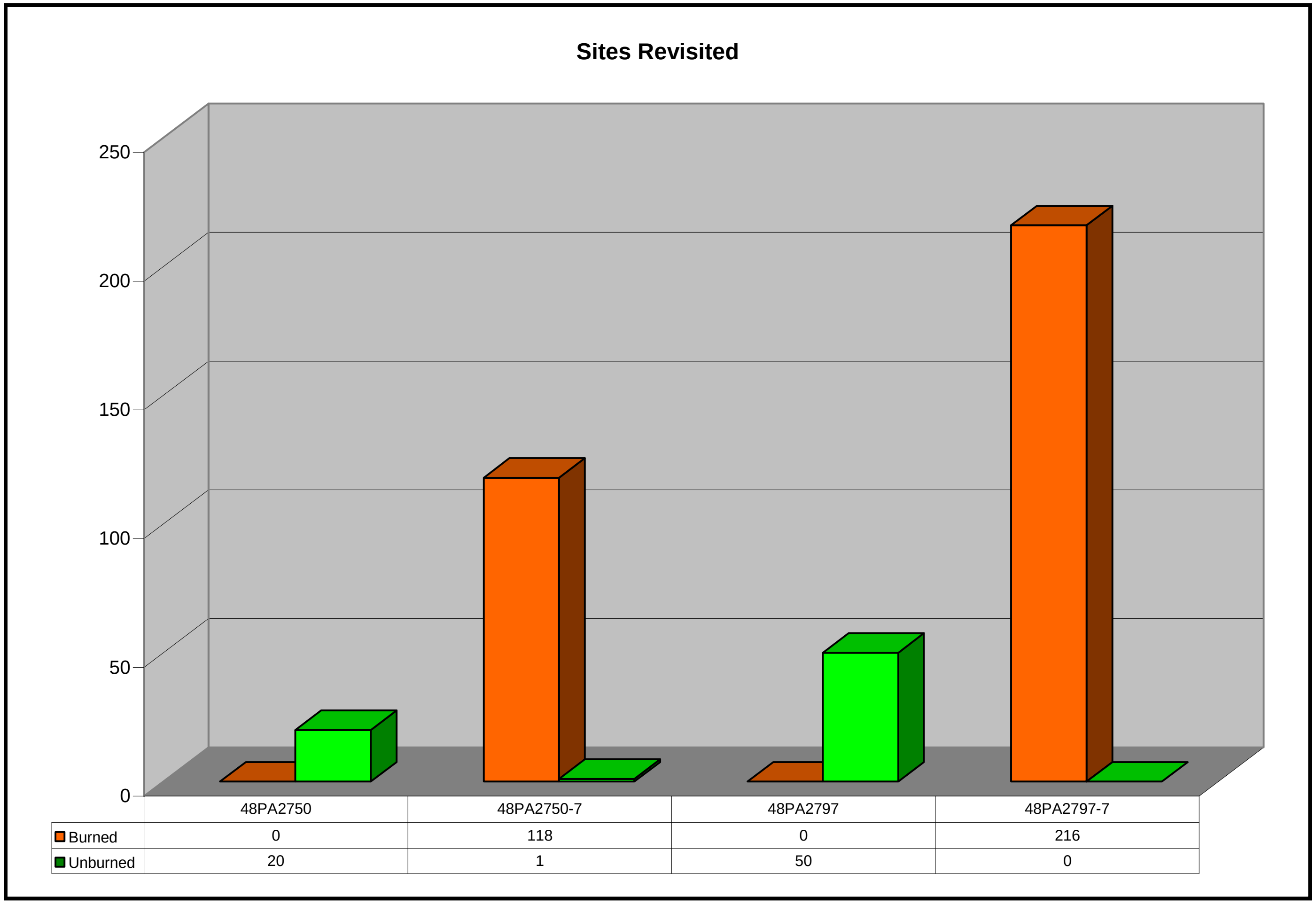
Figure 3.1. Contrasting ground surface contexts of artifacts found in the Upper Greybull drainage during 2006 and 2007 surface surveys. Burned values are the counts of artifacts that were recorded on surfaces that had been burned by the LVF. Unburned values are the counts of artifacts that were recorded on those surfaces not disturbed by the LVF. All artifacts reported are within the LVF burn perimeter, but individual items are located in the mosaic of unburned vegetation within the perimeter of the LVF.

SITE	Burned	Unburned	Rodent Burrow	Pack Trail	Unspecified
022-07	483	0	1	0	2
023-07	537	0	0	0	0
024/025-07	419	1	0	0	1
48PA3139	104	0	0	0	14
014-07	186	63	0	0	0
48PA3140	34	4	0	0	0
06-020	195	2	0	0	16
027-07	20	1	0	0	0
48PA3128	447	493	1	5	16
48PA3130	170	71	2	0	1
48PA3131	156	0	0	0	0
48PA3132	38	0	0	0	0
48PA3141	97	27	0	0	0
034-07	12	1	0	2	0
035-07	22	0	0	0	0
036-07	0	42	0	1	0
037-07	97	475	2	5	0
038-07	358	118	3	1	0
039-07	161	0	0	0	0
040-07	113	1	0	0	0
48PA2749	1931	2	0	0	9

🟨 = areas surveyed pre-fire, but no site found

Table 3.1. Surface composition of a portion of the sites found during Colorado State University's archaeological field school in 2007. Burned areas were created by the LVF in 2006. Those sites highlighted represent areas previously surveyed, but cultural materials were not found and site designations were not given until cultural material was exposed after the area was burned. Columns are the surface conditions where the artifacts were recorded. Burned surfaces were exposed by the LVF, unburned were non disturbed surfaces, Rodent Borrow are those disturbed by rodent activity such as burrowing, Pack Trails were disturbed by both animal and humans foot traffic, and Unspecified surfaces were those that were either ambiguous or no data were collected.

Figure 3.1 and Table 3.1 illustrate how fire can dramatically increase the visibility of cultural material on known prehistoric sites. As discussed earlier, after the LVF the ground surface was a mosaic of burned and unburned areas. On all but three of the sites represented in Figure 3.1, more artifacts were documented in areas where the LFV had burning away the surface vegetation. Further, Table 3.1 shows that the artifacts found on the burned contexts not only outnumbered those of unburned ground surface, but also greatly outnumber the other types of contexts that can increase ground surface visibility (pack trails and rodent burrows) (Bechberger 2010). From Figure 3.1 and Table 3.1, 80% of the artifacts were found on burned ground surfaces, 19% were documented on an unburned surface, and only 1% were found in other contexts (rodent burrow, pack trail, or unspecified).



	48PA2750	48PA2750-7	48PA2797	48PA2797-7
🟧 Burned	0	118	0	216
🟩 Unburned	20	1	50	0

Figure 3.2. Comparison of sites documented both before and after the LVF. The top row is the site numbers. Those ending with “-7” represent data collected the summer after the fire.

SITE	Burned	Unburned	Rodent Burrow	Pack Trail	Unspecified
48PA2750	0	20	0	0	0
48PA2750-7	118	1	7	0	20
48PA2797	0	50	0	0	0
48PA2797-7	216	0	0	0	66

🟩 = pre-fire
🟧 = post-fire

Table 3.2. Artifact counts from two sites recorded before and after the LVF. Site numbers ending with “-7” represent data collected the summer after the fire.

Figure 3.2 and Table 3.2 use two sites (48PA2750 and 48PA2797) as examples to demonstrate the change in artifact counts on archaeological sites after the LVF. Both of these sites were documented before the LFV and both were revisited the following summer. Both examples had nearly five times the number of surface artifacts.

The previous examples illustrate a collective change in the visible artifact densities on archaeological sites that have burned ground surfaces. The cumulative affect across the landscape will be an increase in the knowledge potential from each of the surface assemblages. The scope is not to relate the overall changes to the entirety of the archaeological record of the GRSLE project. To give a small suggestion of how much information can change in a post fire environment, the rest of this section will focus a portion of one site (48PA2772), that exhibited discrete patches of burning, to show how the interpretation of the site changed because of the increase in visibility. This site has served as an example of the benefits of longitudinal research. Burnett (2005:19) constructed a detailed artifact map that demonstrated the effect of sampling design on artifact densities. During one of the field sessions the crew used Modified Whittaker sample plot and noodle surveyed, pedestrian surveyed at 70cm transects, and crawl surveyed (crawling on hands and knees at 30cm transects) a 20m by 50 m area. (Burnett 2005:18). The areas that were intensity documented inside the Modified Whittaker overlapped with ground surfaces that were burned by the LVF.

During the LVF, localized areas of intense burning created oxidized sediment patches on site 48PA2772 (Koepsell 2007). These patches burned discrete areas of the site that had been previously documented. Because of the intensity of documentation pre and post fire, these areas can be compared as having the same scale of recording. In 2007, these discrete burned areas, and the artifacts within, were recorded so the number of visible artifacts could be compared to those previously observed. Table 3.3 shows artifact counts observed pre and post the LVF within a circular area that extends out in a five meter radius from the center of each oxidized sediment patch.

Oxidized Sediment Patch #	Number of Materials Observed in 2003-2006	Number of Materials Observed in 2007
109	4	49
110	2	18
111	0	5
112	0	14
114	0	54
115	0	23
116	9	9
117	0	17
118	0	8
120	62	92
121	0	28
122	0	30
123	0	38
124	0	123
125	0	87
126	0	13
127	0	8
128	0	20
129	0	37
130	0	20
137	16	102
138	0	8

Table 3.3. Materials observed surrounding each oxidized sediment patch on 48PA2772. These counts include artifacts and bone fragments. For detailed maps of each of oxidized sediment patch and the associated materials refer to Appendix B.

With the variety of materials found surrounding the oxidized sediment patches, it is useful to break apart those materials in order to understand the different sources of information (materials) uncovered by the fire. Figure 3.3 shows the number of chipped stone documented in the areas surrounding each OX patch in the field seasons before and after the LVF.

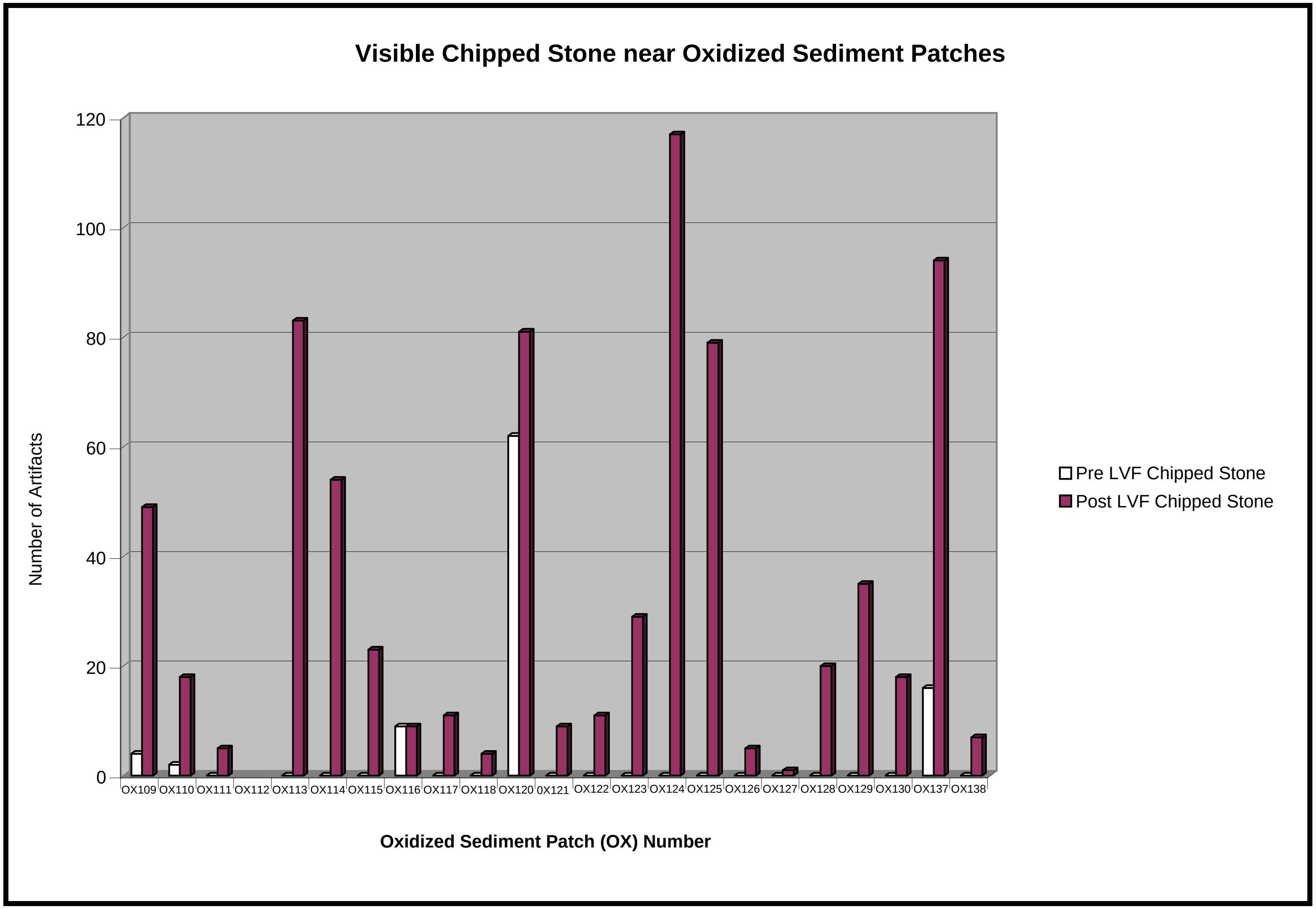


Figure 3.3. Counts of chipped stone observed within the 5 meter radii areas surrounding each oxidized sediment patch (OX) on 48PA2772.

The count of visible artifacts increased within the area of each radius surrounding the oxidized sediment patches. This strongly suggests that burning increases the ground surface visibility. What this means for archaeologists is that more artifacts can be observed on a site after a fire burns away vegetation. Many of those artifacts that were protected from surface exposure (and potential looting) can now be added to the dataset of that site. Interestingly, on this site the mean maximum length for chipped stone flakes only decreased by 1 mm. In the years before the LVF the mean maximum lengths of artifacts was 12 mm while after the fire the mean dropped to 11 mm. Figure 3.4 is a box and whisker plot of the distribution of artifact sizes pre and post the LVF.

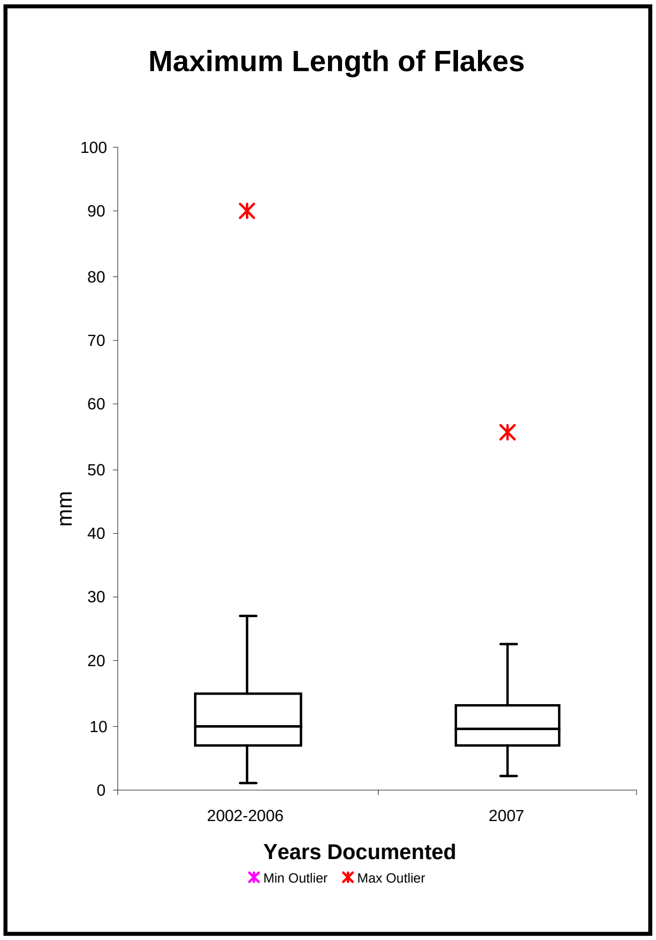


Figure 3.4. Box and whiskers plot of the variation of maximum length of artifacts documented on 48PA2772 before and after the LVF.

Though the mean maximum length decrease of 1 mm is not substantial, the proportion of smaller flakes can change the interpretation of the function of the site. Figure 3.4 shows that the lower quartile range (Q_1) of the maximum length of the artifacts is seven mm for both the pre and post artifact datasets. The upper quartile range (Q_3) shows a two mm difference between the 2002-2006 documentations (15mm) and that of the 2007 documentation (13mm). Very small artifacts were found before and after the fire. However, this takes into account the averages across the entire area of the site. The 2007 recorded only focused on a fraction of the site. Table 3.4 shows how the average length of artifacts compares only those areas within the areas of each radius surrounding the OX patches.

Oxidized Sediment Patch	Average Length 2003-2006	Average Length 2007	Artifact Density (Count/m^2) 2003-2006	Artifact Density (Count/m^2) 2007
109	13	10.6	0.05	0.62
110	19	12.5	0.03	0.23
111	N/A	11.9	0.00	0.06
112	N/A	11.9	0.00	0.18
114	N/A	11.8	0.00	0.69
115	N/A	11.7	0.00	0.29
116	22	17.9	0.11	0.11
117	N/A	9.1	0.00	0.22
118	N/A	12.6	0.00	0.10
120	9	10.5	0.79	1.17
121	N/A	14.9	0.00	0.36
122	N/A	11.4	0.00	0.38
123	N/A	11.1	0.00	0.48
124	N/A	13.0	0.00	1.57
125	N/A	12.0	0.00	1.11
126	N/A	11.1	0.00	0.17
127	N/A	10.0	0.00	0.10
128	N/A	13.6	0.00	0.25
129	N/A	12.2	0.00	0.47
130	N/A	11.3	0.00	0.25
137	11	10.4	0.20	1.30
138	N/A	9.6	0.00	0.10
Overall Average	14.8	11.9	0.05	0.46

Table 3.4. Average maximum lengths of artifacts and densities per patch recorded within the area of each 5m radius patch on 48PA2772. Those cells with N/A designate patches where no artifacts were documented before the LVF.

In the localized areas surrounding the oxidized sediment patches, there was a decrease in the average maximum length of artifacts. Again, since the 2007 recording only documented a small sample of the site area, these data suggest that a higher quantity of smaller flakes might be documented on the site if this site were to be recorded after the surface vegetation across the entire site was removed. The small windows created by the

OX patches and those data gathered from them could greatly aid predictive modeling used to locate archaeological material. The more information obtained about the site; the more accurate the models become. Coupling models that predict where archaeological sites are likely to occur with models of fire behavior would increase efficiency when planning where surveys should be conducted after fires (Ryan 2010).

Not all archaeological investigations are about the maximum size of artifacts. The last two columns in Table 3.4 are the densities of artifacts in each OX patch. Densities were calculated by dividing the quantity of artifacts (Table 3.4) by the area of each OX patch. Each circular patch was calculated to have an area of $78.5m^2$ ($\pi*5^2$). As expected, the artifact densities for each patch increased after the LVF. Before the LVF, the average density in those areas was 0.05 artifacts per m^2. After the fire, the density increased to 0.46 artifacts per m^2.

Returning to the question of what an increase in quantity of visible material means, the argument can be made that the types of artifacts observed relates a great deal of information about the site. An increase in the artifact density also translated to a greater chance of observing diagnostic material. The patches create windows into the site and allow archaeologists to see examples of types of materials that may have otherwise walked off the site in a looter's pocket. Table 3.5 is a breakdown of the temporally diagnostic material recorded on site 48PA2772 during the pre and post LVF recordings of the site.

WAYPOINT ID /Artifact Number	Year	Element	Time Period		WAYPOINT ID /Artifact Number	Year Found	Element	TIME
2244	2007	Metal Projectile Point	Protohistoric		246	2003	Chert Projectile Point	Early Archaic
2242	2007	Mucket Percussion Cap	Protohistoric		247	2003	Chert Projectile Point	Late Archaic
2245	2007	Metal Projectile Fragments	Protohistoric		263	2003	Chert Projectile Point	Late Archaic
2246	2007	Metal Band	Protohistoric		287	2003	Chert Projectile Point	Late Archaic
2247	2007	Lead Ball	Protohistoric		384	2003	Chert Projectile Point	Late Archaic
2243	2007	Faceted Green Trade Bead	Protohistoric		241	2003	Chalcedony Projectile Point	Late Prehistoric
3201	2007	Faceted Green Trade Bead	Protohistoric		387	2003	Chert Projectile Point	Late Prehistoric
2255	2007	Red Trade Bead	Protohistoric		530	2003	Chert Projectile Point	Late Prehistoric
2256	2007	Red Trade Bead	Protohistoric		245	2003	MAD Projectile Point	Late Prehistoric
2258	2007	Red Trade Bead	Protohistoric		230	2003	Obsidian Projecile Point	Late Prehistoric
2259	2007	Red Trade Bead	Protohistoric		248	2003	Obsidian Projecile Point	Late Prehistoric
2257	2007	White Trade Bead	Protohistoric		204	2003	Obsidian Projecile Point	Late Prehistoric
2260	2007	White Trade Bead	Protohistoric		206	2003	Obsidian Projecile Point	Late Prehistoric
2260	2007	White Trade Bead	Protohistoric		296	2003	Obsidian Projecile Point	Late Prehistoric
4871	2007	Chert Projectile Point	Unspecified		383	2003	Obsidian Projecile Point	Late Prehistoric
3340	2007	Chert Projectile Point	Paleoindian		520	2003	Obsidian Projecile Point	Late Prehistoric
2250	2007	Chert Projectile Point	Paleoindian		599	2003	Obsidian Projecile Point	Late Prehistoric
2271	2007	Chert Projectile Point	Unspecified		26	2003	Obsidian Projecile Point	Late Prehistoric
4896	2007	Obsidian Projectile Point	Unspecified		30	2003	Quartzite Projectile Point	Late Prehistoric
2166	2007	Obsidian Projectile Point	Unspecified		239	2003	Quartzite Projectile Point	Late Prehistoric
4422	2007	Obsidian Projectile Point	Unspecified		385	2003	Quartzite Projectile Point	Late Prehistoric
2241	2007	Obsidian Projectile Point	Unspecified		386	2003	Quartzite Projectile Point	Late Prehistoric
2264	2007	Obsidian Projectile Point	Unspecified		465	2003	Quartzite Projectile Point	Late Prehistoric
2265	2007	Obsidian Projectile Point	Unspecified		222	2003	Silicified Sediment Projectil Point	Late Prehistoric
2266	2007	Obsidian Projectile Point	Unspecified		96	2003	Chert Projectile Point	Late/Late Prehistoric
2267	2007	Obsidian Projectile Point	Unspecified		13	2003	Chert Projectile Point	NLP
2165	2007	Phosphoria Projectile Point	Unspecified		80	2003	Chert Projectile Point	Unspecified
2169	2007	Quartzite Projectile Point	Unspecified		19	2003	Chert Projectile Point	Unspecifiied Archaic
2253	2007	Quartzite Projectile Point	Unspecified		388	2003	Chert Projectile Point	Unspecifiied Archaic
					399	2003	MAD Projectile Point	Unspecifiied Archaic
					999	2004	Petrified Wood Projectile Point	Late Prehistoric
					8	2005	Obsidian Projecile Point	Unspecified
					8	2005	Chalcedony Projectile Point	Late Prehistoric
					12	2005	Chert Projectile Point	Late Prehistoric
					5	2005	Obsidian Projecile Point	Late Prehistoric
					4	2005	Obsidian Projecile Point	Unspecified
					21	2006	Chert Projectile Point	Late Prehistoric
					22	2006	Chert Projectile Point	Late Prehistoric
		Total Diagnostics	28				Total Diagnostics	38
		Artifacts Recorded/Diagnostic	33				Artifacts Recorded/Diagnostic	146

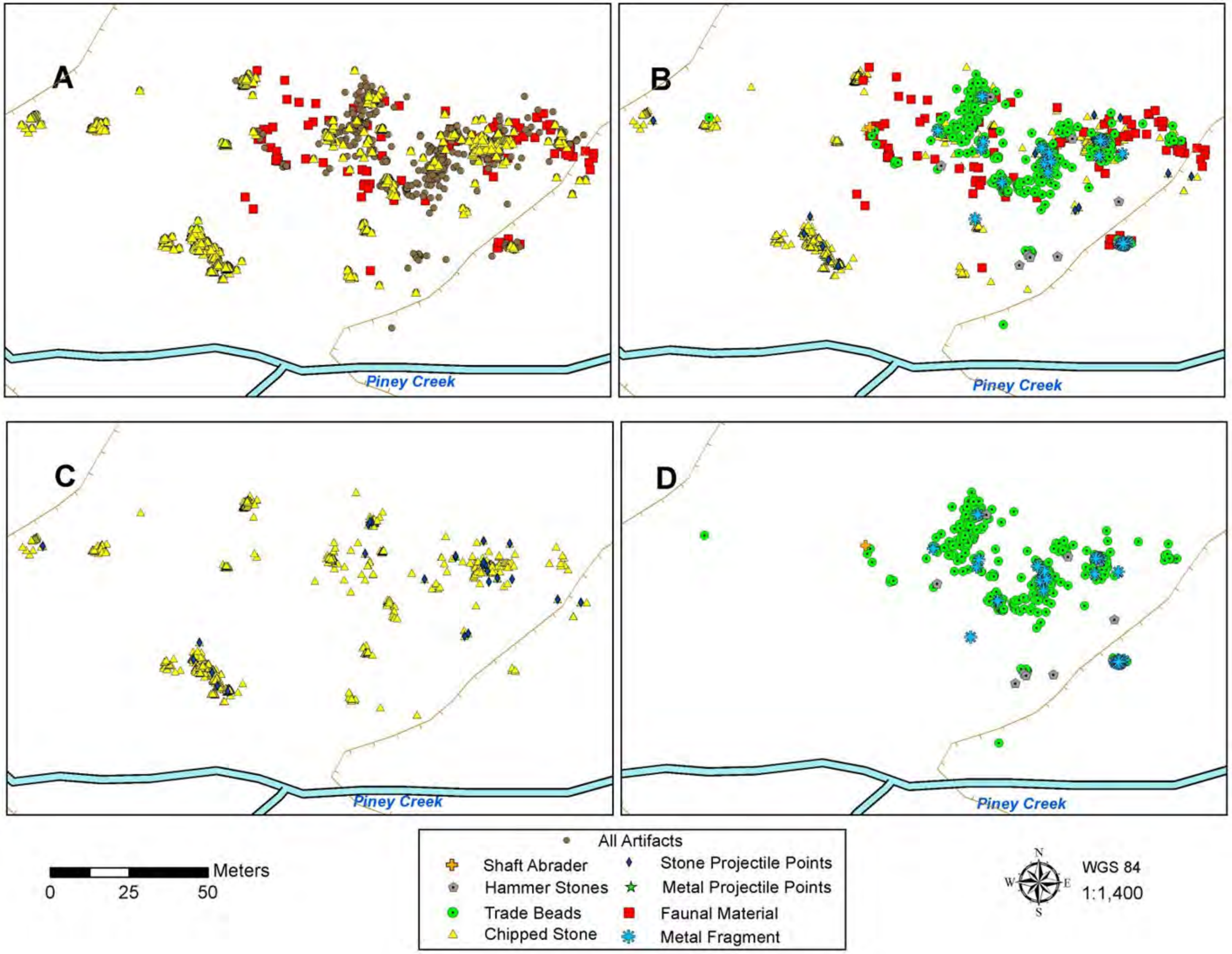
Table 3.5. Temporally diagnostic artifacts found on 48PA2772. From left to right the columns state the year the artifact was found, the type of artifact (element), and the time period.

