Cultural Resources and Wildland Fire Management:
An Investigation into the Operational Effects of Prescribed Burning to a Simulated Archaeological Record

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Authorization to Submit Thesis

This thesis of Kaitlyn G. Eldredge, submitted for the degree of Master of Arts with a Major in Anthropology, and titled "Cultural Resources and Wildland Fire Management: An Investigation into the Operational Effects of Prescribed Burning to a Simulated Archaeological Record," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

Wildfire is one of many natural forces that has challenged humans for thousands of years. In just over the last one hundred years, methods to suppress and manage wildfire in the United States were formally developed. Wildfire prevention and suppression is necessary to the management of many natural and cultural resources. Cultural resources are nonrenewable resources that require consideration by those who manage wildland fire. Though there has been previous research conducted on the direct impact of fire to cultural resources, there is a dearth of information on how operational effects, such as fireline construction, impact cultural resources including archaeological sites. What limited information is available on the subject suggests that mechanical fireline construction and rehabilitation are no less of a threat to cultural resources than fire is. Working within the framework of experimental archaeology, I simulated an archaeological site using replica precontact artifacts and authentic historic materials. A fireline was mechanically constructed through the simulated site, a prescribed burn was conducted, and the fireline was mechanically rehabilitated.

Data were gathered on the spatial displacement and physical impacts to experimental artifacts. The findings of this study reveal that mechanical fireline construction consistently displaces artifacts by several meters. Fireline rehabilitation also contributes to the displacement of artifacts. Both of these operational effects are no less directly threatening to cultural resources than fire is, and have irreversible impacts that severely inhibit the ability to interpret or recover an archaeological site. Physical impacts to artifacts in this study include breakage and staining from combustive residue. By quantifying the impacts of fireline construction and rehabilitation to the simulated archaeological site, this study provides a means for cultural resource specialists and wildland fire managers to make appropriate decisions towards the preservation of our Nation’s heritage.

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With the UIEF I would like to thank the employees and University of Idaho students who assisted me with the fireline construction and prescribed burn. I greatly appreciate that many of you shared your knowledge; your patience ensured a memorable first fire experience.

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CHAPTER 1: INTRODUCTION TO THE RESEARCH PROJECT

Cultural resources are susceptible to damage or loss from a myriad of sources. One such source that has received some attention is wildland fires. For the large part, research has been focused on the direct physical impact of fire to various cultural resources (Traylor et al., 1990; Buenger, 2003; Sturdevant, 2009; Ryan et al., 2012a). In much of the available literature on the subject, there is an occasional and brief mention of wildland fire management actions; in essence, management actions have negative impacts on cultural resources. An exception to the brief mention is a statement in Timmons, deBano, and Ryan (2012) that suppression activities and rehabilitation efforts "present the most consistent adverse impacts [to archaeological sites] and pose the greatest risk to cultural properties" (p. 176). A general lack of data and elaboration on the consequences of wildland fire management practices motivated me to conduct this study. I developed the Cultural Resources and Wildland Fire Management (CRWFM) Project to identify and understand the impacts of wildland fire management practices to cultural resources. In particular, the impacts associated with the wildland fire management practice of prescribed burning is the focus of this study. Field research began in October of 2019 and concluded in late November of the same year. The field research was accomplished with the assistance of four of my peers and colleagues, as well as a team of 11 individuals who conducted the prescribed burn. The purpose of my research was to gather data on how mechanical fireline construction and rehabilitation can impact an archaeological site. The goal of this study is to contribute quantifiable data to be used in the training of cultural resource specialists and wildland fire managers and personnel.

The impacts of wildland fire management will frequently be referred to as both indirect impacts and as operational effects. Indirect impacts are those that are dependent on the occurrence of fire and can change the context in which a cultural resource is found (Ryan et al., 2012b). Operational effects are a type of indirect impact that are associated with fire management operations (Ryan et al., 2012b). Complete definitions for these terms as well as an overview of wildland fire can be found in Chapter 2. The major indirect fire impacts and operational effects associated with prescribed burning include fireline construction and rehabilitation, and erosion. Indirect impacts and operational effects may occur before, during, and/or after a fire incident. Impacts to resources including obsidian and chert lithics, and glass, metal, ceramic, and synthetic artifacts from the early 20th century are the focus of this study.

Methodology

The CRWFM Project combines the methods of experimental archaeology, participant observation, field survey, and laboratory research. The experimental aspect of the project was conducted within the University of Idaho Experimental Forest (UIEF) south of Princeton, Idaho. The project involves simulating an archaeological record, and three phases of research conducted in the forest, followed by data analysis. The three phases of the project occur before, during, and after a prescribed burn. Operational effects associated with these phases include fireline construction, prescribed burning, and fireline rehabilitation. Data collection consisted of survey, photography, and mapping of the area, as well as tracking disturbance to experimental artifacts, and recording of fire management methods, measurement of firelines, and fire behavior data. A more in-depth discussion of the project area and methodology can be found in Chapter 3.

The first phase of this research (Chapter 4) involved mapping and photographing the prescribed burn area as well as placement of experimental artifacts within that area, prior to the burn. The experimental artifacts were placed specifically in locations where a fireline was to be constructed. Observation and documentation of fireline construction were also part of Phase 1. Throughout the project, locations of where experimental artifacts were placed and collected were recorded using a Nikon DTM 322 total station. For the second phase (Chapter 5), during the prescribed burn, data collection involved observing the fire management methods used by University of Idaho students and employees as well as recording fire behavior data. Finally, data collection during the third phase (Chapter 6) occurred after the prescribed burn and involved re-survey