Table 3.5 shows that there were more temporally diagnostic artifacts observed across the entire site; however, the area examined after the fire was only a fraction of the overall site area. In the seasons prior to the fire, there were a total of 5559 materials documented. In reference to the 38 diagnostic artifacts listed in Table 3.5, for every 146 artifacts on the site, one added a temporal element to the site assemblage. During the post fire field season of 2007 the crew documented 919 artifacts. Of those, 28 were temporally diagnostic. This means that for every 33 items recorded, one of those yielded information pertaining to when the site was occupied. The increase in diagnostics observed on the site changed the occupational range spanning the Early Archaic through the Late Prehistoric to a Paleoindian through Protohistoric site. Further, the size of the areas examined during the 2007 season was substantially smaller than the entire site area documented during the previous seasons. During 2003, the cultural material across the entire surface of the site (6.9 ha) was documented. With 5559 artifacts, this breaks down to 809 artifacts/ha. Again, 48PA2772 is a large site with a wealth of data and it was so even before the fire burned the surface. However, the OX patches on the site only count for a fraction of the total size. At $\pi 5m^2$, those patches account for a total area of .19 ha which is only 2.75% of the total site area. Comparing this to the breakdown of 2003 recording, the average artifact density in the 2007 recording was 29491 artifacts/ha. This increase in surface visibility the artifact density (though only examined in small area) increased information potential on this site and broadened occupation of this site to include the Paleoindian and Protohistoric periods. Thousands of years of activity were added to the interpretation of this site because of the artifacts documented after the fire.

Branch 2: Archaeology of the Upper Piney Creek Site (48PA3277)

During Colorado State University's archaeological fieldschool in Northwestern Wyoming, researchers documented the cultural material on the surface of 48PA3277, the Upper Piney Creek Site (UPCS). Figure 2.6 shows the overall location of the UPCS in relation the LFV. The fire burned across nearly the entire surface of the site. Of the 1698 artifacts observed on the site, 1661 were recorded in a burned context. Since there was no previous recording of this site, there can be no comparison of assemblage change due to increase surface exposure. However, since this area was surveyed before the fire and no material was observed at this location, it can be assumed that the increase in surface exposed caused by the burning was one of the factors that aided the finding and recording of the site. Relating this back to Branch 1, the LFV influenced the discovery of this site and how much material was documented. Figure 3.5 illustrates artifacts and features broken down by material type and components.

Figure 3.5. Material recorded on 48PA3277. **(A)** artifacts in relation to all of the faunal material**..** **(B)** breakdown of the various artifact types found on the site. **(C)** the stone material that can be assigned to the prehistoric component. **(D)** artifacts that are associated with the Protohistoric occupation.



The UPCS has both Prehistoric and Protohistoric materials. Initial temporal designations were assigned to prehistoric surface sites found in the GRSLE project area using a modified projectile point chronology developed by Frison (1991) for Northwestern Wyoming (Burnett 2005:29). For a more detailed description of the archaeological chronology of the Upper Greybull region refer to Burnett (2005). There are 950 pieces of chipped stone on the UPCS, 23 of those are stone projectile points, four are bifaces, two core fragments, 11 utilized flakes, and four worked flakes. Additionally there is one sandstone shaft abrader and 15 complete and fragmentary hammer stones. The lithic projectile points of the UPCS represent the Late Prehistoric. The Protohistoric materials on the site include 603 glass trade beads, three metal projectile points, 29 metal fragments, two brass balls, and one metal button. In addition to the prehistoric lithic materials found on the site, European trade goods, such as metal projectile points and glass trade beads, were used to assign a Protohistoric component to the UPCS.

Faunal elements were also recorded as part of the assemblage and collected for radiocarbon sampling. The majority of these remains were identified as bison (*Bison bison)* with a MNI of 13 (Craft 2008). Of those, six bison long bones exhibited cut marks and six exhibited impact fractures (Craft 2008). In addition to the bison remains, there were two bighorn sheep (*Ovis canadensis)* faunal elements documented. The faunal materials were clustered around 17 features. Two samples of bison bone were submitted from Feature 1 and analyzed by Beta Analytic. The first sample (Beta-237478) yielded a date of 200±40 BP and the second (Beta-248547) dated to 290±40 BP. Sample Beta-248547 exhibited a green bone fracture. The results of these radiocarbon analyses can be found in Appendix C. Table 3.6 is a summary of those dates noting both their 95% probability ranges and those points where the calibration curve crosses the intercept line for the radiocarbon samples.

Laboratory number	C^{14} age yr BP	2 Sigma calibrated results: (95% probability)	Intercept of radiocarbon age with calibration curve
Beta-237478	200±40 BP	Cal AD 1640 to 1700 (Cal BP 310 to 260) Cal AD 1720 to 1820 (Cal BP 220 to 140) Cal AD 1920 to 1950 (Cal BP 30 to 0)	Cal AD 1670 (Cal BP 280) Cal AD 1780 (Cal BP 160) Cal AD 1790 (Cal BP 160)
Beta-24854 7	290±40 BP	Cal AD 1480 to 1660 (Cal BP 4 70 to 280)	Cal AD 1640 (Cal BP 310)

Table 3.6. Radiocarbon dates from bison bone (*Bison bison*) recovered from Feature 1 on 48PA3277.

Trees, again, have come to the aid of archaeological investigation in terms of helping to calibrate radiocarbon samples to changes in global carbon 14 concentrations over time (Beta Analytic 2011, http://www.radiocarbon.com/tree-ring-calibration.htm). Tree rings whose growth year is known from dendrochronology are radiocarbon dated and those results are compared multiple times. From those comparisons, radiocarbon samples can be calibrated to calendar years (Beta Analytic 2011, http://www.radiocarbon.com/tree-ring-calibration.htm). Beta Analytic used the *IntCa l04* calibration database for the radiocarbon dates from the UPCS samples.

These radiocarbon dates correspond to the date ranges provided by the artifacts on the UPCS. The radiocarbon dates (Beta-237478 and Beta-248547) place the occupation of this site during the Late Prehistoric and continuing through the Protohistoric. Although at the earlier end of what is usually thought of as the Protohistroric in WY, the 14C dates agree with the date range evidenced by the metal projectile points, glass trade beads, brass balls, and other European trade goods. These archaeological data provide strong evidence for the timing of activity at one of the features at the UPCS. In terms of what was happening in the environment surrounding this site, attention can now be turned to the tree ring records.

The Timing of Humans and Fires in the Piney Creek Drainage: Dendrochronological and Fire Scar Results

The crossdating for this research was limited to the five needle pines of the Piney Creek Drainage. These cores were visually crossdated and skeleton plotted to illustrate the tree ring sequences across the drainage. The complacent samples were not used in compiling a tree ring chronology for this drainage. Of the 269 five needle pines sampled, 86 were skeleton plotted, and 48 of those exhibited ring patterns that allowed for crossdating. Six of those samples were measured to provide accuracy testing to the visual skeleton plots. The longest tree ring sample skeleton plotted extends back to 1493 CE (TC-060). Also, many of the trees had put on annual growth when they were sampled in the summer of 2008. These measured samples were entered into COFECHA to test to inter-series correlation between each sample (Grissino-Mayer 2001). Detailed information for COFECHA outputs can be found at the National Oceanic and Atmospheric Administration (NOAA) Paleoclimatology website (http://www.ncdc.noaa.gov/paleo/treering/cofecha/userguide.html). Table 3.7 shows the descriptive statistics of the COFECHA output.

Sample Number	Year Interval	Number of Years	Segments	Number of Flags	Inter-Series Correlation
TC198	1832-2007	176	4	0	0.583
TC196B	1741-2008	268	6	0	0.589
TC289	1894-2006	113	3	0	0.559
TC021B	1840-1990	151	3	0	0.602
TC189	1627-2005	379	6	0	0.642
TC055	1715-1994	280	5	0	0.623

Table 3.7. Descriptive results and statistics produced by COFECHA for samples measured to test the visual crossdating results. Sample Number is the tree-ring series, Year Interval are the earliest and latest crossdated rings, Number of Years is the number of rings including the earliest and latest, Segments are the number of 50 year lengths on the sample, Number of Flags is the number of problem segments, and Inter-Series Correlation is the strength of the measure signal between samples.

These measured samples were entered into the computer program ARSTAN (autoregressive standardization). ARSTAN was developed by Cook (1985) as a method of standardizing the autocorrelation created by growth trends in a tree ring sequence to compare climatic patterns recorded in the tree-ring series. Because a tree-ring series is an, "aggregation of several signals that become signal or noise only within the context of a specific hypothesis test or application," (Cook et al. 1990:97) those series have to be standardized to account for the individual "signal or noise" in each tree-ring series. "Signals" in tree-ring series are patterns that are relevant to a particular hypothesis (Cook et al. 1990:97). A common example of a "signal" indentified by a dendrochronological study is climatic patterns (Helama et al. 2004:240). The growth trends removed by ARSTAN are considered "noise" because the width of the tree rings is influenced by the age of the tree (Cook 1985; Helama et al. 2004). As a tree grows, the radial growths of the outer ring decrease because the annual ring from the previous growth period enlarged the surface area of the tree both horizontally (tree diameter) and vertically (tree height), (Douglass 1919:22). Figure 3.6 shows the chronology based on the measured samples with the growth trends removed by ARSTAN.

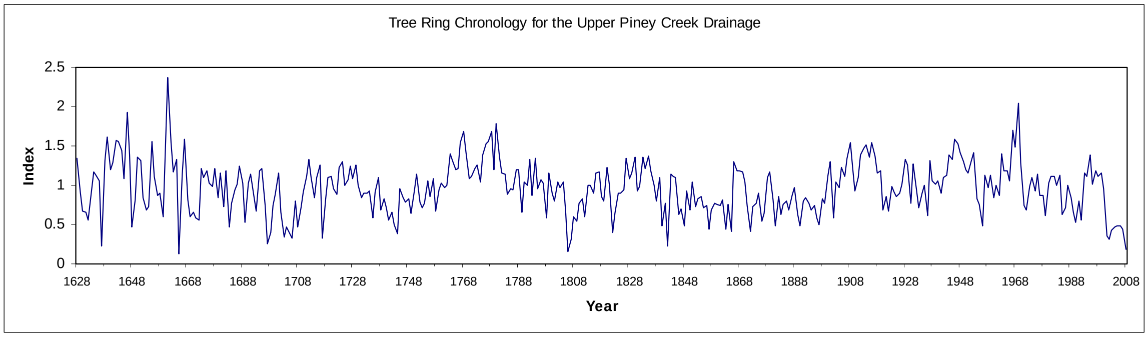


Figure 3.6. Tree ring chronology for the Piney Creek drainage. The growth index for each year has been standardized to a common mean of 1.0, using ARSTAN (Cook 1985).

One false ring was observed in the years between 1880 and 1890 CE on two of the samples (TC-026 and TC-147A). One false ring was also observed between 1920 and 1927 CE on sample TC-195. A “false ring” happens when the tree has two growth cycles within one season. This can happen for several reasons. For example the weather in the middle of the summer could be cold enough to cause the tree to shut down growth. When the weather warms later than summer, the tree begins growing again. Alternatively, it could become warm enough during a winter or early spring to start the growth cycle of the tree and then become cold enough during a harsh storm to again shut down the growth cycle. In both of these instances, the tree would exhibit two growth rings in a single year. Interestingly, Reiser (2010) compared the diaries of Otto Franc (a prominent figure in the history if this region) and other historic documents to the tree ring chronology she developed for the Jack Creek drainage, which is only about 10 km south/southwest of the Piney Creek drainage. Both the historic records and the chronology show that the 1880s experienced harsh winters (Reiser 2010:109-112). The winter of 1886-1887 was noted in the diaries and other historic letters and records to exhibit more than average snow fall and cold temperatures (Reiser 2010:108). Other documents noted little snow accumulation in the 1883 winter (Reiser 2010:111). Further, the tree rings show 1885 to be the smallest ring in the decades surrounding the 1880s (Reiser 2010:110). These dates noted by Reiser (2010) correspond to the small ring pattern between the 1880s and 1890s shown in the tree ring chronology for the Piney Creek drainage. The historic records described by Reiser (2010) match the false rings on the trees sampled in the Piney Creek drainage. Evidence Reiser (2010) describes supports the crossdating of Piney Creek tree ring samples. Further, this suggests that five needle pines and Engelmann spruce within larger Greybull River drainage are giving consistent regional patterns. Future tree ring research within the GRSLE project area, and the Greater Yellowstone Ecosystem, will expand these regional tree ring patterns and fire histories.

Six of the five needle (5N) pines in the Piney Creek drainage were visually identified to have fire scars. Those samples were crossdated against the master skeleton plot. Table 3.8 is a list of the scar dates that have been crossdated with the master tree-ring chronology constructed for the Piney Creek Drainage.

Tree Number	Year of Scar
TC-046	1951, 1971
TC-073	1648, 1797, 1931
TC-079	1821
TC-184	1973
TC-192	1954
TC-203B	1648
TC-226	1921

Table 3.8. Dates for the fire scars. These dates are based on the visual crossdating and skeleton plot comparisons from the sampled trees surrounding the UPCS.

These scars were sampled across the drainage to examine the spread of previous fires. Figure 3.7 illustrates the location of each of the fire scarred trees listed in Table 3.8 in relation to both the boundary of the LVF and the UPCS. Two of these samples (TC073 and TC-203B) share the same fire date. The spacing of these samples also suggests that the fire of 1648 CE spread through this drainage and covered much of the immediate area surrounding the UPCS. Further, the age of the trees sampled also gives proxy evidence that in 1648 CE there was a large, stand replacing fire. Figure 3.8 shows that the majority of the pith dates (year the tree started growing) are after 1700 CE. This suggests that the area of the Piney Creek drainage surrounding the UPCS was cleared of many of the whitebark pines after the 1648 CE fire. Figure 3.9 is a map of the pith ages of the trees sampled in the drainage.

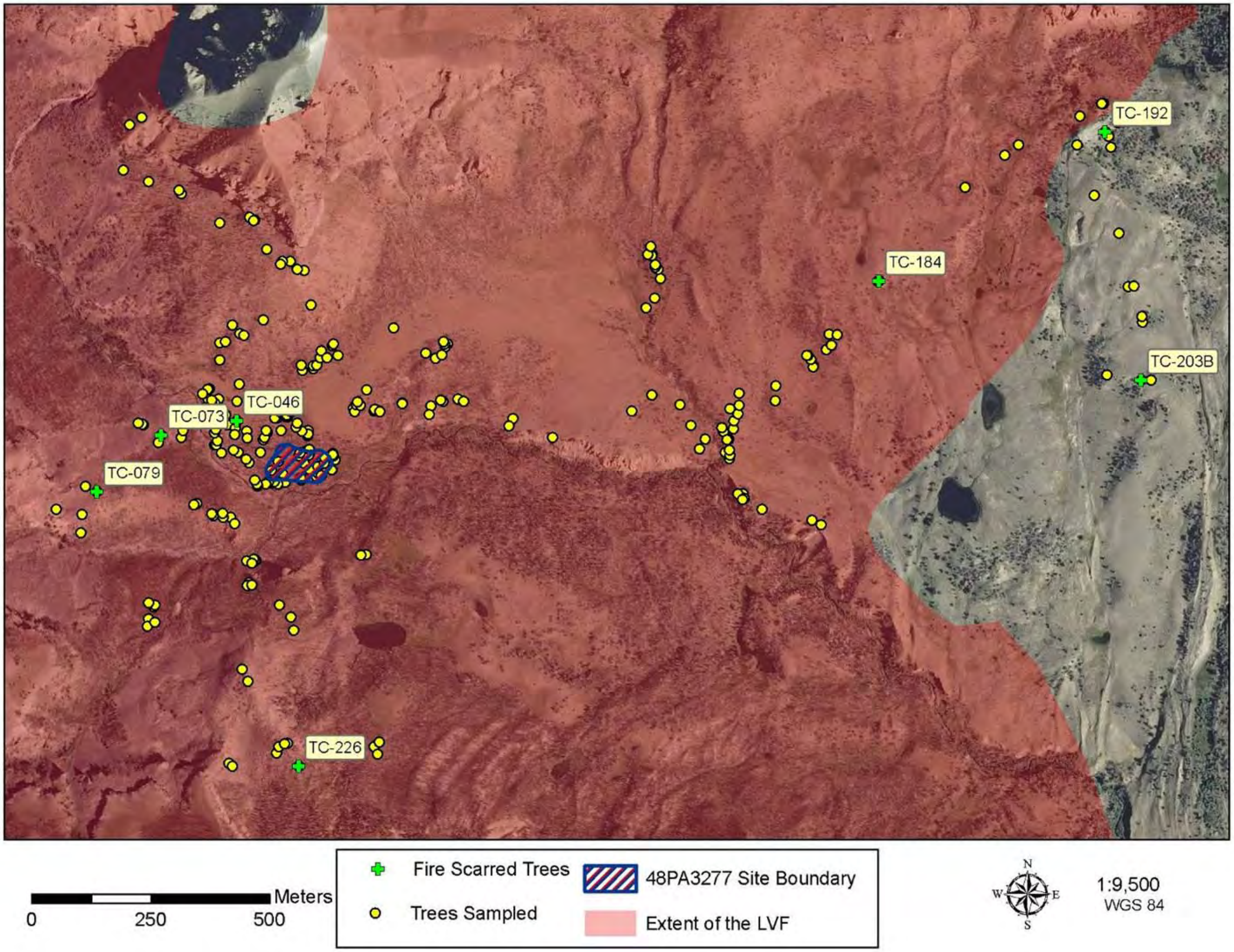


Figure 3.7. Location of the fire scarred 5N pines sampled in the Piney Creek Drainage.

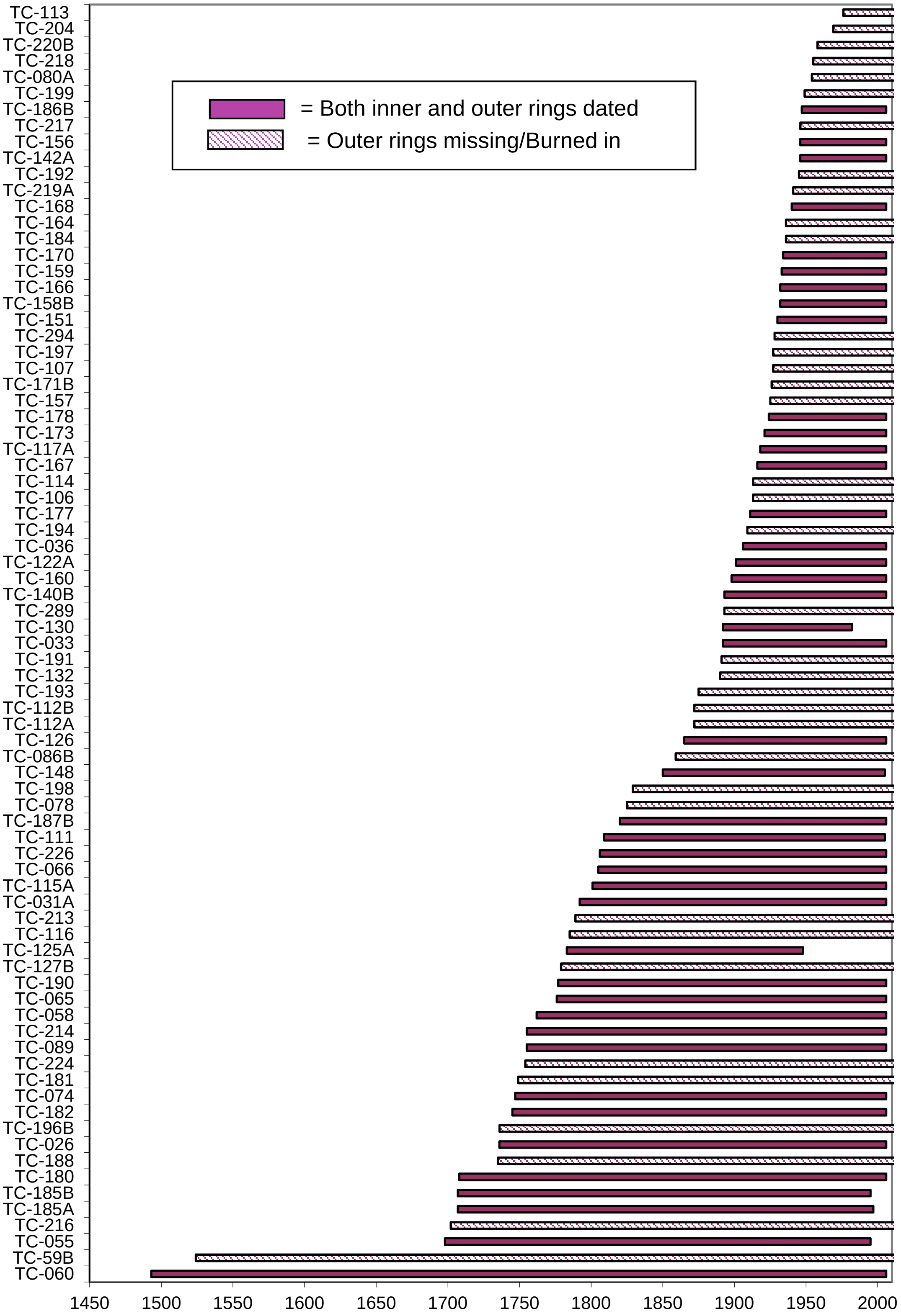


Figure 3.8. Pith dates for a subset of the trees sampled.

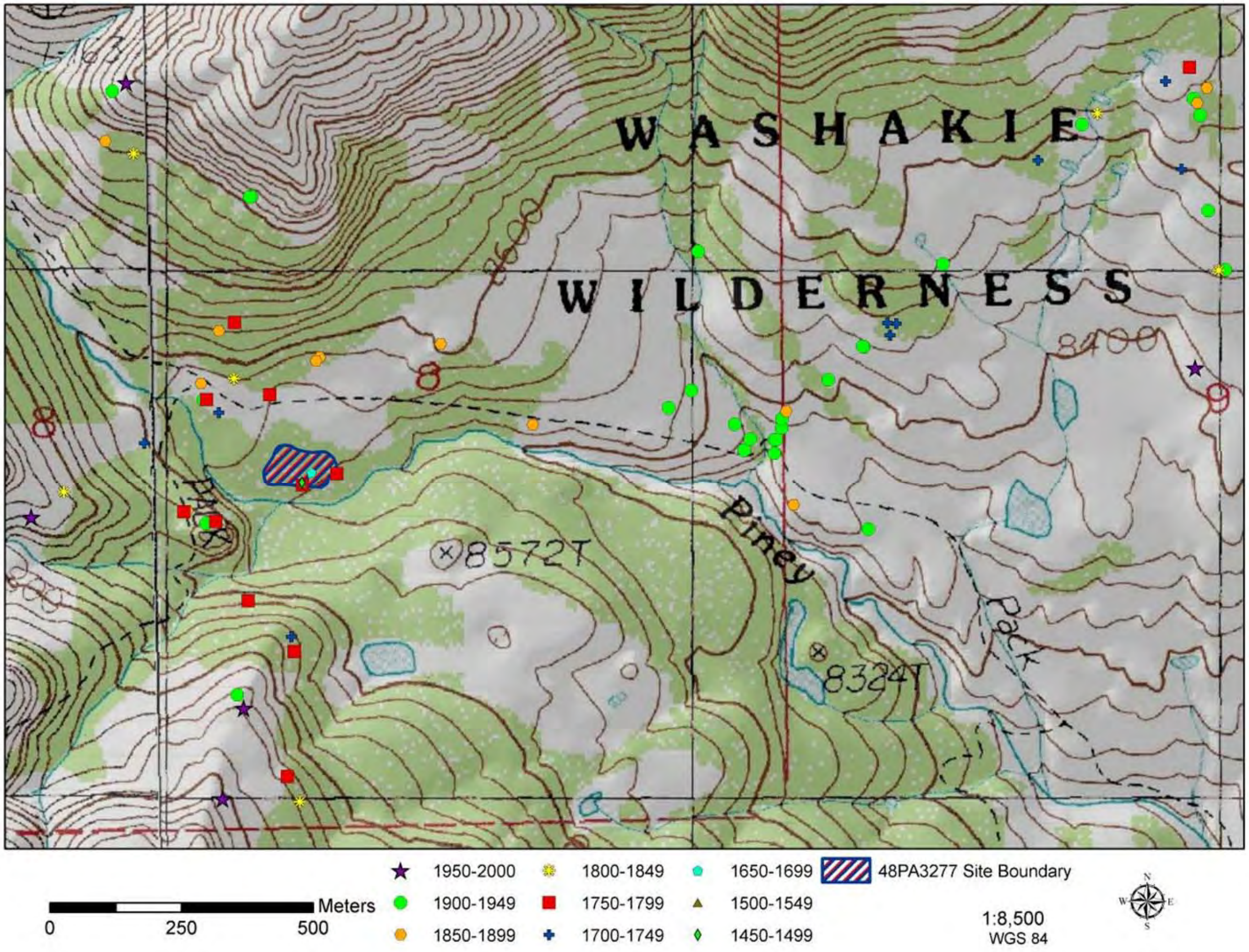


Figure 3.9. Distribution of trees sampled in the Piney Creek Drainage broken down by age class.

All of the other scars are single scar events and their identification is unclear. Single scars represent a unique challenge in determining the cause of injury (Walsh 2005:19). However, visual identification of the fire scars on TC-073 was also used to identify the cause of the scars. TC-073 serves as a sort of Rosetta Stone for timing past fires in the Piney Creek drainage to the occupation sequence of the UPCS. Multiple scars were recorded on this tree sample. Figure 3.10 is the cross section taken for TC-073 noting the years of each fire scar. The tree ring variation of this cross-section crossdates with the master skeleton plot created for the Piney Creek Drainage.

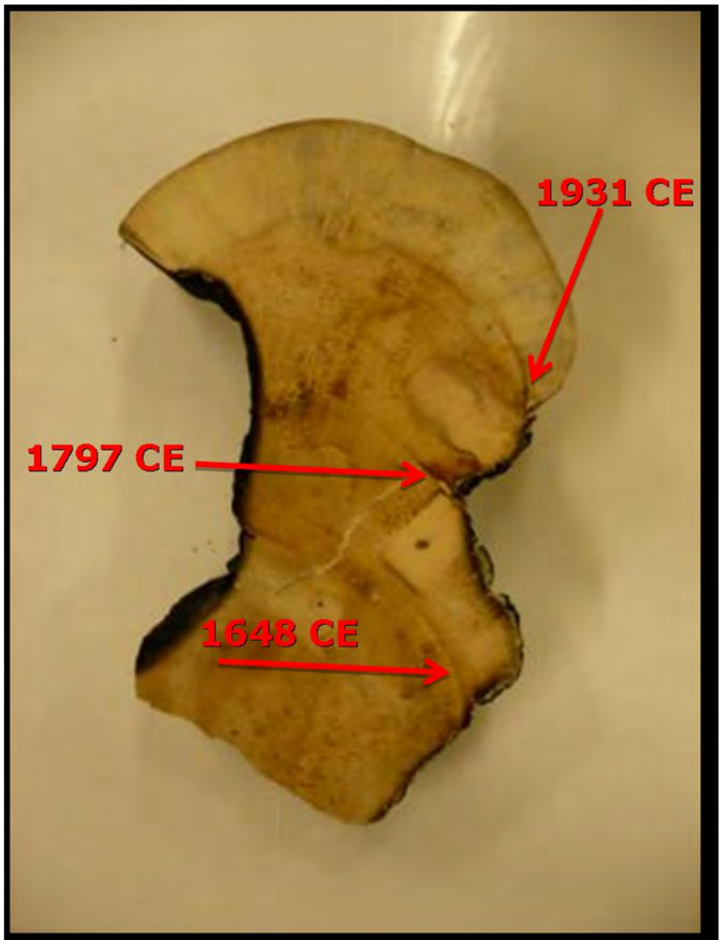


Figure 3.10. Cross section (TC-073) with fire scars. The dates of the scars are 1648 CE, 1797 CE, and 1931 CE.

The earliest fire scar (1648 CE) shown in Figure 3.10 falls within the standard deviation of the radiocarbon dates for the UPSC (Figures 3.11 and 3.12) suggesting that humans were occupying the site in the years surrounding this fire. Further corroboration of this timing is evidenced by the artifacts on the UPCS. The obsidian tri-notched point suggesting a Late Prehistoric occupation overlaps with the 1648 CE fire and both the trade beads and metal projectile points representing the Protohistoric occupation overlap both 1648 CE and 1797 CE fires.

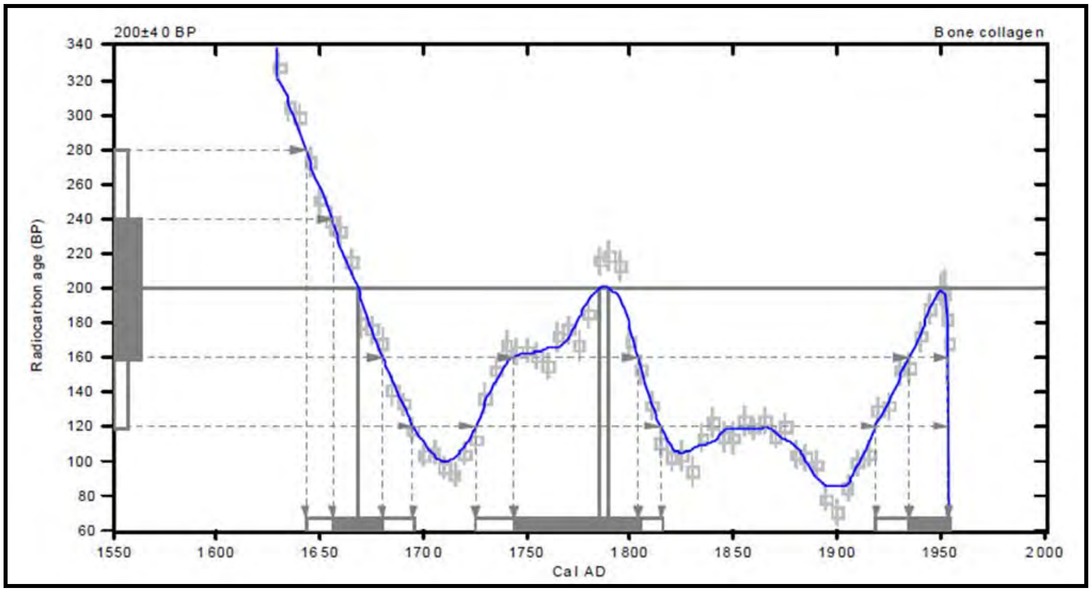


Figure 3.11. Beta-237478 radiocarbon sample from the bison bone found in proximity to Feature 1 on the UPCS showing the relationship between the radiocarbon age and the calibration curve.

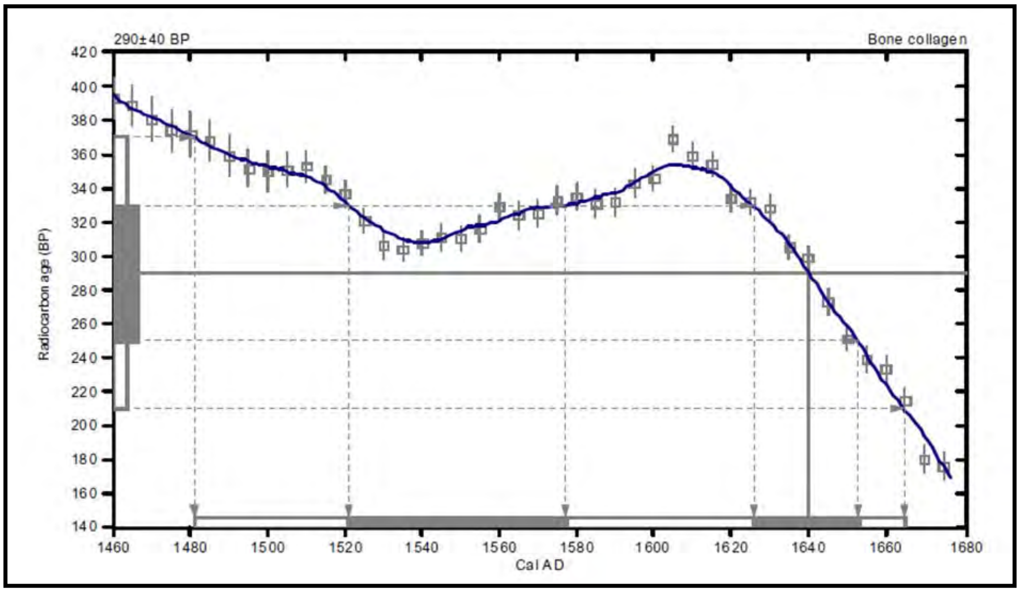


Figure 3.12. Beta-248547 radiocarbon sample recovered in proximity to Feature 1 on the UPCS. Sample collected from bison bone in proximity to Feature 1.

Figure 3.13 compares the sets of dates (fire dates and radiocarbon dates). The dates of the fires fall within the 2 sigma calibrated radiocarbon dates from the faunal material. This suggests that people were occupying the UPCS in the years surrounding past fires. Though these results cannot show specific years people were using this site, the overlapping date ranges of the two radiocarbon samples does suggest that the Mountain Shoshone might have been living in this drainage in the years immediately surrounding the fire 1648 CE.

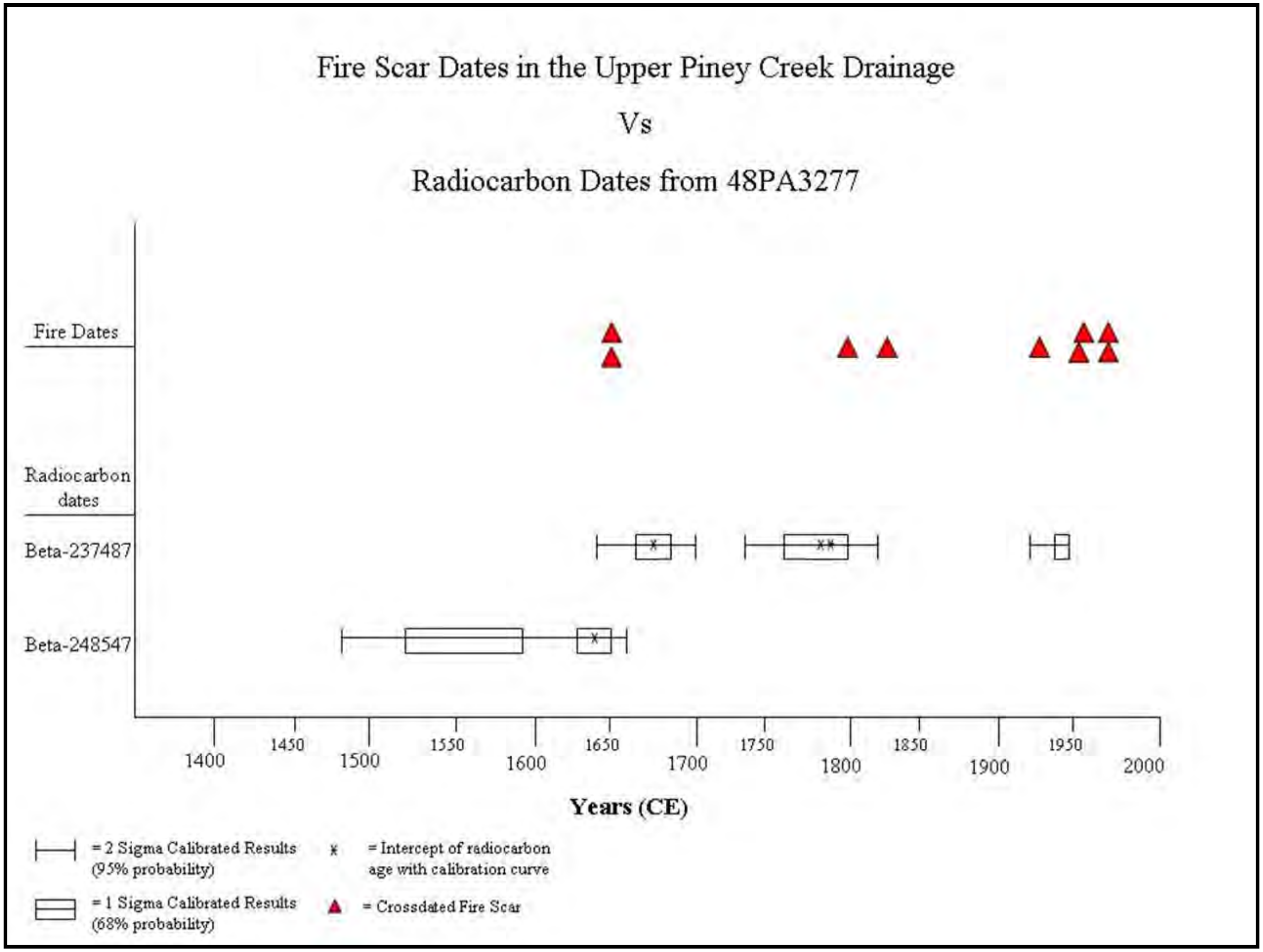


Figure 3.13. Calibrated radiocarbon dates from the faunal material (bison) from 48PA3277 compared to the fire scar dates. Note that the fire scar dates fall within the standard deviation of the radiocarbon dates.

Summary

This chapter discussed the results of both branches described in Figure 1.1. For Branch 1 (comparing the change in artifact densities in pre and post fire environments), burned ground surfaces exhibit an increased number of artifacts recorded. Fires increase the visibility of surface artifacts and increase the access to diagnostic artifacts during surface documentation of archaeological material. Examples from multiple sites across the GRSLE project area show that this happens on both the broad and small scale. The majority of sites documented in 2007 exhibited a greater number of artifacts in areas where the vegetation had been removed by the LVF. The analysis of flake debris offers important information for archaeological investigations (Sullivan and Rozen 1985:755; Shott 1994:69). Having the most reliable and effective research strategies helps archaeologists plan and execute field work (Binford 1964:433). Stand replacing fires in subalpine settings burn across large areas removing much of the surface vegetation. These burned areas should be targets for archaeological investigations (Burnett and Todd 2008). Rerecording of sites after fires not only gives researchers the chance to document additional material at that specific location, but they act as field experiments to understand site formation processes (Todd 2008). Fires impact the discovery and documentation of archaeological sites in modern contexts by removing the vegetative cover and allowing researchers to document the material underneath.

The results of Branch 1, the increase in surface visibility, lead to the discovery of the UPCS and helped compare the timing human occupation to when past fires burned the Piney Creek Drainage. Artifacts and faunal elements that had been protected by the vegetation covering the ground surface were exposed as a result of the LVF. Additionally for Branch 2 (comparing the years of past fires of the Piney Creek Drainage to when UPCS was used), the visually identified and crossdated fire scars indicate that previous fires have burned through this drainage. The archaeological materials and the radiocarbon samples indicate that people have been living in the Piney Creek drainage in the years surrounding the 1648 CE fire. Grouping the pith dates indicates that many of the trees surrounding the UPCS germinated after 1700 CE. Additionally, very few (N=2) trees sampled germinated before 1650 CE. This suggests that many of the trees died in the 1648 fire, and that parts of this drainage remained relatively free of whitebark pine for several decades. The overlap of the two radiocarbon samples from the bison bone and the time periods associated with the temporally diagnostic artifacts strongly suggest people were occupying the UPCS in the years surrounding 1648 CE fire. The complex, interwoven relationship between this fire, plant and animals communities living in this drainage, and the humans using the UPSC warrants more discussion than can be provided in this brief chapter summary. As ecological systems, their relatedness often compounds their complexity. The following chapter will examine these interactions in greater detail.

CHAPTER 4: DISCUSSION AND IMPLICATIONS

This chapter will discuss how the fire of 1648 CE would have impacted the resources for the people occupying the UPCS. The following section will focus on the interactions between fires, bighorn sheep, and bison populations. The vegetation that comprises understory plant communities (grasses, forbs, and shrubs) responds quickly to fires in that many species are adapted to regenerate in post fire environments (Lentile et al. 2007:104). This vegetative response influences the habitats of animals that forage in subalpine settings and increases the quantity and nutrient richness of forage in areas of the Rocky Mountains (Lyon et al. 2000). Since no post fire vegetative study had been conducted in the Upper Greybull region, much of the evidence for this section will rely on studies conducted elsewhere on both vegetation responses after fires as well as bighorn sheep and bison responses to post fire environments.

This research serves as a pilot study in understanding the timing of human occupations to past fires. Future research will be discussed because it is crucial for broadening this approach and accumulating a robust knowledge base to understand this relationship over the broad scale. This chapter will end with a section relating the potential danger of fires to the archaeological record.

Timing Humans and Fire on the UPCS

Radiocarbon dates will not reflect every year humans were on or in the area of the UPCS. Nor can each faunal specimen be sampled from the site. Radiocarbon dates (as well as other types of dating methods predominately used in archeological research) can be accurate at the century scale. They represent a general time range (Guilderson et al. 2005). The Mountain Shoshone, or Sheep Eaters, were known to have lived in what is now the Greater Yellowstone Ecosystem. Mummified human remains from Mummy cave that date to 1230 radiocarbon years BP have been associated with the Sheep Eaters (Loendorf and Stone 2006:23). The radiocarbon dates and artifact typologies represent the period the Mountain Shoshone could have frequented this area. The remainder of this section will discuss some the benefits for the Mountain Shoshone if the date range for their occupation of the UPCS was in the pre or post fire years surrounding the 1648 CE fire. Further, since the trees sampled in this area were dominated by five needle pines, and given the elevation range of the Piney Creek Drainage, this section will focus on the large stand replacing fires that typify the fire regimes of whitebark pine communities.

Whitebark pine communities are thought to have three types of fire regimes (Walsh 2005:3). Each of those regimes would have influenced how the pre and post environment surrounding the UPCS would have developed. Mixed-severity fire regimes have been documented in lower elevation whitebark pine communities (Larson et al. 2009:292; Walsh 2005:3). The Piney Creek Drainage is a subalpine environment. Given that many similar environments are typified by infrequent, high severity fire regimes (Allen et al. 2002; Larson et al. 2009; Romme and Turner 2004; Schoennagel et al. 2004; Sherriff et al. 2001; Turner et al. 1994; Walsh 2005) it can be assumed that infrequent, high severity fires typified the fire regime of the Piney Creek Drainage.

These stand replacing fires effect the ecology of the whitebark pine. Whitebark pine nuts were an important food resource to the Mountain Shoshone (Adams 2010:96) and even treated as a delicacy (Loendorf and Stone 2006:158-159). These nuts are "one of the densest forms of calories per kilogram in the Greater Yellowstone Ecosystem," (Adams 2010:95). In fact, the high fat content of these nuts is very important to bears in the Greater Yellowstone Ecosystem (Mattson and Reinhart 1997; Podruzny et al. 1999). Red squirrels accumulate large caches of whitebark pine cones to later harvest the nuts (Podruzny et al. 1999:131). When large caches of whitebark pine nuts are available, they comprise the overwhelming majority of bear diets (Mattson and Reinhart 1997:927). Bears have been known to consume 90% of an individual cache during a single sitting (Mattson and Reinhart 1997:92).

These large whitebark pine caches would have been a valuable food source for the Mountain Shoshone if they would been occupying the UPCS in the years preceding the 1648 CE fire. Whitebark are adapted to germinate in a post fire environment (as discussed in Chapter 1). During these periods of whitebark dominance the availability of whitebark pine cones and nuts is highest for the bear, squirrels, Clarks Nutcracker, and humans. In one example from the Bitterroot Mountains of Montana, a whitebark pine community lasted 200 years before being replaced by subalpine fir (Keane 2001:176). Stands in subalpine zones of the Greater Yellowstone dominated by whitebark pine are often self-replicating communities (Tomback et al. 2001:11). Rather than slowly transitioning back and being replaced by a stand community dominated by shade tolerant tree species, high-severity fires typically truncate this transition (Baker 2009:305).

Translating this back to humans, the Piney Creek drainage was likely dominated by whitebark pine before the 1648 CE fire. Abundance of whitebark pine nuts would have been an advantage to the humans occupying the site. The location of the UPCS before the 1648 CE fire would have been advantageous if whitebark pine nut acquisition was one of the main activities. There is no direct evidence of the consumption of these nuts on the UPCS. However, another benefit of pine nuts is that they do not need to be roasted to be digestible (Adams 2010:95). This lack of roasting or processing required by pine nuts does not leave a large material record.

The butchering of animals does leave a material record. Both big horn sheep (*Ovis canadensis*) and bison *(Bison bison)* were important resources to the Sheep Eaters of the Piney Creek drainage. Both of those species would have been likely to frequent a post-fire environment for the following reasons. Bison are graminivorous and in the western forests of the Rocky Mountains, the biomass of grasses and forbs generally increases after the first 5-10 years following a stand replacing fire (Lyon et al. 2000:56). Additionally, evidence for the bison seasonally choosing area burns comes from the Plains regions and other grassland ecosystems (Coppedge and Shaw 1998; Wallace and Crosthwaite 2005). Though not in the same environment, studies of bison on the plains can be used as a proxy for the behavior of bison in a post-burn environment. However, bison and elk in Yellowstone have been documented to frequently graze burned areas in the winter months (Pearson et al. 1995; Turner et al. 1994). The possibility exists that grazing in those burned areas in winter is more productive for the ungulates (Pearson et al. 1995:752).

Additionally, reduction of sagebrush after a fire is advantageous for big horn sheep because it opens the area for more shrubs (Peek et al. 1979:30). Also, the sheep prefer the open environments (like those that follow disturbances such as fire) because they can see predators (Risenhoover and Bailey 1985; Smith et al. 1999). Rocky Mountain bighorn sheep avoid areas with tall thick vegetation and come into areas after that vegetation (tall grasses, large shrubs, and trees) have been removed (Risenhoover and Bailey 1985:802). Further, burns in the San Gabriel Mountains of California have been documented to increase the carrying capacity for big horn sheep (Holl et al. 2004). Additionally, on the Bear Mountain Plateau in the Flaming Gorge National Recreation Area of Utah, big horn sheep were documented to frequent the areas where logging and prescribed burning were used to thin dense sagebrush and juniper-encroached meadows (Smith et al. 1999: 842).

The bottom line is that bighorn sheep are known to preferentially occupy areas that have recently burned more than unburned, heavily forested areas (Bentz and Woodard 1988). In the Interior Subalpine regions of the Rocky Mountains in Alberta Canada bighorn sheep pellets (fecal material) are more frequent in downslope burned areas (Bentz and Woodard 1988:190). Bentz and Woodard (1988) sampled four fire disturbed stands on the eastern slopes of the Rocky Mountains in Alberta Canada to understand the movement of bighorn sheep. To assess whether the sheep preferred burned versus unburned settings, they documented the frequency of bighorn sheep pellets. Documenting the frequency of pellets in 100 meter intervals, they found that in all sample areas, the density of pellets was higher in and closer to those areas burned (Bentz and Woodard 1988:191).

Burning also increased the crude proteins in all herbs sampled as part of Cook et al.’s 1995 study near Prospect Mountain outside of Douglass Creek in Wyoming. The study examined the post fire vegetative response at five burned plots at roughly 2400 meters in elevation (Cook et al. 1995:297). Burning increased the quantity of crude protein in all herbs at all southcentral Wyoming locations studied by Cook et al. 1995.

While the growth of many of the plants that big horn sheep typically forage on (herbs, shrubs, and forbs) were depressed in the first post burn year (Cook et al. 1995:299), the second and third years witnessed significant increases in the herbaceous vegetation (Cook et al. 1995:298). These increases in both vegetative quantity and quality benefit both bison and bighorn sheep, and by extension the humans using these animals.

Native Americans, in other areas of the west, recognized the vegetative benefits of burning to create open areas and promote horse pastures (Williams 2003:3). For example, before the Willamette Valley was the destination for many travelers crossing the Oregon Trail, the Kalapuya used fire to modify the valley to horse pasture (Williams 2002:11). However, the Mountain Shoshone of the Piney Creek drainage did not have large horse herds during the mid 1600s. According to the Captain Bonneville's 1835 recordings, the "Sheepeaters," had no horses (Dominik 1964:135; Loendorf and Stone 2006:4). Though early accounts of the Mountain Shoshone are derogatory (Loendorf and Stone 2006:5), many of those accounts agree that much of the Mountain Shoshone's time was spent in the mountains, far from white settlements and horses (Dominik 1964). Allen (1913) retold a conversation in an elderly Sheepeater woman who stated that her group had no dogs or horses and when they encountered a party of mounted Sioux stated that, "the ponies in the valley below were strange looking creature so us; we had never seen them before" (Allen 1913:17).

In the 1730s, established trade routes extending from New Mexico did bring horses to the Mountain Shoshone and allowed for them to extend their range farther into the plains (Loendorf and Stone 2006:13). However, when subsisting on bighorn sheep, the use and reliance on horses may not have been practical (Dominik 1964:42-43).

Wintering, for the Mountain Shoshone, probably followed the game to lower elevations but still near the foothills of the mountains (Dominik 1964:43). When travel did return to the mountains, many of the steep and narrow trails would have been difficult to traverse on horseback (Dominik 1964:43). The reliance of Mountain Shoshone on the bighorn sheep could have limited their need for horses before the trade routes extended in the mid 1700s.

Though the majority of the faunal material present on the UPCS is bison, the ethnographic literature on this region states the importance of big horn sheep to the Mountain Shoshone (Sheep Eaters) (Loendorf and Stone 2006). This site is only one example in a vast collection of sites, and the dominance of bison in the assemblages can be taken as evidence that the Mountain Shoshone probably relied on a wide range of resources and game. However, given the dominance of bighorn sheep in the ethnographic literature, the remainder of this section will focus on the interaction between big horn sheep and fire.

The behavior of the big horn sheep would have been very important to the Mountain Shoshone, also known as the Sheep Eaters (Loendorf and Stone 2006). Not only were the big horn sheep an important food source, but they were also crucial for the impressive bow technology of the Mountain Shoshone (Loendorf and Stone 2006). To construct the bows, the horn cores from big horn sheep would be soaked in a hot spring to soften the keratin sheath rendering the horn pliable. The curve of the horn was then reversed, shaped, and left to dry. Later, “sinew-backing” would be applied to the curved horn. Resulting from this process was a bow 75 to 100 cm long with impressive 60-70 pound pull strength (Loendorf and Stone 2006:125). If big horn sheep would have been drawn to the post burn environment of the 1648 CE fire, the Sheep Eaters would have likely been drawn to those areas in search of their namesake. In sum, the post fire environment of the 1648 CE fire would have yielded beneficial conditions for the bison and sheep that humans used for resources. Since the humans living in Piney Creek drainage would have had to follow the bison and big horn sheep, they too would have been drawn to these burned environments.

Future Research

. This thesis is a drop in the bucket of research that has been accomplished in this region. GRSLE projects have encompassed an impressive array of research topics. From the dating of historic cabins (Reiser 2010), the influence of pocket gophers on site formation process (Bechberger 2010), understanding the timing and influence of large scale disturbance events on geomorphic process (Ollie 2008), understanding prehistoric landuse through obsidian sources (Bohn 2007), high altitude structures (Kinneer 2007), the correlation between temperature gradients and habitat structure (Derr 2006), economic aspects of historic mining in the Absaroka Mountain (Mueller 2007), projectile point typologies and lithic clustering patterns through time (Burnett 2002), and how landscapes help shape the archeological record (Reitze 2004). Together these projects (and the large body of continuing research) have sought to understand this ecosystem holistically while documenting the interaction of large geomorphic processes on archaeological materials.

As discussed in Chapter 1, the relationship between humans and fire has spanned the course of human prehistory. The archaeological information that has been recorded in the Upper Greybull can be compared to the fire history across this region. Past thesis research has already constructed a master tree ring chronology for the Jack Creek Drainage to the south of the Piney Creek drainage (Reiser 2010). These tree ring records can not only help construct the fire history of this region, but they can also map out the climatic variation for the past several hundred years. This climatic pattern, when coupled with the fire history and pattern of landscape change, can also help to understand how fires act as disturbance agents in the geologic processes of this region (Ollie 2008). Additionally, further tree ring studies and climatic reconstruction can add a great deal to documenting the timing of past fires. Subalpine fires are connected with global climatic teleconnections (Baker 2009; Schoennagel et al. 2005). Two things can come from this type of analysis. Paleoclimate reconstructions can be compared with the records of prehistoric populations to help understand broad scale patterns in both mobility and subsistence. Also, more research needs to be conducted on the role whitebark pine nuts play in subsistence strategies. Currently, research pertaining to the roll of climate on human subsistence is being conducted in the Wind River Range of Wyoming (Losey 2012:7). Losey's study is using whitebark pine (and their nuts) to understand the human responses to climate. The whitebark of the Piney Creek drainage (and the Upper Greybull at large) would be a great compliment to that research.

Further, gathering tree rings for paleoclimate research will have the benefit of providing pre-made chronology for dating perishable archaeological structures. With this region's history of sheep traps, wickiups, and historic cabins, having sources that could quickly provides dates to many of these remains will add to the ability of archaeologist to identify and protects these vanishing resources. The timing of this work is crucial as more fires burn across many areas of the west that have been undocumented to inadequately surveyed for archaeological remains.

Additionally, it can be tested whether or not those paleoclimatic records match the fire histories in the drainages of the Upper Greybull. The importance of this question reaches for the role humans played in the fire regimes of subalpine systems. As discussed in the introduction, fires in subalpine settings need certain environmental conditions (early summers, fuel loads, and ignition sources) to burn naturally. Connecting the fire histories across multiple drainages strengthens evidence for the size of past fires. If these fires are burning in times when the climate alone does not support large subalpine fires, humans may have played a role in either their ignition or promotion.

Increasing surface visibility obviously has research potential to archaeological surface survey. One avenue that will be explored in this section is predictive modeling. For example, additional archaeological materials add strength to predictive models of site locations (Burnett and Todd 2008). One question that can be asked is “could the new artifacts documented after the LVF on the previously recorded sites change a predictive model of site location in the Upper Greybull region?” Because the GRSLE project has been conducting research since 2002, there were a number of sites documented both before and after the fire. Not only would these types of data benefit taphonomic research curiosities, but it would also serve as evidence to governmental organizations for potential decreases in future resource management costs. Building better predictive models would speed the location of archaeological sites. Less time spent on survey in areas that have low probability of yielding archaeological material means more time spent in higher probability areas and more time documenting the resources in those locations.

While preparing for the defense of this thesis an announcement by the Joint Fire Sciences Program called for proposals examining the interaction between fire and other fields (http://www.firescience.gov/JFSP_funding_announcements.cfm). One of those fields was cultural resources. My current supervisor at the USDA Forest Service, and I used results and methods of this thesis to outline a research proposal (Appendix D) that will be kept up to date and on file for future projects.

Fire Introduced Dangers to the Archaeological Record

So far I have described the benefits fire can provide to both people of the past and the archaeologist who are trying to interpret and preserve that human record. However, fires that happen today can have negative impacts on the archaeological record. In the same way fire can help increase the potential for knowledge on an archaeological site; it can also lead to the destruction or removal of that knowledge.

Fire-related alteration of the archaeological record comes in multiple forms. First, intense fire can destroy perishable items such as textiles, rock art, and wooden structures (in the project area, specifically wikiups, mountain sheep traps, and historic cabins). The destructive power of fire to perishables can be easily understood in that fire is fueled by a mixture of oxygen and organic material. However, analyzing how fire affects rock is more difficult to conceptualize (Thompson & Hunt 2007). When rock is exposed to high levels of heat the outer layer is shed and creates thermal spalling (Buenger 2003:6). An example of this type of spalling damage comes from art panels exposed to high temperatures. After a portion of the panel has spalled the rest will most likely be lost through spalling of the rock surface (Johnson 2004).

According to the Zyroth law of thermodynamics the temperature from a warmer body transfers to a cooler body until the two temperatures are equal (Incropera and Dewitt 2002). This process creates a thermal stress on materials such as stone tools (Buenger 2003:14). In terms of lithic artifacts, this rapid release of energy and thermal stress can cause heat fracturing and the thermal spalling. These thermal spalls on artifacts are called "potlids" Figure 4.1 is an artifact that has both potlidded and fractured as a result of exposure to the LVF.

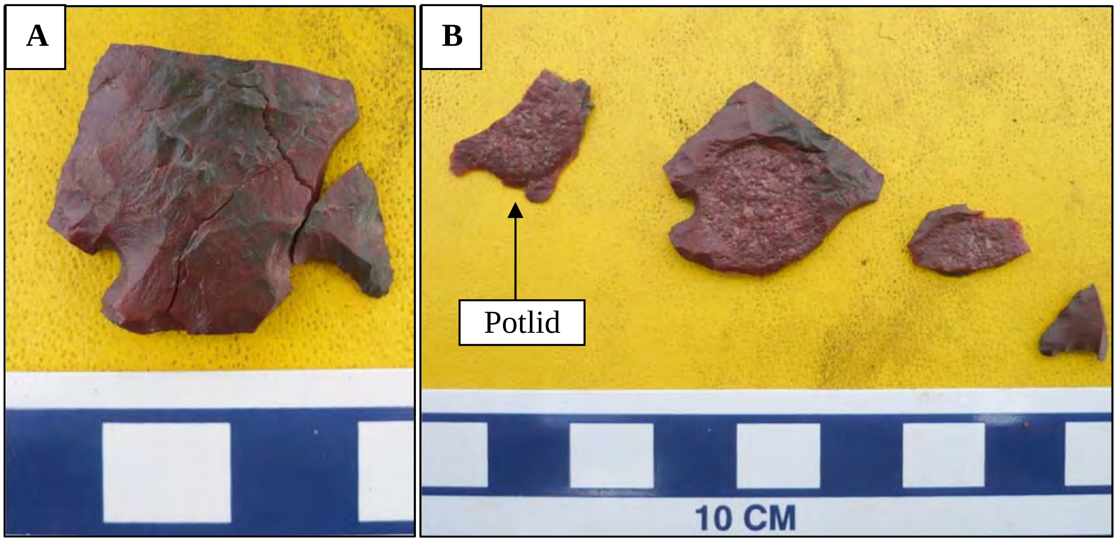


Figure 4.1. Potlidded and fractured Late Archaic phosphoria projectile point from Site 48PA3132 found after the LVF. Artifact number TRIMB07-6613. **(A)** fractured artifact and potlid refit. **(B)** fractured artifact and potlid separated. The arrow points to the potlid that spalled from the main body of the projectile point.

While it is very likely that objects representing cultural heritage such as rock art and other material remains have at some point been exposed to fire (McCabe et al. 2007), the degree of exposure to variable levels of thermal alteration depends on types of fuel loads (Buenger 2003:8). For example, the probability is low that fine fuel compositions of riparian and sagebrush areas will provide the necessary soil surface temperature to thermally alter stone artifacts unless they are directly under the fuel source (Buenger 2003:309-310). For riparian areas, this means artifacts would have to be directly under large willow species. In sagebrush environments the artifacts would need to be immediately sheltered by sagebrush canopies (Buenger 2003:310).

However, in areas dominated by high intensity crown fire regimes, temperatures can reach between 500˚C and 750˚C providing temperatures needed to thermally alter stone artifacts and even ceramics (Connor et al. 1989). The introduction of large crown fires into areas that were once typified by low intensity surface fires exposes artifacts to high intensity fires that they may not have been subject to in the past.

These fires not only physically damage the artifacts, but they also expose the artifacts by removing ground surfaces that have protected the underlying materials. Ironically, this second danger to the archaeological record is also one of the greatest advantages to archaeologists after a fire has burned an area. Fire clears vegetation and increases surface visibility of archaeological remains (Johnson 2004). When fires burn away surface vegetation of previously surveyed areas, or even known archaeological sites, they expose otherwise covered materials and the potential increases to change the density and visible distribution of cultural materials within and around an area or site. Altering densities and survey coverage areas can be seen as a site formation process

(Burnett 2005:18). In archaeological analyses, types of artifacts and other cultural materials (including features) form the basis for interpretation and analysis of archaeological sites. However, if aspects of sites are missed by surveyors and archaeologists because of dense surface vegetation or other aspects of survey design then crucial pieces to interpretation of these areas and sites will not be factored into analysis. Uncovering pieces of the archaeological puzzle adds additional information that can potentially increase the time, space, and interpretations a site represents. Surface burning increases the amount of information that can be gathered by surface survey,

As potentially helpful as fires are to archaeologists seeking to preserve and interpret the past, they are also dangerous (Burnett and Todd 2008). Decreasing the amount of surface vegetation increases exposure to looting. Looting practices have had a large cumulative effect on the archaeological record (Brodie and Renfrew 2005; Clewlow et al. 1971; Labelle 2003). Again, missing pieces from the archaeological record can lead to missing lines of data that can potentially hinder interpretations of the past.

When the frequency of low end looters, collectors, and surface hunters is considered in the Great Plains region since the Dust Bowl, the long-term impacts of their ubiquitous and cumulative low-level looting become very severe (LaBelle 2003). Coupling the frequency of artifact looting in North America with the decreasing protective ground cover, heightens the risk of theft to cultural remains. In areas that have been frequented by low severity surface fire regimes, such as lower elevation Ponderosa Pine forests, danger to the materials was lessened through fire suppression activities. In contrast, high elevation subalpine forests dominated by infrequent high severity crown fire regimes, surface vegetation has remained more intact during the long gaps between stand replacing events. In subalpine settings, increasing post-settlement contact through recreation and habitation at a time when global climate change may increase the size and severity of large stand replacing fires will further expose cultural remains to contact with potential looters. This situation means that there is urgency for more archaeological research to be conducted as soon as possible after the protective ground cover has been removed (Burnett and Todd 2008).

For example, the two components (Paleoindian and Protohistoric) were previously unknown to researchers on site 48PA2772 even through previous summers of intensive surface documentation. The burning allowed the crews to not only uncover a Protohistoric occupation, which gave the site much more recent context, but also extended the occupation history to include the Paleoindian record. If looters would have arrived at site 48PA2772 after the burn, but before GRSLE field crew, they would have had the potential to steal those archaeological material that had been hidden by surface vegetation (taphonomically active zone) taking away those components and the people they represent. Since artifacts are the "basic units of observation," (Binford 1992: 44) their removal from sites hinders foundational archaeological assessments.

Understanding the timing of these stand replacing events in subalpine settings can tell researchers when materials will be exposed and when the best times are to view sites underneath the taphonomically active zone adding great potential to better understand occupations without time consuming excavations. However, archaeologists must beat looters to these exposed areas before the unprotected materials (and the information the artifacts represent) are stolen by collectors.

Answering the Main Question

Do fires impact the locations of archaeological sites? Yes. Fires as large scale disturbance events play a role in landscape evolution. Humans and other animals, as parts of those systems, interact with the conditions brought about by these large scale landscape processes. Although the relationship between the radiocarbon dates, diagnostic artifacts, and fire scars can only suggest a relationship, additional research may provide direct linkages between the events. In the meantime, this thesis serves as a pilot study for understanding the relationship between human occupations and past fires. Using the example of the 1648 CE fire, the plant and animal communities of the Piney Creek drainage would have responded and adapted to a pre or post fire environment. Humans would have adapted and responding to these conditions in terms of both the timing and placement of their resource acquisitions.

There have been two scenarios discussed for the UPCS. Scenario 1; before the 1648 CE fire, there would have been an abundance of whitebark pine nuts in this drainage. Subsisting on these would have been an effective strategy for people using the UPCS. These nuts take no external processing to digest, have a very high caloric return, and are often collected en masse by squirrels. Scenario 2; after a large fire, following bison and bighorn sheep into post burn environments may have been an effective strategy for the Mountain Shoshone living in the Piney Creek Drainage. The placement of the UPCS may reflect this strategy. Bison and bighorn sheep were likely drawn to the recently burned areas because of the increased quality and quantity of the understory vegetation. Additionally, bighorn sheep were probably frequenting areas in this drainage because of the decrease in snags, large brush, and dense overstory vegetation. This increase in food (grasses and forbs) combined with the ability to detect predators would have promoted additional bighorn sheep habitat in this drainage. The placement of the UPCS between two fire scars from the 1648 CE indicates that if this site was occupied in the years after the fire, occupation would have occurred within the boundaries of the 1648 CE burn.

These two scenarios can only be answered through future research. A more comprehensive fire history for this region needs to be conducted and compared with many more sites that both have an abundance of faunal material and with those that lack butchered animal bone. There are multiple types of patterns that could start to emerge. For example, if radiocarbon dates from many sites with abundant faunal material overlap with fire dates, then it is likely that these areas were being frequented after the fires. Alternatively, if the sites that are contemporaneous with fire do not exhibit faunal material and are instead dominated by artifacts such as groundstone, it is more likely that whitebark pine nuts are being heavily used. In these instances, the archaeological material will help understand if humans were occupying a site immediately before or immediately after a fire. By extension this type of research will help to understand the role of humans in that ecosystem, and the role within that fire regime.

While these situations are speculative, more evidence from future research can help to narrow the window between fires and human occupations in the Piney Creek Drainage. In modern contexts, the increase in ground surface visibility increases the potential to view the archaeological material that would otherwise be covered by surface vegetation. This thesis showed that fires not only help increase visibility in locating previously undocumented archaeological materials, but fires also uncover new material from previously recorded sites, contributing significant information regarding extant archaeological assemblages. To tie the two branches together, the fire of 1648 CE may have influenced why the Mountain Shoshone camped in Piney Creek drainage and the increase in surface visibility caused by the LVF of 2006 helped to uncover the archaeological material that allowed us to interpret that site today.

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APPENDIX A: TREE RING DATA

Table of descriptive tree core sample information. Those highlighted were crossdated to build the tree-ring chronology. Column heading from left to right are; Tree Number (sample ID), Tree (species code), Sample Type (core of cross section), Green Needles (whether or not green needles were observed in the canopy), Direction (direction sampled portion of tree was facing), Bluestain (whether or not blue stain was observed in sample), Recruitment Date (approximation of pith date), Year of Scar if Present (if a scar was observed, the calendar date of that scar), and Skeleton Plot (whether or not that sample has been skeleton plotted). All those cells with values of “999” represent no data recorded.

Tree Number	Tree	Type of Sample	Alive When Cored	Direction Cored	Blue Stain	Killed in LV Fire	Outside Date	Pith Age	Tree Age	Scar	Year of Scar	Skeleton Plot
TC-018	5N	TC	N	SW	Y							N
TC-019	PIEN		N	NE	N							N
TC-020	5N	TC	N	SE	N							N
TC-021A	5N	TC	N	N	Y	Y	2006			Y	-999	Y
TC-021B	5N	TC	N	NE	Y	Y	2006			Y	-999	Y
TC-021C	5N	TC	N	NW	N							N
TC-022	PIEN		N		Y							N
TC-023	PIEN		N	N	Y							N
TC-024A	5N	TC	N	E	N							N
TC-024B	5N	TC	N	N	Y							N
TC-024C	5N	TC	N	S	N							N
TC-024D	5N	TC	N	N	N							N
TC-025	PIEN		N	NW	N							N
TC-026	5N	TC	N	SW	Y	Y	2006	1736	270	-999	-999	Y
TC-027	5N	TC	N	999	N							N
TC-028A	5N	TC	N	S	N							N
TC-028B	5N	TC	N	S	N							N
TC-029A	5N	TC	N	S	N							N
TC-029B	5N	TC	N	N	N							N
TC-030	5N	TC	N	W	N							N
TC-031A	5N	TC	N	W	N		2006	1792	214	N	-999	Y
TC-031B	5N	TC	N	E	N							N
TC-031C	5N	TC	N	999	Y	Y						N
TC-032	999		N	E	N					Y		N
TC-033	5N	TC	N	NE	N		2006	1892	114	N	-999	Y
TC-034	5N	TC	N	SW	Y							N
TC-035	999		N	NE	N							N
TC-036	5N	TC	N	NE	N		2006	1906	100	Y	1956	Y

TC-037	999		N	SW	N							N
TC-038A	PIEN		N	E	Y					Y	1954	N
TC-038B	PIEN		N	W	Y							N
TC-039	PIEN		N	N	N							N
TC-040A	5N	TC	N	S	N							N
TC-040B	5N	TC	N	W	N							N
TC-041	5N	TC	N	NW	N							N
TC-042	PIEN		N	NW	N							N
TC-043A	999		N	SW	N							N
TC-043B	999		N	SW	N							N
TC-044	5N	TC	N	SE	N							N
TC-045A	999	TC	N	SE	Y							N
TC-045B	999	TC	N	SE	Y							N
TC-046	5N	CS	N	S	Y	Y				Y	1951, 1971	Y
TC-047A	999	TC	N	NE	Y							N
TC-047B	999	TC	N	NE	Y							N
TC-048	5N	TC	N	NE	Y							N
TC-049	5N	TC	N	W	Y							N
TC-050	5N	TC	N	SW	N							N
TC051	5N	TC	N	S	N							N
TC052	5N	TC	N	N	N							N
TC-053A	5N	TC	N	NE	Y							N
TC-053B	5N	CS	N	NE	Y	Before				Y		N
TC-054A	5N	TC	N	W	Y							N
TC-054B	5N	TC	N	N	Y							N
TC-054C	5N	TC	N	NE	Y							N
TC-055	5N	TC	N	W	Y		1995	1698	297	N	-999	Y

TC-056	5N	TC	N	SW	Y							N
TC-057	999	TC	N	SW	N							N
TC-058	5N	TC	N	S	Y		2006	1762	244	N	-999	Y
TC-059B	5N	TC	N	W	Y							N
TC-060	5N	TC	N	W	Y		2006	1493	513	N	-999	Y
TC-061A	5N	TC	N	SW	N							N
TC-061B	5N	CS	N	999	N							N
TC-062	5N	TC	N	S	Y							N
TC-063	999	TC	N	E	Y							N
TC-064	PIEN	TC	N	S	Y							N
TC-065	5N	TC	N	NE	Y	Y	2006	1776	230	N	-999	Y
TC-066	5N	TC	N	NE	Y	Y	2006	1805	201	N	-999	N
TC-067	PIEN	TC	N	S	N							N
TC-068	PIEN	TC	N	N	Y							N
TC-069A	999	TC	N	S	Y							N
TC-069B	999	TC	N	SW	Y							N
TC-070	999	TC	N	S	Y							N
TC-071A	5N	TC	N	S	N							N
TC-071B	5N	TC	N	S	N							N
TC-071C	5N	TC	N	S	N					Y		N
TC-072	PIEN	TC	N	NE	N							N
TC-073	5N	CS	N	999	N	Before				Y	Y	
TC-074	5N	TC	N	N	N	Y	2006	1747	259	N	-999	Y
TC-075	5N	TC	N	N	Y							N
TC-076	PIEN	TC	N	N	N							N
TC-077	PIEN	TC	N	NE	Y							N

TC-078	5N	TC	Y	NE	N	N	9999	1825	225	N	-999	Y
TC-079	5N	TC	N	999	Y	Y	2006			Y	1821	Y
TC-080A	5N	TC	Y	999	N	N	9999	1954	96	N	-999	Y
TC-080B	5N	TC	Y	999	N	N						N
TC-081	5N	TC	Y	999	N	N					1955?	Y
TC-082A	5N	TC	N	SW	N							N
TC-082B	5N	TC	N	NE	N							N
TC-083	5N	TC	N	E	Y							N
TC-084A	5N	TC	N	E	Y	Before	2005			N	-999	Y
TC-084B	5N	TC	N	E	Y							N
TC-085	5N	TC	N	NE	N							N
TC-086	5N	TC	N	W	Y							N
TC-086B	5N	TC	N	W	Y	Before	9999	1859	191	N	-999	N
TC-087	5N	TC	N	W	Y							N
TC-088	PIEN	TC	N	W	Y							N
TC-089	5N	TC	N	NE	Y	Y	2006	1755	251	N	-999	Y
TC-090	5N	TC	N	NE	Y							N
TC-091	5N	TC	N	E	N							N
TC-092	5N	TC	N	S	N							N
TC-093	5N	TC	N	999	N							N
TC-094	5N	TC	N	N	N							N
TC-095	5N	TC	N	NE	N							N
TC-096	5N	TC	N	E	Y							N
TC-097	5N	TC	N	N	Y							N
TC-098	5N	TC	N	N	Y							N
TC-099	5N	TC	N	W	Y							N
TC-104A	5N	TC	N	S	Y							N
TC-104B	5N	TC	N	S	Y							N

TC-104C	5N	TC	N	N	Y							N
TC-104D	5N	TC	N	NW	Y							N
TC-105	5N	TC	N	SW	Y							N
TC-106	5N	TC	Y	W	N	N	9999	1913	137	N	-999	Y
TC-107	5N	TC	Y	S	Y	N	9999	1927	123	N	-999	Y
TC-108	5N	TC	N	NE	Y							N
TC-109	5N	TC	N	NE	Y							N
TC-110	5N	TC	N	SE	Y							N
TC-111	5N	TC	N	E	N	N	2005	1809	196	N	-999	Y
TC-112A	5N	TC	Y	NE	N	N	9999	1872	178	N	-999	Y
TC-112B	5N	TC	Y	NE	N	N	9999	1872	178	N	-999	Y
TC-113	5N	TC	Y	W	N	N	9999	1976	74	N	-999	N
TC-114	5N	TC	Y	SW	Y	N	9999	1913	137	N	-999	N
TC-115A	999	TC	N	NW	Y	Y	2006	1801	205	N	-999	Y
TC-115B	999	TC	N	NW	Y							N
TC-116	999	TC	N	S	Y		9999	1785	265	N	-999	N
TC-117A	5N	TC	N	S	Y	Y	2006	1918	88	Y	1937	N
TC-117B	5N	TC	N	S	Y							N
TC-118	5N	CS	N	999	Y							N
TC-119	5N	CS	N	999	Y							N
TC-120A	5N	TC	N	N	Y							N
TC-120B	5N	TC	N	SE	Y							Y
TC-121	5N	TC	N	NE	Y							N
TC-122A	5N	TC	N	SW	Y	Y	2006	1901	105	N	-999	N
TC-122B	5N	TC	N	SW	Y							N
TC-123	5N	TC	N	E	Y							N
TC-124	999	TC	N	N	Y							N
TC-125A	5N	TC	N	NE	Y	N	1948	1783	165	N	-999	Y
TC125B	5N	TC	N	NE	N							N

TC-126	5N	TC	N	NW	N	Y	2006	1865	141	N	-999	N
TC-127A	5N	TC	N	SE	Y							N
TC-127B	5N	TC	N	SE	Y		9999	1779	271			Y
TC-128	5N	TC	N	SE	Y							N
TC-129A	5N	TC	N	SE	Y							N
TC-129B	5N	TC	N	SE	Y							N
TC-130	5N	TC	N	SE	N		1982	1892	90	N	-999	Y
TC-131	5N	TC	N	SE	N							N
TC-132	5N	TC	N	SE	N	Y	9999	1890	160	N	-999	N
TC-133	999	TC	N	S	Y							N
TC-134	999	TC	N	SE	N							N
TC-135	999	TC	N	SE	Y							N
TC-136	999	TC	N	E	N							N
TC-137	999	TC	N	SE	N							N
TC-138	PIEN or Doug Fir	TC	N	SW	N							N
TC-139	5N	TC	N	SE	N							N
TC-140A	5N	CS	N	NW	N							N
TC-140B	5N	TC	N	S	N	Y	2006	1893	113	N	-999	N
TC-141A	5N	TC	N	NW	Y		2006					N
TC-141B	5N	TC	N	NW	Y							N
TC-142A	5N	TC	N	NE	Y	Y	2006	1946	60	N	-999	N
TC-142B	5N	TC	N	NE	Y							N
TC-143	999	TC	Y	999	Y	N						Y
TC-144	5N	TC	N	999	N							N
TC-145	5N	TC	N	999	N							N
TC-146A	5N	CS	N	999	N							N
TC-146B	5N	TC	N	999	N							N

TC-146C	5N	TC	N	999	N							N
TC-146D	5N	TC	N	W	N							N
TC-147A	5N	TC	Y	NE	N	N	-999			N	-999	Y
TC-147B	5N	TC	Y	NW	N	N	-999			N	-999	Y
TC-148	5N	TC	N	NW	N	Y	2005	1850	155	N	-999	N
TC-149	999	TC	Y	NE	N	N						N
TC-150	Aspen	CS	N	999	N							N
TC-151	5N	TC	N	W	N	Y	2006	1930	76	N	-999	N
TC-152	PIEN	TC	N	E	N							N
TC-153	Aspen	CS	N	999	N							N
TC-154	Aspen	CS	N	999	N							N
TC-155	Aspen	CS	N	999	N							N
TC-156	5N	TC	N	999	N	Y	2006	1946	60	N	-999	N
TC-157	5N	TC	Y	999	N	N	9999	1925	125	N	-999	Y
TC-158A	5N	TC	N	999	Y							N
TC-158B	5N	TC	N	999	Y	Y	2006	1932	74	N	-999	N
TC-159	5N	TC	N	W	Y	Y	2006	1933	73	N	-999	N
TC-160	5N	TC	N	999	Y	Y	2006	1898	108	N	-999	Y
TC-161	999	TC	N	S	Y							N
TC-162	5N	TC	N	W	Y							N
TC-163	5N	TC	N	E	Y							N
TC-164	5N	TC	Y	E	N	N	9999	1936	114	N	-999	Y
TC-165	5N	TC	N	SW	Y							N
TC-166	5N	TC	N	S	Y	Y	2006	1932	74	N	-999	N
TC-167	5N	TC	N	E	Y	Y	2006	1916	90	N	-999	N
TC-168	5N	TC	N	999	Y	Y	2006	1940	66	N	-999	N
TC-169	Aspen	TC	N	N	N							N
TC-170	5N	TC	N	SE	N	Y	2006	1934	72	N	-999	N
TC-171A	5N	TC	Y	NW	N	N						Y

TC-171B	5N	TC	Y	NW	N	N	9999	1926	124	N	-999	Y
TC-172	5N	CS	N	999	N							N
TC-173	5N	TC	N	E	N	Y	2006	1921	85	N	-999	N
TC-174A	5N	CS	N	NE	Y					Y		N
TC-174B	5N	TC	N	SW	N							N
TC-174C	5N	TC	N	SW	N							N
TC-175A	PIEN	TC	N	SW	N							N
TC-175B	PIEN	TC	N	SW	N							N
TC-176A	5N	CS	N	E	N					Y		N
TC-176B	5N	TC	N	SW	N							N
TC-177	5N	TC	N	SW	N	Y	2006	1911	95	N	-999	N
TC-178	5N	TC	N	NE	Y	Y	2006	1924	82	N	-999	N
TC-179A	5N	TC	N	SW	N							N
TC-179B	5N	TC	N	SW	N							N
TC-180	5N	TC	N	S	N	Y	2006	1708	298	N	-999	Y
TC-181	5N	TC	N	S	Y		9999	1749	301	N	-999	Y
TC-182	5N	TC	N	S	N	Y	2006	1745	261	N	-999	Y
TC-183	5N	TC	N	N	N							N
TC-184	5N	TC	Y	N	N	N	9999	1936	114	Y	1972	N
TC-185A	5N	TC	N	NW	Y		1997	1707	290	N	-999	N
TC-185B	5N	TC	N	NW	Y		1995	1707	288	N	-999	Y
TC-186A	5N	TC	N	S	Y	Y						N
TC-186B	5N	TC	N	S	Y	Y	2006	1947	59	N	-999	N
TC-187A	5N	TC	N	S	Y							N
TC-187B	5N	TC	N	S	Y	Y	2006	1820	186	N	-999	N
TC-188	5N	TC	Y	N	Y	N	9999	1735	315		-999	Y
TC-189	5N	TC	N	N	Y	Before						Y
TC-190	5N	TC	N	N	Y	?	2006	1777	229			Y
TC-191	5N	TC	Y	E	N	N	9999	1891	159	N	-999	Y
TC-192	5N	TC	Y	SE	N	N	9999	1945	105	Y	1954	Y

TC-193	5N	TC	Y	W	N	N	9999	1875	175	N	-999	Y
TC-194	5N	TC	Y	N	N	N	9999	1909	141	N	-999	N
TC-195	5N	TC	999	W	N							N
TC-196A	5N	TC	Y	S	N	N						N
TC-196B	5N	TC	Y	S	N	N	9999	1736	314	N	-999	Y
TC-197	5N	TC	Y	S	N	N	9999	1927	123	N	-999	N
TC-198	5N	TC	Y	N	N	N	9999	1829	221	-999	-999	Y
TC-199	5N	TC	Y	W	N	N	9999	1949	101	-999	-999	Y
TC-200	5N	TC	Y	NE	N	N						Y
TC-201	5N	TC	Y	NE	N	N						N
TC-202A	5N	TC	Y	SE	N	N						N
TC-202B	5N	TC	Y	SE	N	N						N
TC-203A	5N	TC	Y	E	N	N				Y	1648	N
TC-203B	5N	TC	Y	E	N	N						N
TC-204	ABLA	TC	Y	N	N	N	9999	1969	81	-999	-999	Y
TC-205	PSMEG	TC	Y	SE	N	N						N
TC-206	PIEN?	TC	N	SW	N							N
TC-207	PIEN?	TC	N	SW	N							N
TC-208	5N	TC	N	NE	N							N
TC-209	?	TC	N	SW	N							N
TC-210	?	TC	N	SW	N							N
TC-211	5N	CS	N	999	N							N
TC-212	?	TC	N	S	N							N
TC-213	5N	TC	N	NE	Y		9999	1789	261	N	-999	N
TC-214	5N	TC	N	NE	Y		2006	1755	251	N	-999	N

TC-215	5N	TC	N	NE	Y							N
TC-216	5N	TC	Y	NE	N	N	9999	1702	348	-999	-999	Y
TC-217	5N	TC	Y	W	N	N	9999	1946	104	-999	-999	Y
TC-218	5N	TC	Y	W	N	N	9999	1955	95	-999	-999	Y
TC-219A	5N	TC	Y	NW	N	N	9999	1941	109	-999	-999	Y
TC-219B	5N	TC	Y	NW	N	N						N
TC-220A	5N	TC	Y	SW	N	N						N
TC-220B	5N	TC	Y	SW	N	N	9999	1958	92	-999	-999	Y
TC-221A	ABLA	TC	Y	W	N	N						N
TC-221B	ABLA	TC	Y	W	N	N						N
TC-222	5N	TC	Y	S	N	N						N
TC-223	5N	TC	Y	SW	N	N						N
TC-224	5N	TC	Y	NE	N	N	9999	1754	296	-999	-999	Y
TC-225	5N	CS	Y	W	N	N						N
TC-226	5N	CS	N	SW	Y	Y	2006	1806	200	Y	1921	Y
TC-227	5N	CS	N	SW	N							N
TC-228A	5N	TC	N	S	N							Y
TC-228B	5N	TC	N	E	N					Y		N
TC-228C	5N	TC	N	W	N					Y		N
TC-228D	5N	TC	N	SW	N							N
TC-229	5N	TC	N	E	Y							N
TC-230	5N	TC	N	NE	Y							N
TC-231	5N	TC	N	NW	N							N
TC-232	999	TC	N	NE	N							N
TC-233A	999	CS	N	W	Y							N
TC-233B	999	TC	N	999	Y							N
TC-234	999	TC	N	SE	Y							N
TC-235	PIEN	TC	N	E	Y							N
TC-236	PIEN	TC	N	N	Y							N
TC-237	PIEN	TC	N	E	Y							N
TC-238	999	TC	N	SE	N							N

TC-239A	PIEN or Doug Fir	TC	N	E	N							N
TC-239B	PIEN or Doug Fir	CS	N	E	N							N
TC-240	5N	TC	N	N	N							N
TC-241	5N	TC	N	E	N							N
TC-242	5N	TC	N	N	Y							N
TC-243	999	TC	N	N	N							N
TC-244	5N	TC	N	W	N							N
TC-245	999	TC	N	S	Y							N
TC-246A	5N	TC	N	S	Y							N
TC-246B	5N	TC	N	S	Y							N
TC-246C	5N	TC	N	S	Y							N
TC-247	PSMEG	CS	N	NE	N	Y				Y	1931	Y
TC-248A	5N	TC	N	NW	Y							N
TC-248B	5N	TC	N	NE	Y							N
TC-248C	5N	TC	N	S	Y							N
TC-249A	PSMEG	CS	N	NE	N	Y				Y	1954	Y
TC-249B	PSMEG	TC	N	N	N							N
TC-250A	999	TC	N	E	N							N
TC-250B	999	TC	N	N	N							N
TC-251	5N	TC	N	NW	N							N
TC-252	PSMEG	CS	N	SE	N	Y				Y		N
TC-253A	PSMEG	TC	N	SW	N							N
TC-253B	PSMEG	TC	N	NE	N							N
TC-254	5N	TC	N	S	N							N
TC-255	5N	TC	N	E	N							N
TC-256	PSMEG	TC	N	N	N							N
TC-257	5N	TC	N	W	N							N
TC-258	Adler	TC	N	N	N							N

TC-259	Adler	TC	N	W	N							N
TC-260	PIEN	TC	N	999	Y							N
TC-261A	5N	TC	N	W	N	Y				Y		N
TC-261B	5N	CS	N	NE	N	Y				Y		N
TC-262	999	TC	N	NW	Y	Before				N		N
TC-263	PIEN	TC	N	W	Y					N		N
TC-264	5N	TC	N	N	Y					N		N
TC-265	999	TC	N	NW	Y	Before				N		N
TC-266	999	TC	N	W	Y	Before				N		N
TC-267	999	TC	N	S	N	Before				N		N
TC-268	5N	TC	N	W	Y	Y				N		N
TC-269	5N	TC	N	W	N	Y				N		N
TC-270	5N	TC	N	W	N	Y				N		N
TC-271	5N	TC	N	W	Y	Y				N		N
TC-272	5N	TC	N	W	N	Y				N		N
TC-273	5N	TC	N	W	N	Y				N		N
TC-274	5N	TC	N	S	Y	Y				N		N
TC-275	5N	TC	N	S	N	Y				N		N
TC-276	5N	TC	N	S	N	Y				N		N
TC-277	5N	TC	N	S	N	Before				N		N
TC-278	5N	TC	N	S	Y	Before				N		N
TC-279	5N	TC	N	S	Y	Before				N		N
TC-280	5N	TC	N	S	N	Y				N		N
TC-281	5N	TC	N	S	Y	Before				N		N
TC-282	5N	TC	N	SE	Y	Y				N		N
TC-283	5N	TC	N	N	N	Before				N		N
TC-284	5N	TC	N	SE	N	Before				N		N
TC-285	5N	TC	N	S	N	999				N		N
TC-286	5N	TC	N	E	N	Y				N		N
TC-287	5N	TC	N	W	Y	Y				N		N
TC-288	5N	TC	N	W	N	Y				N		N

TC-289	5N	TC	Y	W	N	N	999	1893	157	Y		Y
TC-290	5N	TC	Y	NE	N	N				N		N
TC-291	5N	TC	Y	N	N	N				N		N
TC-292	5N	TC	Y	N	N	N				N		N
TC-293A	5N	TC	N	SW	N	N				Y		N
TC-293B	5N	TC	N	SE	N	N				Y		N
TC-293C	5N	TC	N	N	N	N				Y		N
TC-294	5N	TC	Y	NW	N	N	999	1928	122	N	-999	Y
TC-295	Doug Fir or Subalpine	TC	Y	NW	N	N				N		N
TC-296	PIEN	TC	Y	SW	N	N				N		N
TC-297A	ABLA	TC	Y	NW	N	N				N		N
TC-297B	ABLA	TC	Y	NW	N	N				N		N
TC-298	PIEN	TC	Y	NW	N	N				N		N
TC-299A	PIEN	TC	Y	NW	N	N				N		N
TC-299B	PIEN	TC	Y	NW	N	N				N		N
TC-300A	5N	TC	N	NE	Y	Before				N		N
TC-300B	5N	TC	N	NE	Y	Before				N		N
TC-301	5N	TC	N	NW	N	Before				N		N
TC-302	5N	TC	N	S	N	Before				Y		N
TC-303	5N	TC	N	NE	N	Y				N		N
TC-304	PSMEG	TC	N	E	N	Y				N		N
TC-305	5N	TC	N	SW	Y	Y				N		N
TC-306	5N	TC	N	NE	Y	Y				N		N
TC-307	PSMEG	TC	N	NW	N	Y				N		N
TC-308	PSMEG	TC	N	NW	N	Y				N		N
TC-309	5N	TC	N	SW	N	Y				N		N
TC-310	PIEN	TC	N	NW	N	Before				N		N
TC-311	PIEN	TC	N	E	N	Y				N		N

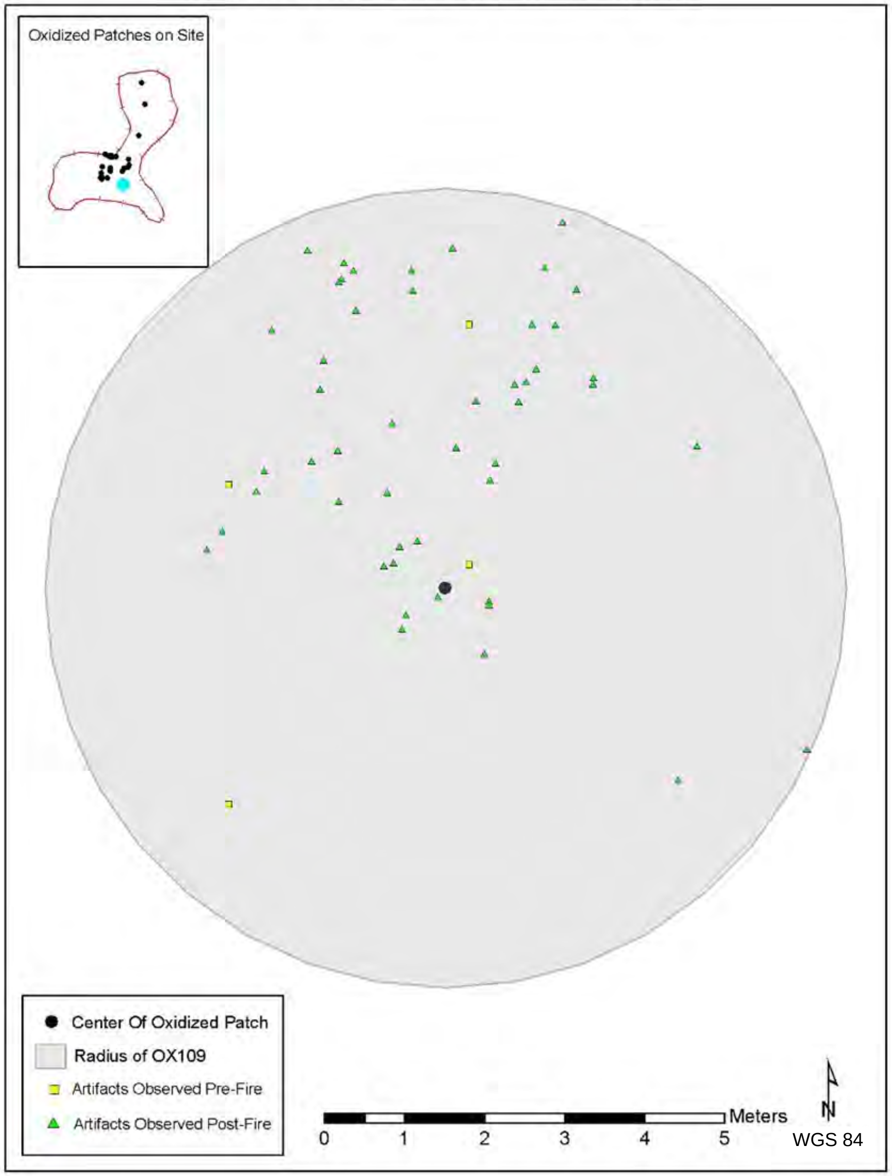
TC-312	PIEN	TC	N	E	N	Before				N		N
TC-313A	PIEN	TC	N	N	N	Before				N		N
TC-313B	PIEN	TC	N	N	N	Before				N		N
TC-314	PIEN	TC	N	N	N	Before				N		N
TC-315	PSMEG	TC	N	NE	N	Before				N		N
TC-317	PIEN	TC	N	N	N	Before				N		N
TC-318	PIEN	TC	N	NE	Y	Before				N		N
TC-319	PIEN	TC	N	NW	N	Before				N		N
TC-320	PIEN	TC	N	NE	N	Before				N		N
TC-321	PSMEG	TC	N	NE	N	Y				N		N
TC-322	PIEN	TC	N	NW	N	Before				N		N
TC-323	PIEN	TC	N	NW	N	Before				N		N
TC-324	PIEN	TC	N	NW	N	Before				N		N
TC-325	PIEN	TC	N	NW	N	Before				N		N
TC-326	5N	CS	N	E	N	999				Y		N
TC-59B	5N	TC	N	W	Y		9999	1524	526	N	-999	Y

APPENDIX B: 48PA2772 PRE AND POST LFV

Data recorded on 48PA2772 pre and post the Little Venus Fire.

Size of OX Patches			
OX Number	LENGTH (m)	WIDTH (m)	DEPTH (cm)
109	1.1	0.6	5.0
110	1.0	0.6	5.0
111	0.5	0.3	4.5
112	1.5	1.5	2.0
113	2.5	0.6	2.0
114	1.0	0.5	4.0
115	1.5	0.8	2.0
116	0.4	0.2	2.0
117	0.5	0.4	1.0
118	10.7	0.4	2.0
119	0.6	0.3	4.5
120	1.8	0.5	2.5
121	1.0	0.6	2.0
122	1.1	0.9	6.3
123	1.4	0.4	2.0
124	0.8	0.4	3.0
125	1.3	7.7	2.0
126	1.0	5.6	1.0
127	0.6	0.5	7.0
128	1.1	0.5	1.0
129	0.2	0.1	1.0
130	0.4	0.4	10.0
131	0.8	0.6	7.0
132	1.1	0.6	1.0
133	1.7	0.7	4.0
134	1.3	0.5	6.0
135	0.8	0.8	0.8
136	0.5	5.4	1.0
137	0.7	0.2	0.1
138	4.3	2.5	1.5

48PA2772
Artifacts Within a 5 Meter Radus to Oxidized Sediment 109 (OX109)

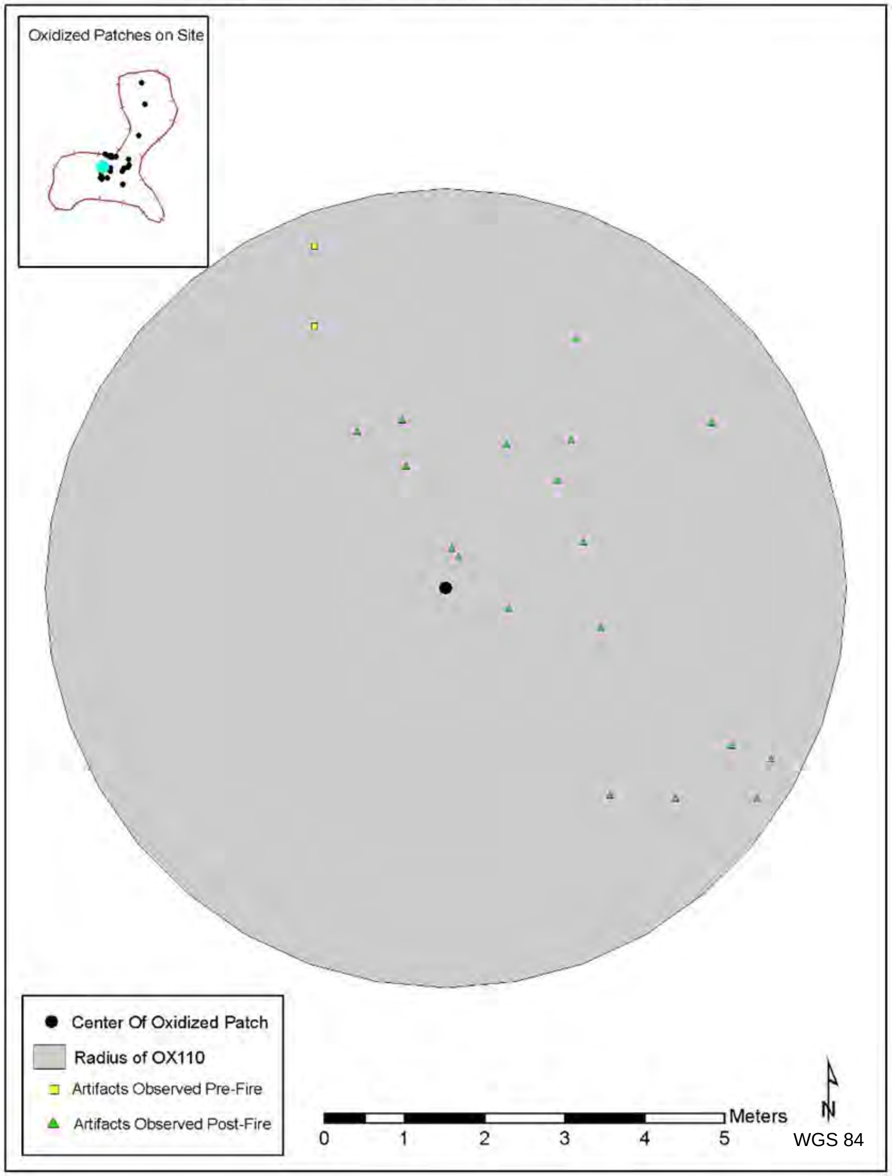


OX109: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	4	13

OX109: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	49	10.6



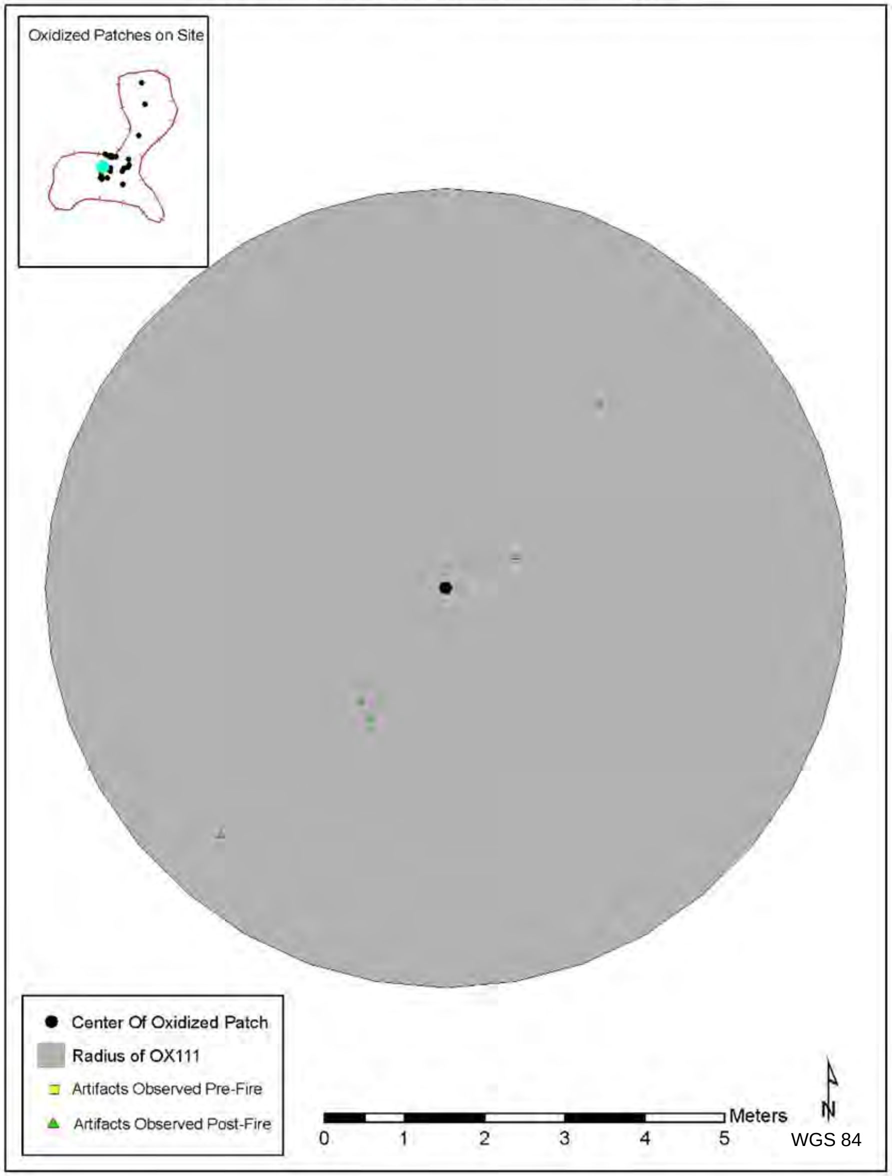
48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 110 (OX110)

OX110: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	2	19

OX110: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	18	12.5


48PA2772
Artifacts Within a 5 Meter Radus to Oxidized Sediment 111 (OX111)

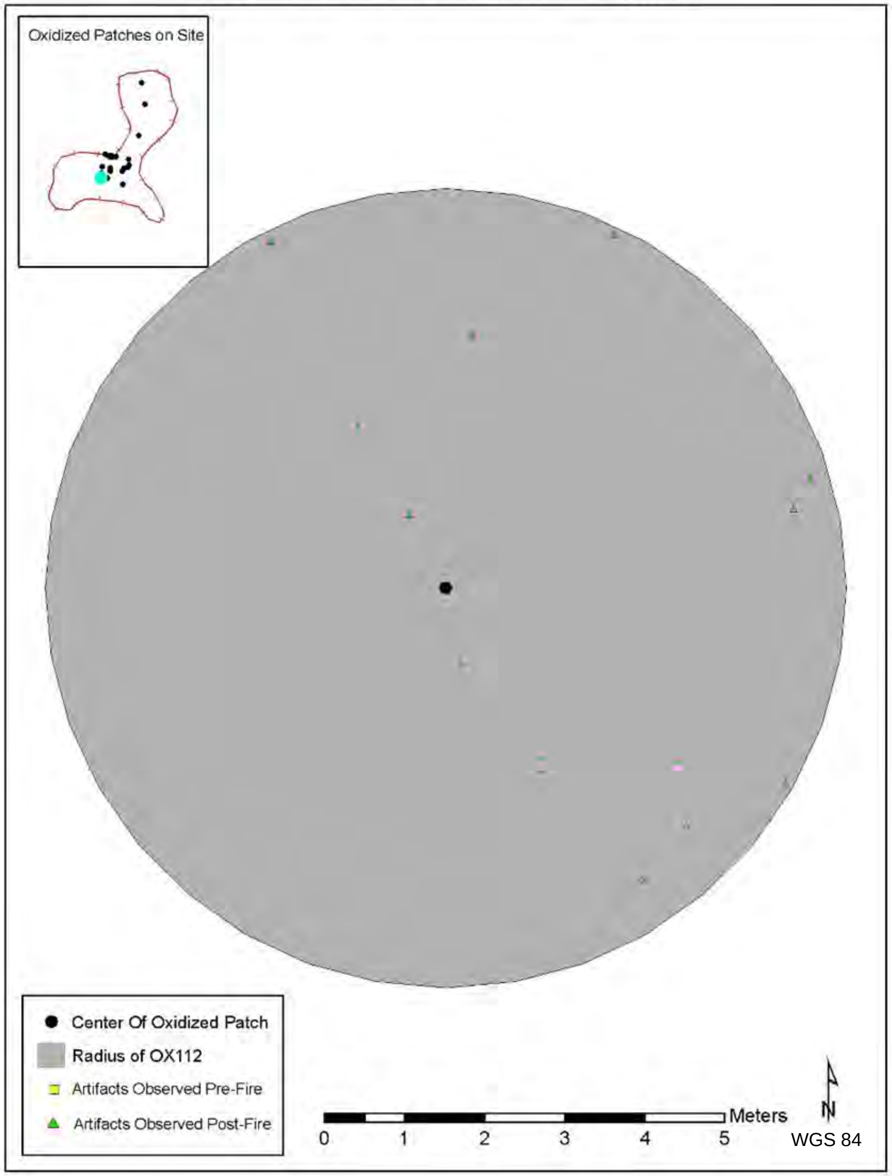
OX111: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX111: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	5	11.9

48PA2772
Artifacts Within a 5 Meter Radus to Oxidized Sediment 112 (OX112)

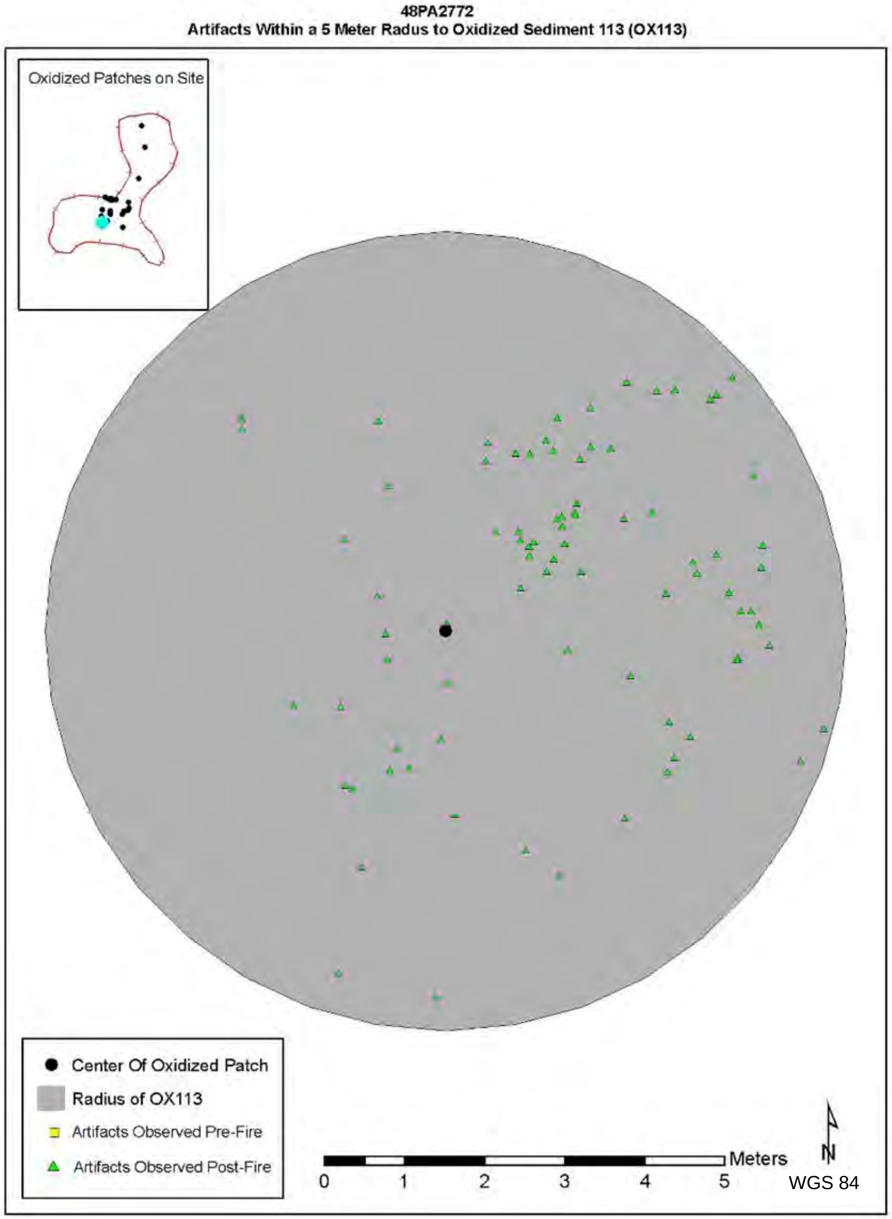


OX112: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX111: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	14	11.9



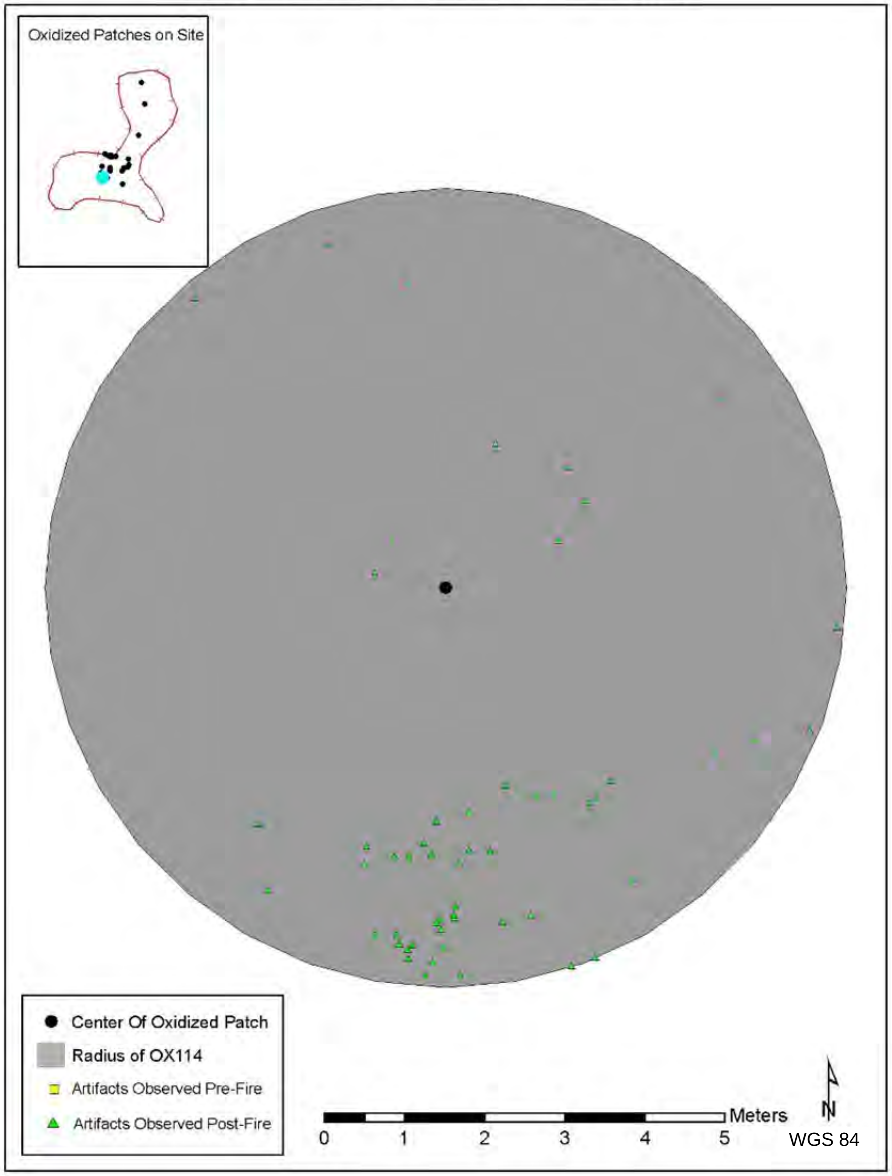
OX113: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX113: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	83	11.9

48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 114 (OX114)



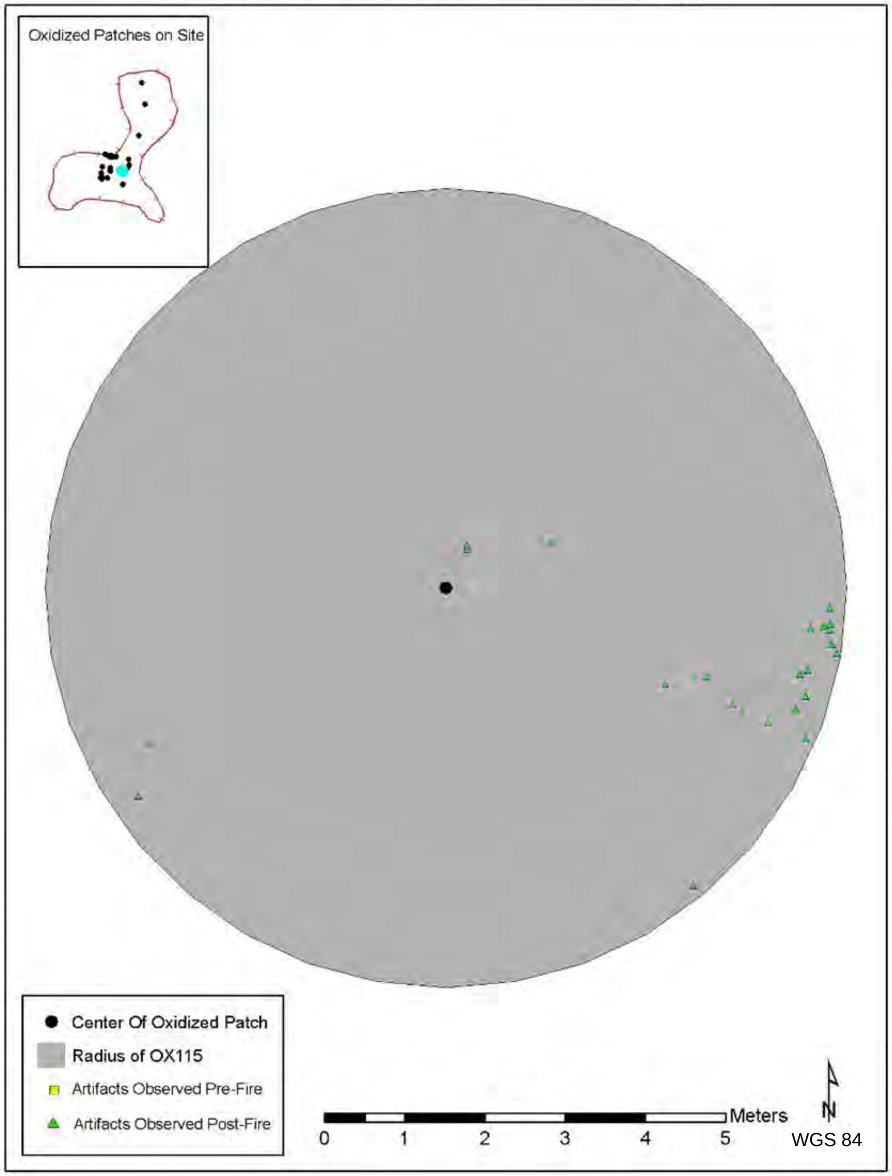
OX114: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX114: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	54	11.8

48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 115 (OX115)

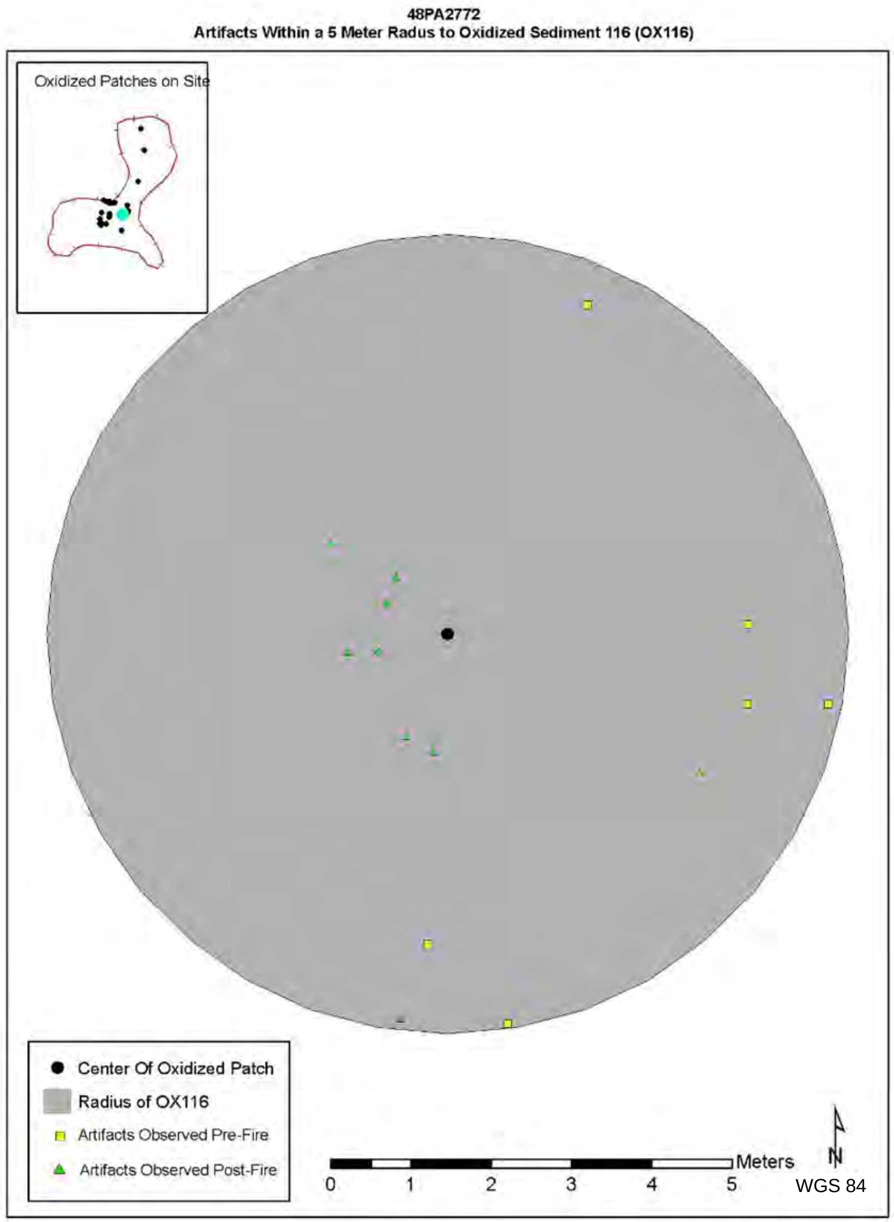


OX115: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX115: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	23	11.7



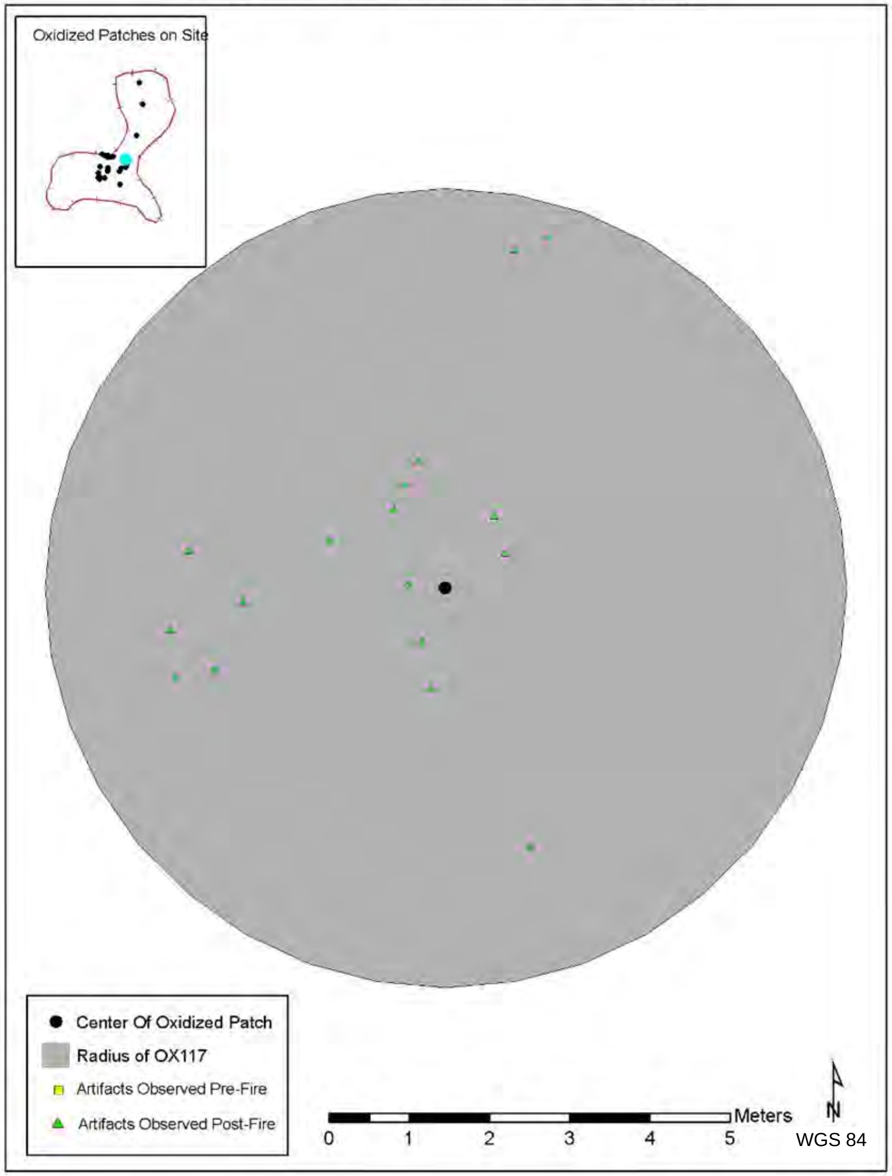
OX116: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	9	22

OX116: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	9	17.9

48PA2772
Artifacts Within a 5 Meter Radus to Oxidized Sediment 117 (OX117)



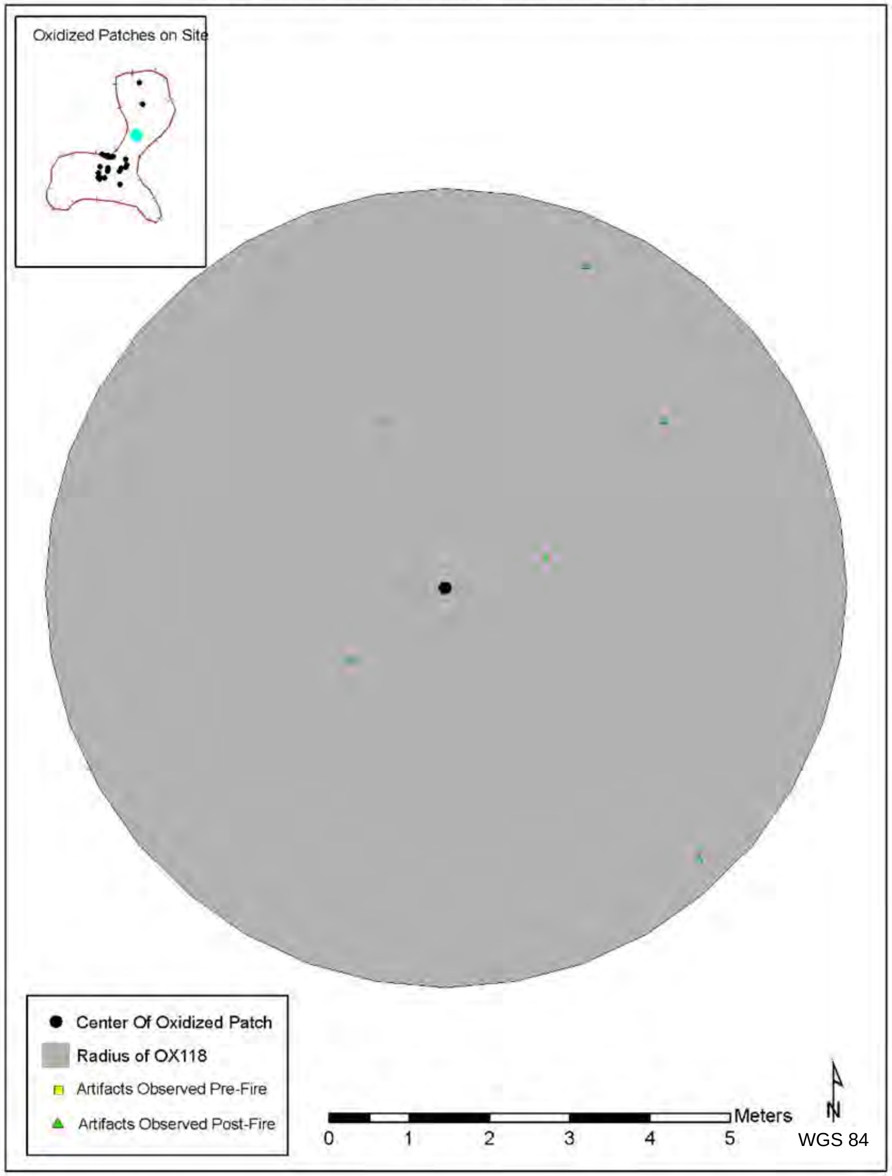
OX117: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX117: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	11	9.1

48PA2772
Artifacts Within a 5 Meter Radus to Oxidized Sediment 118 (OX118)



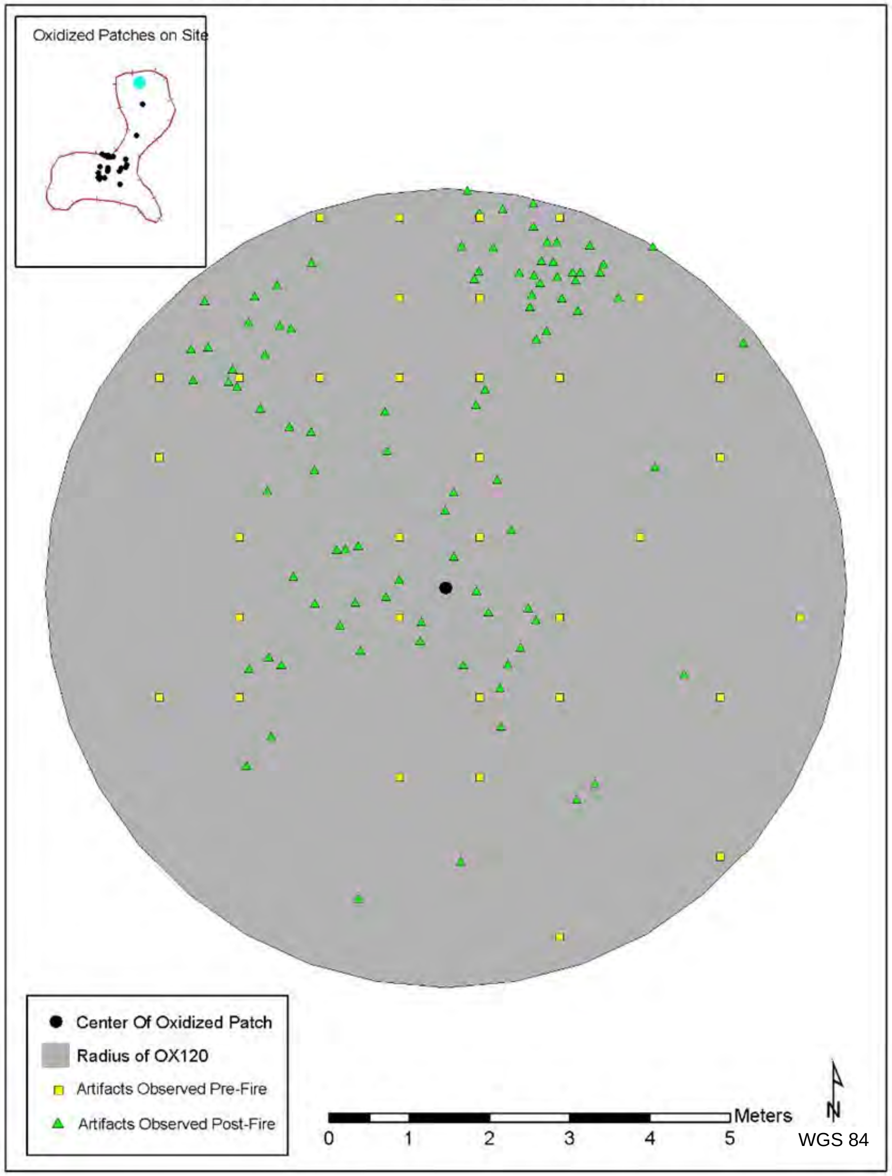
OX118: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX118: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	4	12.6

48PA2772
Artifacts Within a 5 Meter Radus to Oxidized Sediment 120 (OX120)

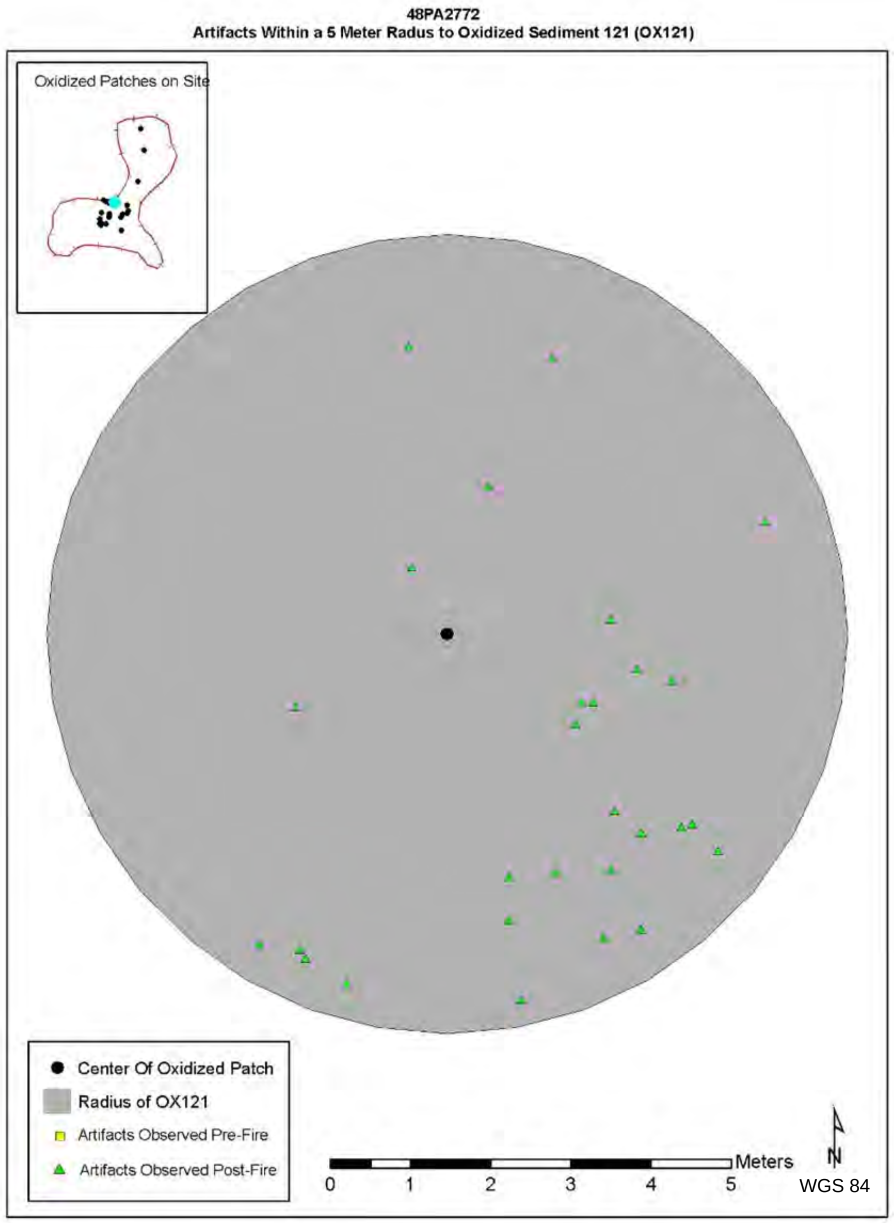


OX120: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	62	9

OX120: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	81	10.5

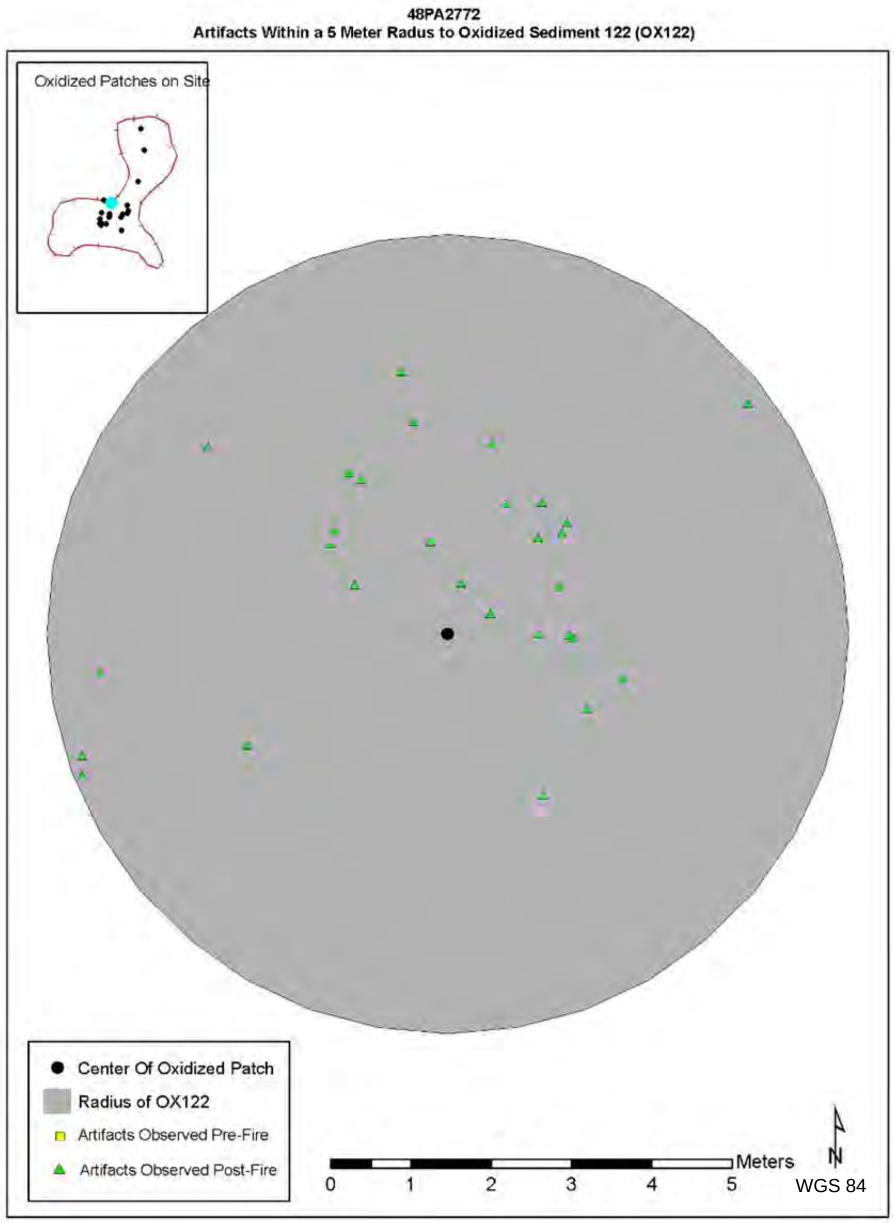


OX121: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX121: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	9	14.9



48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 122 (OX122)

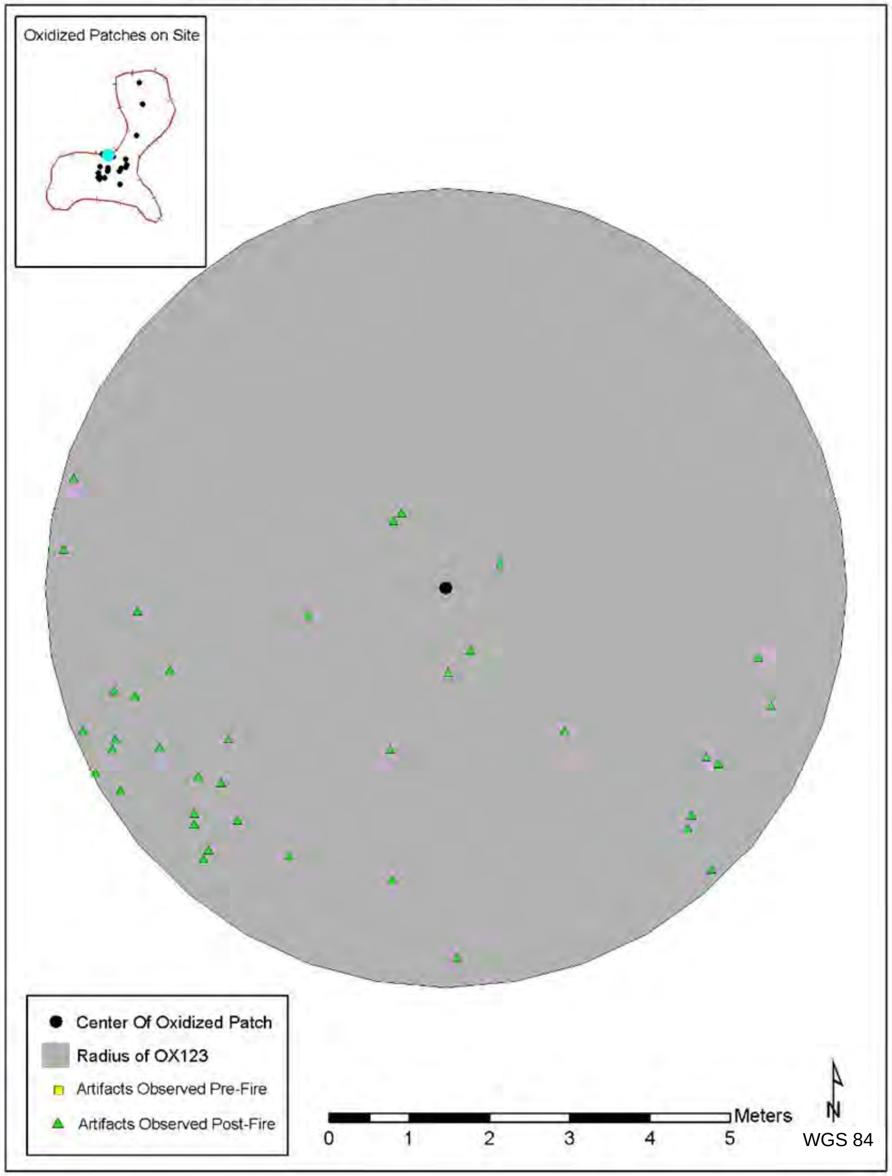
OX122: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX122: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	11	11.4

48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 123 (OX123)

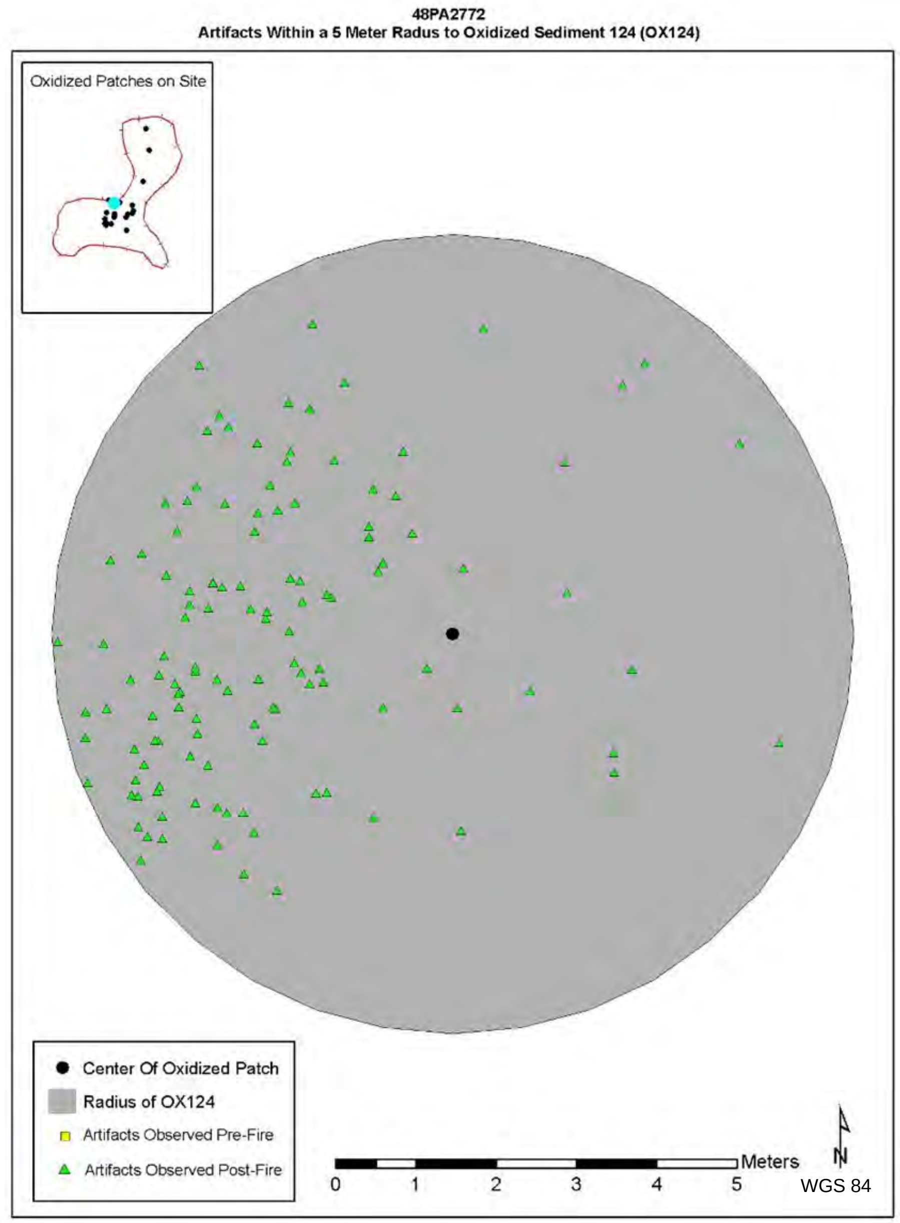


OX123: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX123: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	29	11.1

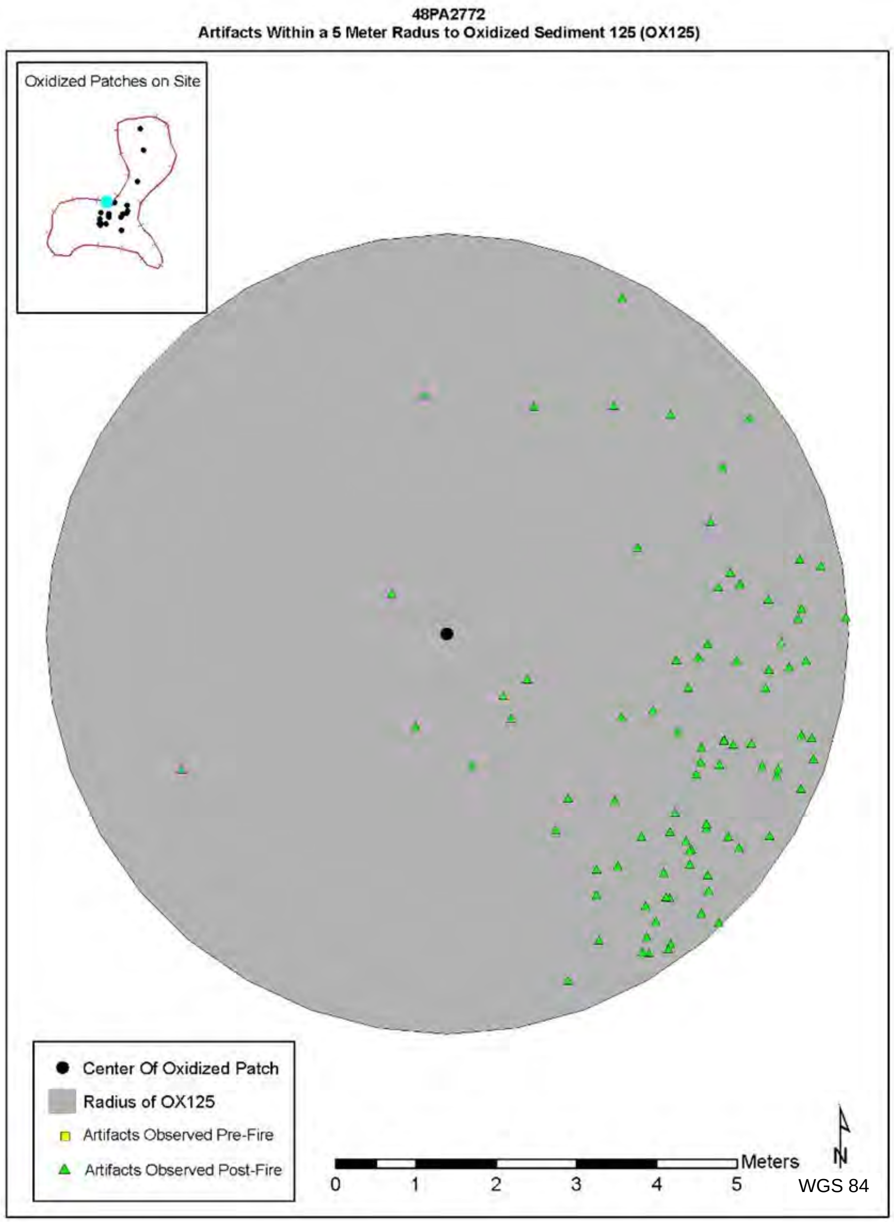


OX124: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX124: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	117	13.0



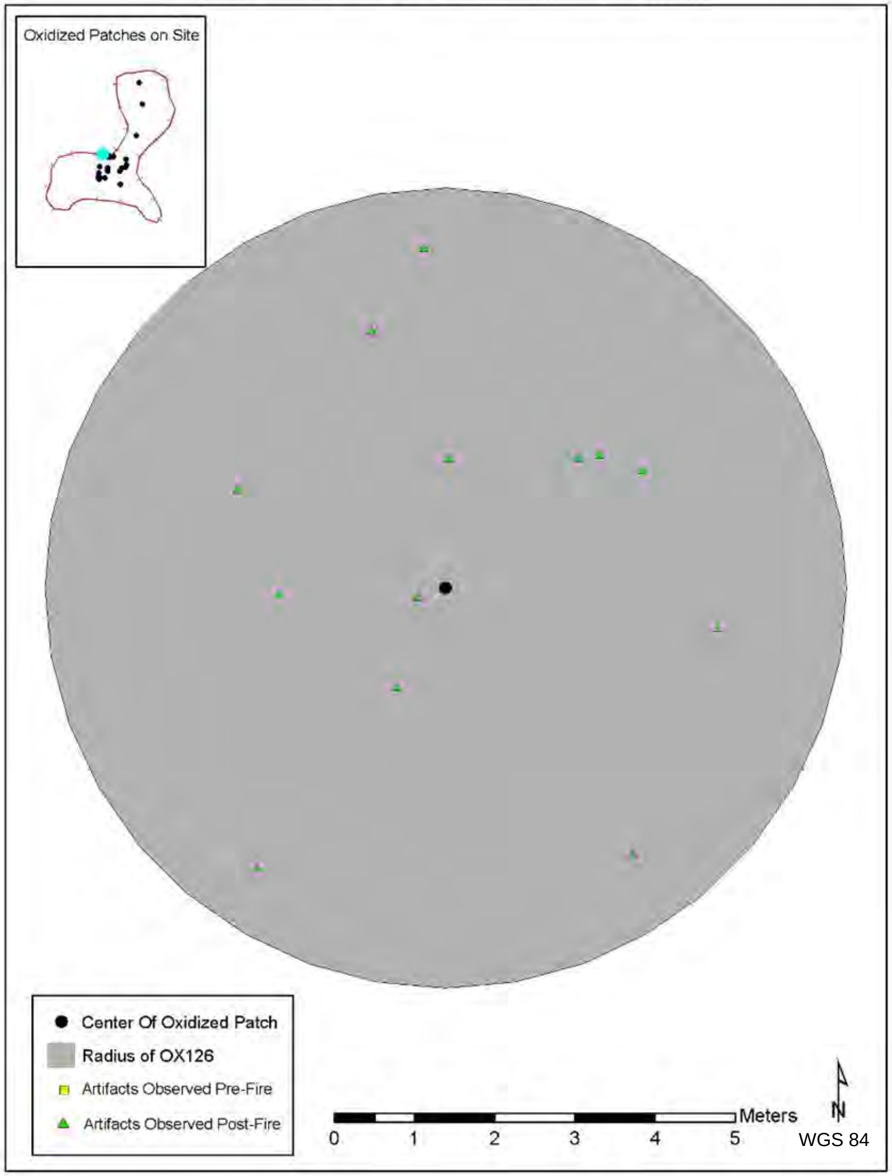
OX125: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX125: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	79	12.0

48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 126 (OX126)

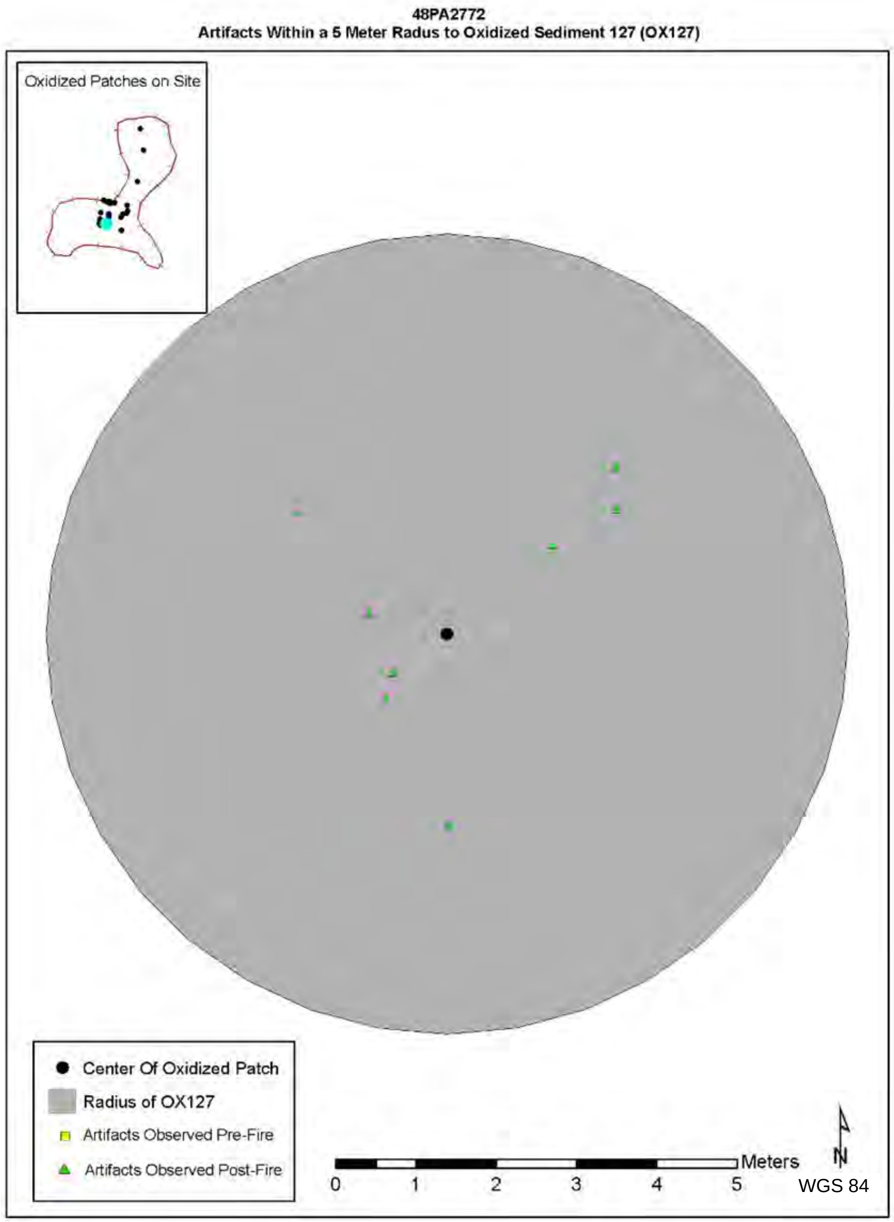


OX126: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX126: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	5	11.1

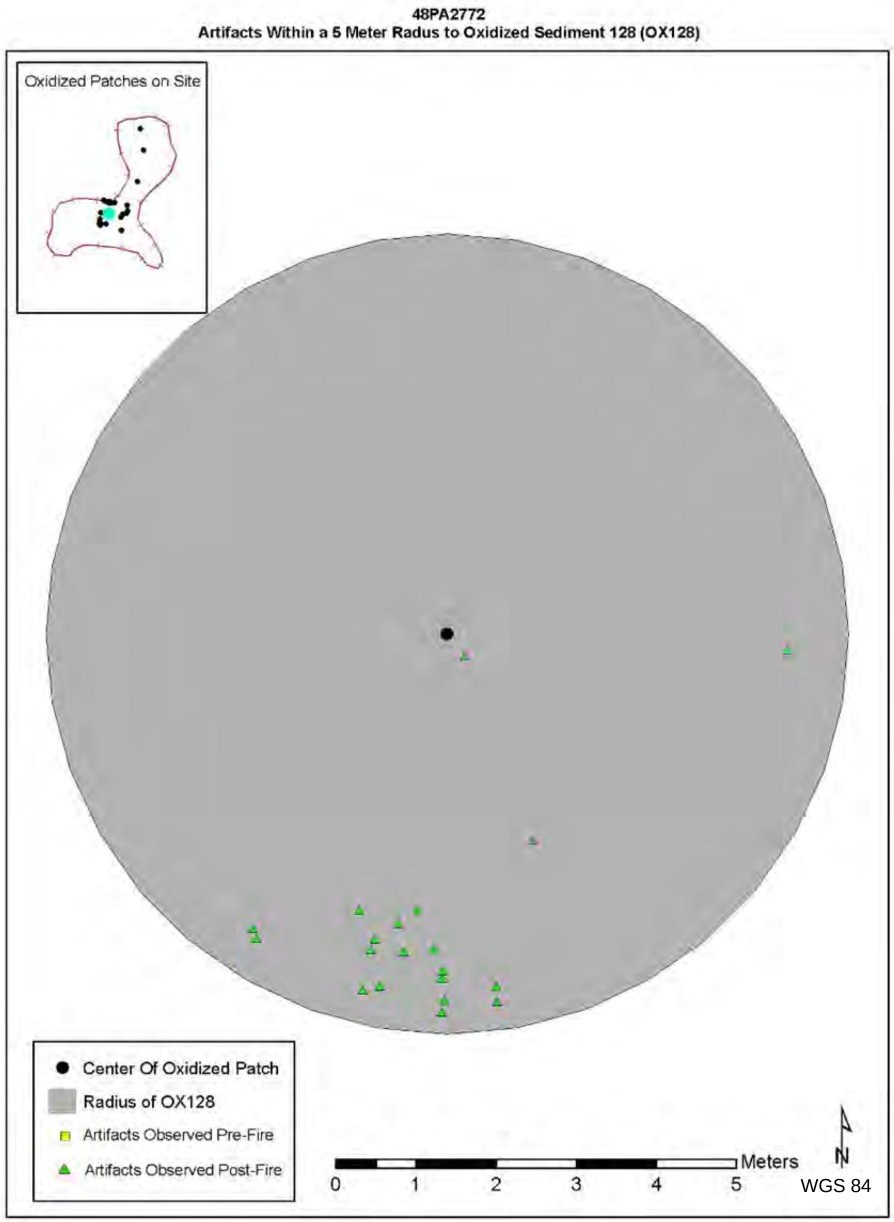


OX127: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX127: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	1	10.0



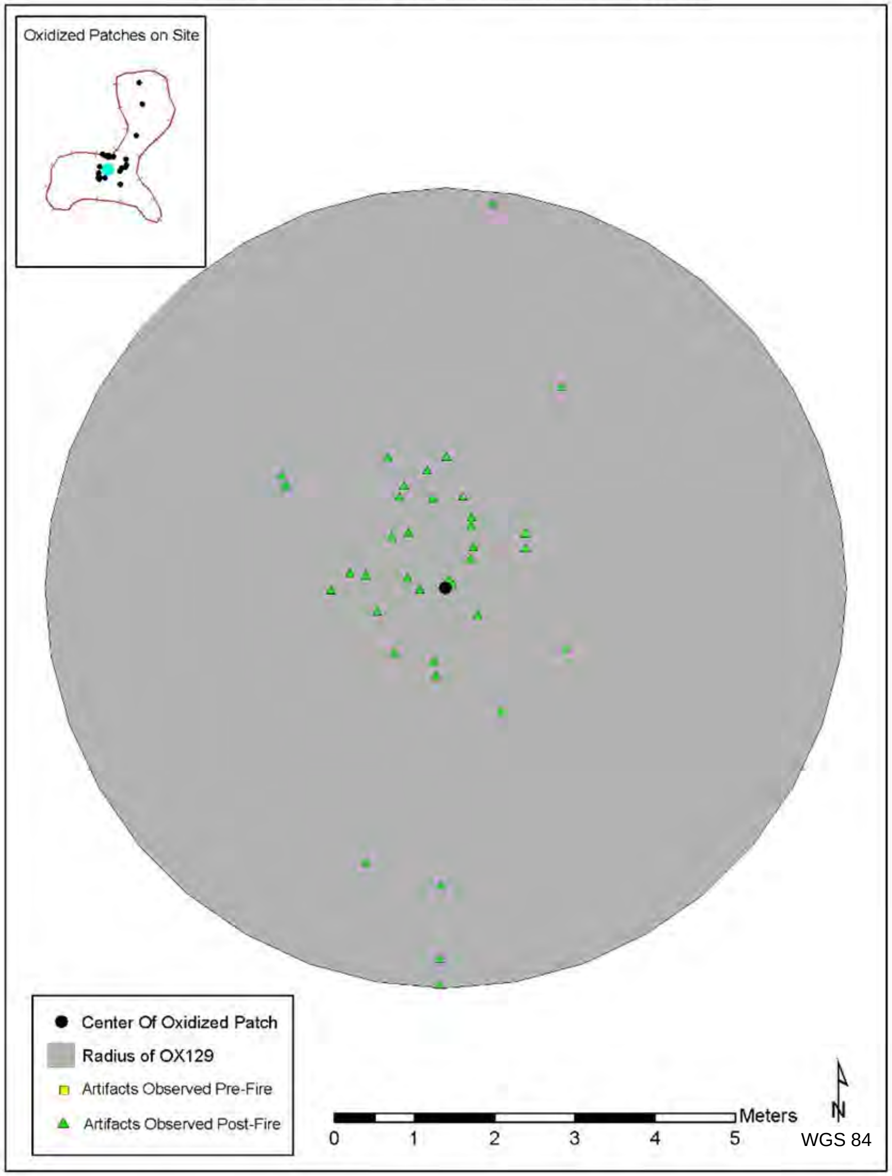
OX128: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX128: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	20	13.6

48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 129 (OX129)

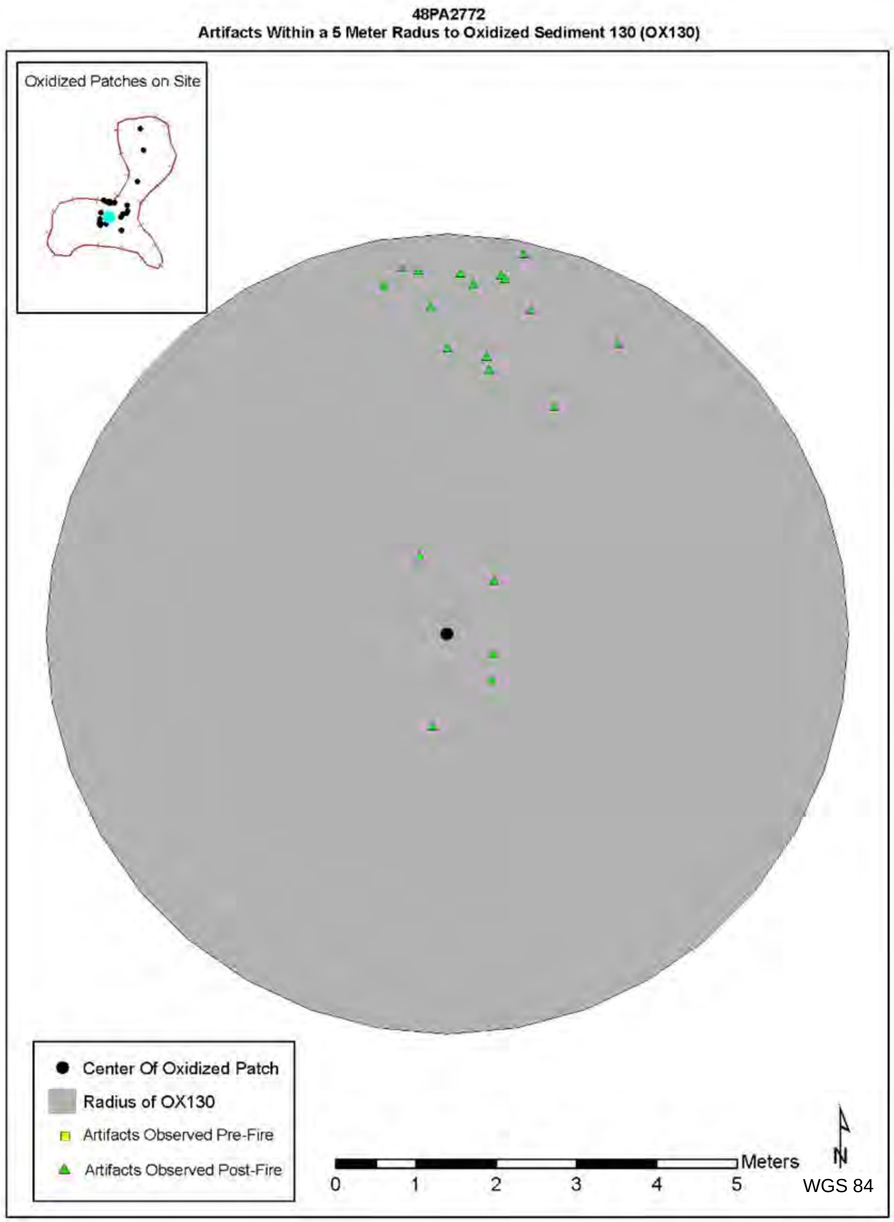


OX129: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX129: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	35	12.2



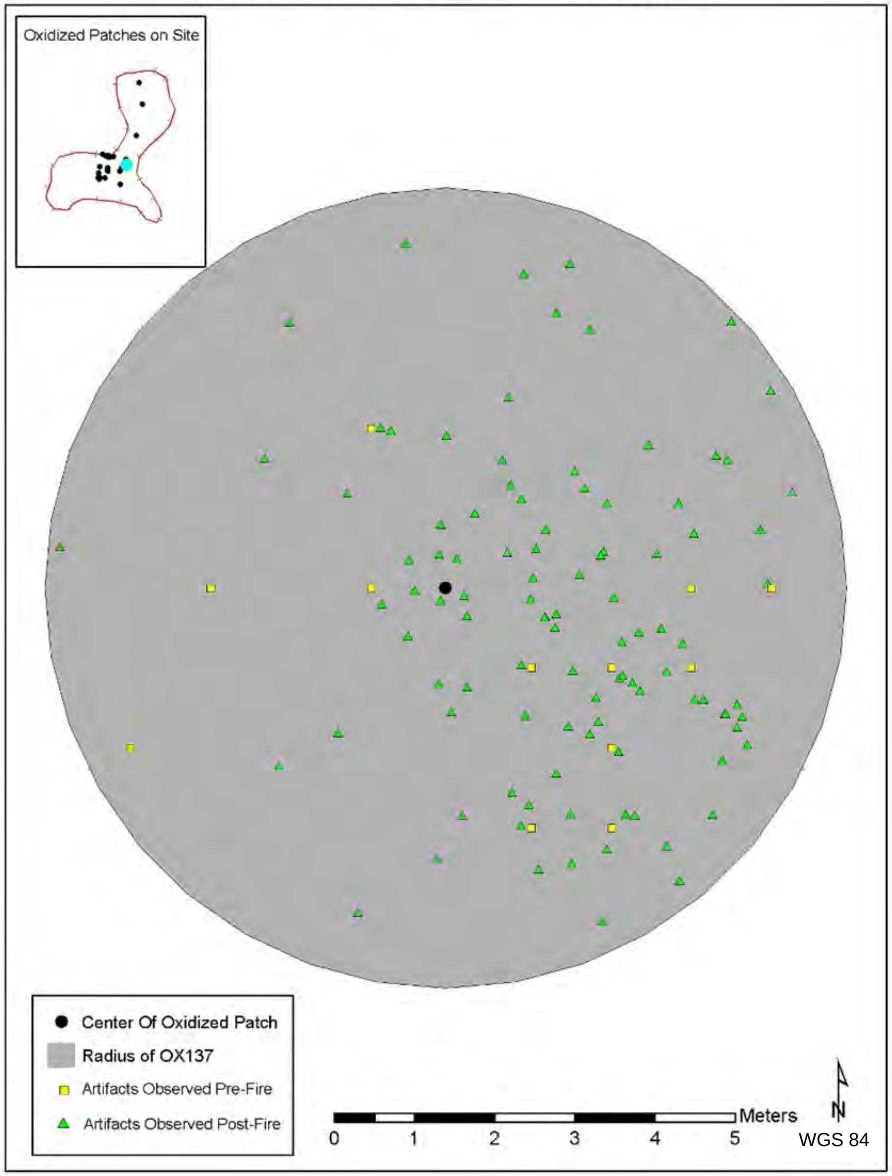
OX130: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	0	N/A

OX130: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	18	11.3

48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 137 (OX137)



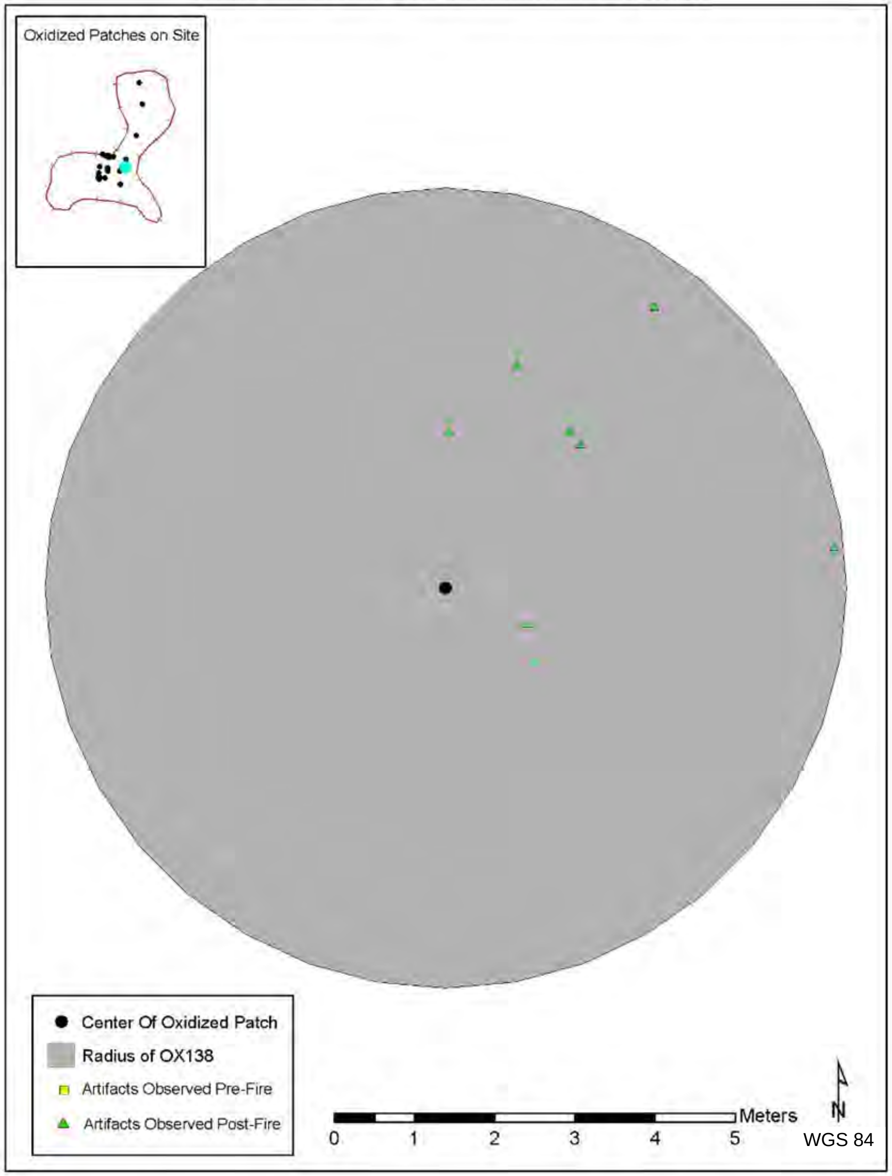
OX137: Materials observed 2003-2006

	Total	Average Length (mm)
Chipped Stone	16	11

OX137: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	94	10.4

48PA2772
Artifacts Within a 5 Meter Radius to Oxidized Sediment 138 (OX138)



OX138: Materials observed 2003-2006

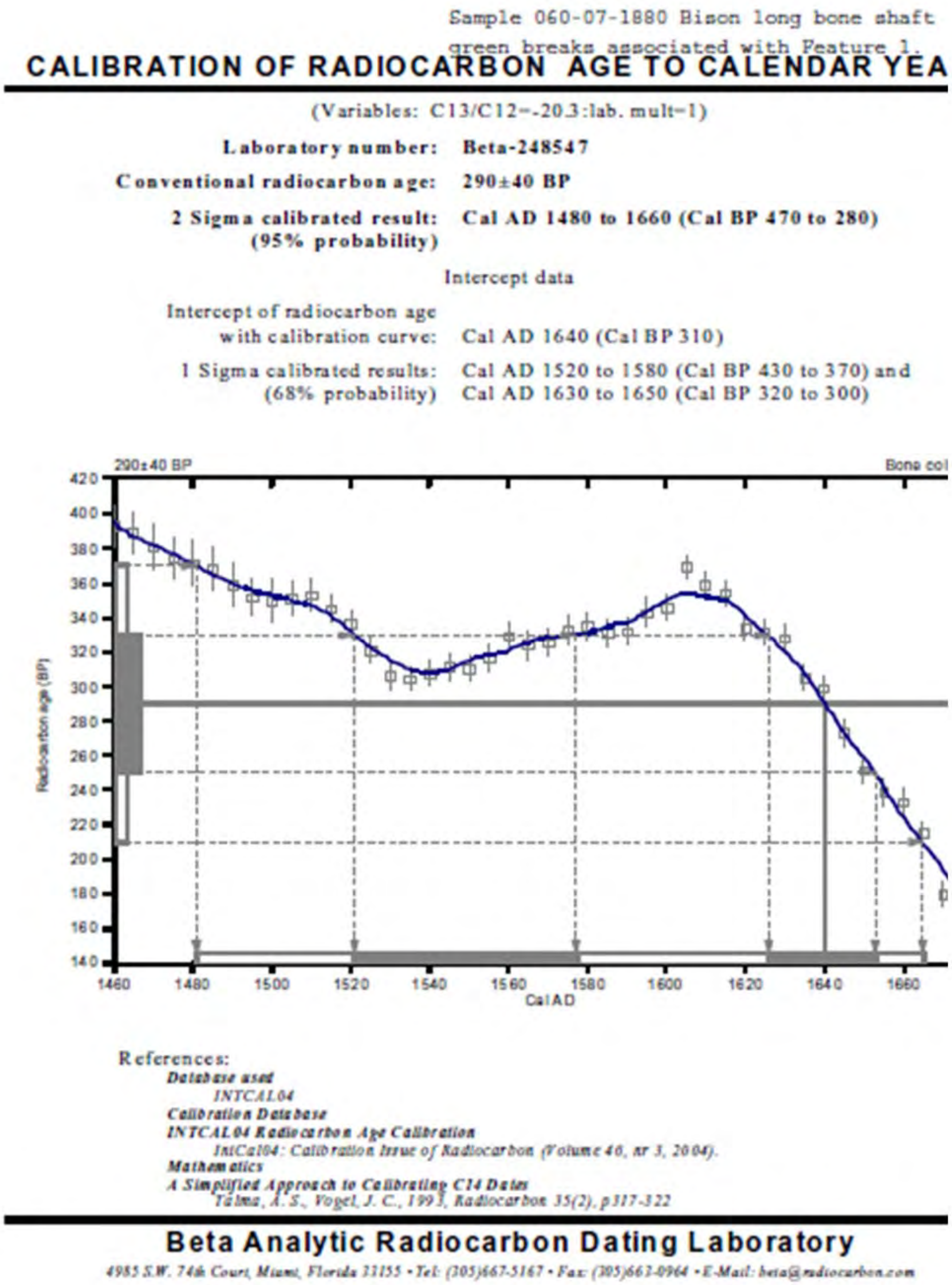
	Total	Average Length (mm)
Chipped Stone	0	N/A

OX138: Materials observed 2007

	Total	Average Length (mm)
Chipped Stone	7	9.6

APPENDIX C: C^{14} RESULTS

Radiocarbon dates calculated by Beta Analytic.



Sample 060-07-1880 Bison long bone shaft green breaks associated with Feature 1.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEA

(Variables: C13/C12=-20.3:lab. mult=1)

Laboratory number:	**Beta-248547**
Conventional radiocarbon age:	**290±40 BP**
2 Sigma calibrated result: **(95% probability)**	**Cal AD 1480 to 1660 (Cal BP 470 to 280)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1640 (Cal BP 310)
1 Sigma calibrated results: (68% probability)	Cal AD 1520 to 1580 (Cal BP 430 to 370) and Cal AD 1630 to 1650 (Cal BP 320 to 300)

References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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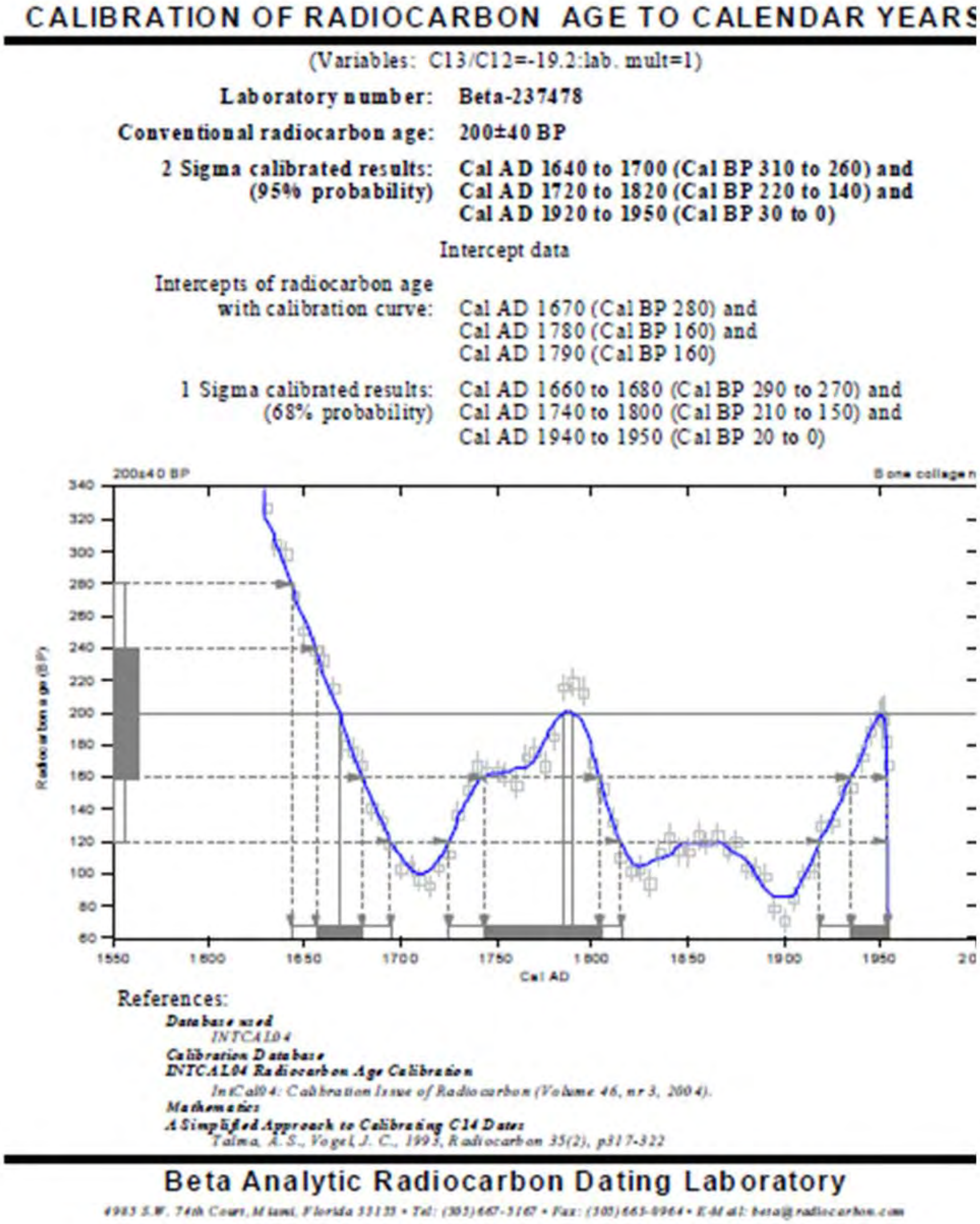

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-19.2:lab. mult=1)

Laboratory number:	**Beta-237478**
Conventional radiocarbon age:	**200±40 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal AD 1640 to 1700 (Cal BP 310 to 260) and** **Cal AD 1720 to 1820 (Cal BP 220 to 140) and** **Cal AD 1920 to 1950 (Cal BP 30 to 0)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 1670 (Cal BP 280) and Cal AD 1780 (Cal BP 160) and Cal AD 1790 (Cal BP 160)
1 Sigma calibrated results: (68% probability)	Cal AD 1660 to 1680 (Cal BP 290 to 270) and Cal AD 1740 to 1800 (Cal BP 210 to 150) and Cal AD 1940 to 1950 (Cal BP 20 to 0)

References:

Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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APPENDIX D: RESEARCH PROPOSAL

Results and methods of this thesis rewritten as a research proposal draft modeled after a call for projects by the Joint Fire Sciences Research program. (http://www.firescience.gov/JFSP_funding_announcements.cfm).

Damage or Data: Measuring the benefits to the archaeological record caused by prescribed and wildland fire

A. Kvale Thompson and Nicole Branton

Archaeologists

Arapaho and Roosevelt National Forests and the Pawnee National Grassland

Overview

This project seeks to understand how fire impacts the management of those archaeological sites. Fires burn the vegetation on the ground surface. This exposes the cultural materials and allows researchers to better observe and record an archaeological site. However, this also increases the danger to looting and non professional artifact collection. Those materials that had once been protected by the surface vegetation are now in full view. To preserve as much of the archaeological record as possible, professional surveys and documentations should take place immediately after fires to mitigate the information lose cause by non-professional surface collection.

This investigation will take place over the course of multiple field seasons (2012-2013) to assess the impact of both prescribed and wildland fires on the documentation and preservation of archaeological material.

Project Justification & Expected Benefits

This project will seek to understand how the visibility changes at two different scales. The first being after large stand replacing fires, and the second is after prescribed fires. This investigation will document examples from both scales and how they relate to the management of archaeological sites. Those two scales are prescribed fires and wildland fires.

In the past, investigations understanding the increase observable materials after fires have been inherently biased because they examine only the post fire environments. The reason for this bias is often because of the unpredictability of fires. This investigation is unique compared to other studies because both archaeological heritage management and wildland fire management departments are under one roof. Both types of data sets are easily accessible and can be combined. For this project this situation allows for long term research to be conducted in the interaction between fires and archaeological material. Under Section 106 of the National Historic Preservation Act (cite), as areas are queued for prescribed burns it is required to have the potential impact of that burning on archaeological materials assessed. These investigations always happen before the prescribed fires take place. However, to many archaeological sites the greatest impact happens after the fire. As the fire burns the surface vegetation it uncovers the materials that are underneath. This exposed those materials and endangers them to looting. To protect these resources, these uncovered and unknown artifacts need to be documented after fires have burned.

For example, Thompson (2012) examined the information gathered on a site in northwestern Wyoming that was recorded prior to and following a large stand replacing fire. Archaeological datasets were gathered in the years before the 2006 Little Venus Fire (2003-2006) and those were compared to archaeological data documented in the summer of 2007 after the ground surface had burned. The 2007 documentation focused on intensely burned areas. A 5 meter buffer was created in ArcGIS 9.3 and the clip tool was used for each of the pre and post datasets to extract only the materials that were inside of the buffer. Figure 1, is an example of the figure created from each buffered area.

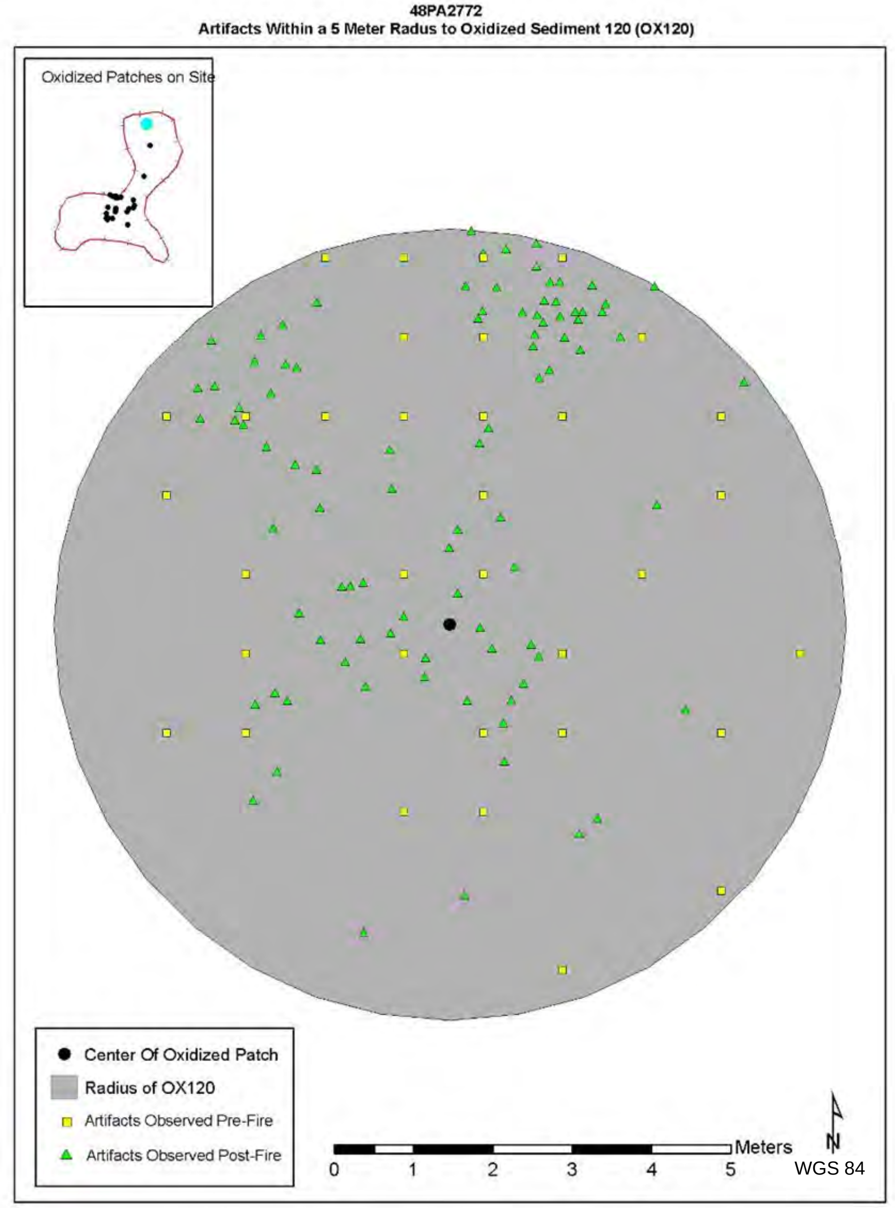

Figure 1. Five meter buffer area. The squares are those artifacts that were recorded before the LVF in the 2003-2006 field seasons. Triangles represent those artifacts documented after the LVF (2007).

Those materials documented within the area the radii were then broken down into types and classes so each separate source of information could be individually classified. For this investigation these methods will be used in areas that that are required to be surveyed before prescribed burns in the summer of 2012. After the prescribed burns have been implemented, those buffered areas with be surveyed for cultural materials

Project Objectives & Hypotheses

The hypothesis of this investigation is that there will be more archaeological material documented after fires. The objectives are to understand this interaction and document how fire can be used as a management tool for archaeological resources. This will be done by surveying areas that have had recent prescribed burns. This will not only help to better protect and manage these archaeological resources, but it will also greatly add to the archaeological record for this region.

Methods

Study Site(s)

This investigation will be conducted in areas that have been previously surveyed for cultural material and have been recently burned by either a wildland use or prescribed fire. Research will be conducted in three locations. Two of those locations will have prescribed burns implemented and one has s recently experience a large wildland fire. These three locations, the Chicken Park area of the Red Feather North Fuels, the Pingree Hill Fuels Reduction Project, and the area burned by the Crystal Fire, are located in the Canyon Lakes District of the Arapaho and Roosevelt National Forests.

Sampling Design

Three separate areas will be sampled. Two of those areas will have prescribed burns implemented during either the summer of 2012 or 2013. The two prescribed burn areas will be the Chicken Park region of the Red Feather North Fuels Reduction Project and the Pingree Hill Fuels Reduction Project. Broad 10-15 meter transect surveys have been conducted across these areas and archaeological sites have been located and recorded. We will return to these documented sites before the prescribed burning is implemented (during the summer of June 2012) and gather the locational data on subsets of the total site areas. These subsets will be five meter radii surrounding previously documented features or artifact concentrations. Also, those areas with a high potential of yielding archaeological material will be resurveyed after the burn.

The third area was burned by the Crystal Fire 10-15 miles west of Fort Collins, Colorado. Of the 1025 acres burned on Forest Service land, 250 of those will be surveyed for this project. On these sites found in this burned acres, locational data will be gathered on formal tools and features. Counts will be given on how many artifacts are on the ground surface of the sites and those counts will be compared to the previous recordings. Surveys will be conducted in this area based the predictive model. Areas where no archaeological material was observed but had a high potential based on the predictive model will be resurveyed to assess whether the increase in visibility increased the chances of observing material.

Resurvey in both the prescribed and wildland fire will be conducted on 25% of the original acres surveyed of 25% of the total area burned. Three weeks will be spent in each of the burned areas. This time will be allocated between survey and site recording.

For the prescribed burn areas (Chicken Park Area and the Pingree Burn Area):

> -One week will be spending in the area before the prescribed burn. This time will be spent documenting the artifacts on the five meter buffered area.
>
> -Two weeks will be spent in each area after the prescribed burns.
>
> -One of these weeks will be spent rerecording the buffered areas after the sites. The number of buffered areas on each of the sites will depend on the number of surface artifacts previously documented and the total site area. The number of buffered areas per site will vary from one to five. Buffered areas will not be recorded on newly recorded sites that are discovered after the prescribed burn. These sites will be recorded using the standard methods practiced by the Forest Service.
>
> -One of these weeks will be spend surveying areas that were previously surveyed

In the area burned by the 2011 Crystal Fire:

> -Three weeks will be spent surveying the area at 10 meter transects and documenting the archaeological sites.
>
> -The sites found during these surveys will be fully recorded as required by the Colorado State Historic Preservation Office. Locational data will not be

gathered on all of the artifacts found. Locational data will be gathered for each feature and formal tool.

Field Measurements.

This investigation will use the methods laid out by Thompson (2012). The diagnostic information that will be gathered on the artifacts will be the time period (historic, protohistoric, general prehistoric, late prehistoric, archaic, and paleoindian). In addition to these data, metric data will be gathered on the individual artifacts. All of these data will be entered into the Trimble GeoXT devices in the field. Site forms required by the Colorado State Historic Preservation Office will also be filled out in the field.

Data Analysis

A part of the analysis for this investigation will take place in the field. Removing many of artifacts from the field would be detrimental to examining the relationship between fires and archaeological material over the long term. In addition to locational data gathered for each artifact, measurements and diagnostic characteristics will be recorded. These data will be downloaded and differentially corrected using Path finder Office 5. Spatial data will be entered and examined using ArcMap 10. Artifact densities in the pre and post fire environments will be calculated in Microsoft Excel and statically compared with a Chi2 test calculated either by hand or though the statistical program SPSS.

During 10 weeks of analysis for this project the three employees will complete the required site forms for each of the new sites documented in the area burned by the

Crystal Fire. Those forms will be compiled in a formal report and submitted to the Colorado State Historic Preservation Office.

The data gathered from the five meter buffered areas in the prescribed areas will be used as a small scale example of how the information from individual archaeological sites is impacted by prescribed fires. The data gathered during the surveys for both prescribed burns and the Crystal Fire area will serve as the data for examining the impact of fire on the archaeological information across the broad scale.

> -Four weeks will be spent finalizing the site form and imputing the field data. Also during this period the initial results and implications will be compiled into a poster presentation to be presented a professional archaeological conference.
>
> -One week will be spent editing, finalizing, and presenting the poster.
>
> -Five weeks will be spent preparing the training webinar for this project.

Materials

Trimble GeoXT GPS devices will be used to gather locational data and store the metric and other diagnostic information for each artifact. Handheld calipers and tape measures will be used to measure the artifacts. The computer programs Pathfinder Office 5 and ArcMap 10 will be used to correct and interpret the data. All of the materials for this project as housed at the Heritage office of the Arapaho and Roosevelt National Forests and the Pawnee National Grassland. No additional materials or computer software will need to be purchased to complete this project.

Project Duration and Timeline

Project Milestone	Description
Completion of pre-field work	20 days of developing predictive model (GIS) and preparing previous site recording/survey data for field work
Completion of Rx Burn Surveys	32 field days of pedestrian survey and site documentation within the Pingree Hil prescribed burn area.
Completion of Crystal Fire Surveys	16 field days of pedestrian survey and site documentation within the Crystal fire area.
Completion of Site Forms/Report	20 days of preparing Colorado Cultural Survey Forms and location and sketch maps for resources found during field surveys.
Completion of post-field analysis	20 days of analysis of field data and preparation of final report and training/webinar
Completion of webinar	Webinar informing federal cultural resource managers of results of project and implications for fuels and cultural resource management
Completion of SAA poster	Presentation of results at Society for American Archaeology

Project Compliance - NEPA and Other Clearances.

The prescribed burns that would be analyzed are covered by the Pingree Hill Fuels Reduction and Red Feather Fuels Reduction Environmental Assessments. Because field work would include only pedestrian inventory and site recording (no ground disturbance in the form of excavation or testing), it meets the definition of an "undertaking with no potential to cause effects," under the National Historic Preservation Act (36 CFR 800.3(a)(1)).

Research Linkage

The methods and implications of this research are developed from the research preciously conducted by the Greybull River Sustainable Landscape Ecology Project (GRSLE) under the direction of Dr. Lawrence Todd in the Shoshone National Forest of northwestern Wyoming. This type of research seeks to documents the how archaeological materials interact with large scale processes. Thompson (2012) used methods developed by GRSLE to interpret the role of recent wildland fire on the documentation of archaeological material. Research for this project will be an extension of the large body of interdisciplinary knowledge that exists when combining fire management with archaeological investigations.

Deliverables and Science Delivery

Fire cannot be removed from the ecosystems where archaeological sites are found. The point of this investigation is to measure and represent how fire can be used to aid in the management of cultural resources. There will be two types of deliverables. First, this information will be dispersed to the JFSP Knowledge Exchange Consortia in the form of a webinar to promote the wide spread exchange of both these methods and additional regional scientific conversation between archaeologist and fire managers.

Additionally, with a larger body of knowledge this type of information and conversation will lead to fine tuning surveys and predictive models of archaeological site location. The second deliverable with be a predictive model that combines the information from this investigation with the predictive model already developed for this region. This fine tuning of the existing predictive model will allow for more accurate archaeological surveys to be conducted especially in those areas that have recently burned.

Table x. deliverable, description and delivery dates

Deliverable Type	Description
Webinar	Description of the methods used and
Conference Poster	Preliminary descriptions of the predictive model

VII. Roles of Investigators and Associated Personnel

Table x. Roles and responsibilities of associated personnel

Personnel	Role	Responsibility
A. Kvale Thompson	Crew Lead	Supervision of project, data analysis, webinar development, data preparation and supervision of project deliverables
Field Technician	Researcher	Documentation and data entry
Field Technician	Researcher	Documentation and data entry

Data Management Plan Template

Proposal Title: Damage or Data: Measuring the benefits to the archaeological record caused by prescribed and wildland fire

I. Project Data Management

1. Data types

There will be two types of data gathered for this investigation. The main type will be locational data gathered for each artifact found before and after the prescribed and wild fires. The second type of data will be the general diagnostic information about each artifact including the type, age range, and metric information. Both of these data sets will be gathered in the field on the Trimble GPS units. Also, this investigation relies on previous surveys and site documentations that have been conducted by this office to identify areas that will be intensively documented before the prescribed burns are implicated. For those areas that will have prescribed burning, the location of 5 meter radii on prehistoric and historic sites with be chosen based on both the presence of known archaeological material. To determine the statistical significance in the change in the density of artifacts the density per $5m^2$ buffer will be calculated and a Chi^2 test will be run on those datasets.

Areas that have been subject to larger fires will be chosen based on the predictive model for archaeological site location developed by this office. Five meter radius areas will be intensively examined on previously documented sites and in areas that have a high potential for archaeological material.

2. Quality Assurance

The accuracy of the locational data for the archaeological material is crucial to the interpretations that will come from this investigation. To ensure accuracy, the Trimble GeoXT devices will gather at least 10 satellite positions for each artifact. These data will then be post processed and differentially corrected using the program Pathfinder Office.

3. Data Access

Immediate access to these data will be limited to forest service personnel who have access to the national server. Other types of access will be permitted though requests to the Forest Service Heritage department. Exposed archaeological materials are often at high risk for non-professional collection. When these materials are taken from sites without proper data collection techniques, the information they relate about past human activity is also taken. Since the documentation for this investigation will leave the majority of the artifacts in place it is important to limit access to those data and preserve further research potential.

Budget Narrative

Project Title: Damage or Data: Measuring the benefits to the archaeological record caused by prescribed and wildland fire

The budget for this project will cover temporary personnel time spent preparing and organizing the information needed to conduct the field component of this project. Before the field portion of this project, one GS-7 employees to spend five weeks (20 days) applying a predictive model to areas scheduled for prescribed burns, and to those areas that were burned by the Crystal Fire (2011). Also, previous survey and site recording data will be compiled, examined, and entered into a Trimble GeoXT (already owned by the Forest; not included in budget). The total cost of for this portion of the project is $XXX

Three temporary employees would conduct the field component of this project. A crew of three would conduct field work and document the materials. This crew will consist of one GS-7 crew lead with sufficient experience and knowledge supervising two archaeological technicians (GS-5) conducting field inventory and site documentation as well inputting the artifact data into the Trimble GeoXT devices. This crew will conduct the field surveys and site recordings during the field season of 2012 (June-August). This amounts to 50 days (10 weeks) of field work per crew member. The total cost from this portion of the project is $XXX.

A vehicle would be leased to transport the crew to and from the field at a rate of xxxx per day for 50 days.

Post-fieldwork data analysis will be conducted by one GS-7 and two GS-5 employees over an eight weeks (40 days per employee) period. During this time, the site forms required by the Colorado State Historic Preservation Office for the redocumented sites and newly discovered sites will be prepared and submitted in a formal Cultural Resource report. Additionally, the information for the informational webinar and the conference paper will be prepared. The cost of this post-field portion of the project is $XXX.

The total cost of the project is $xxx.

Salary Justification

Certification to the Joint Fire Science Program

Justification of Need for Salary Support

I hereby certify the attached justification of need to provide temporary salaries for full-time permanent employee (s)_Thompson__*(list name of employee(s))* is necessary and appropriate to enable him/her (them) to fully and directly participate in the proposed project.

Justification:

This project will require Mr. Thompson to spend considerable preparing the Trimble devices with the proper data dictionaries, base maps, and predictive models necessary to effectively conduct this field research. Mr. Thompson has supervised research teams using these methods during multiple field seasons. Additionally, he has experience preparing, organizing, directing, and implementing, the large field projects. Mr. Thompson also has experience interpreting these types of datasets. A large portion of his Masters Thesis was interpreting the impacts of wildland fire in the modern archaeological record. Further, Mr. Thompson has created predict models and maps for archaeological sites locations.

The salary for Mr. Thompson is based on both time spend preparing for this investigation and the time spent implementing the field research for this project.

I understand that salary funding for this/these employee(s) directly involved in the proposed project is temporary and will not be provided beyond the duration of the proposed project.

Signature /s/ ____________________________ Date____________________

Title ___________________________Phone No. ___________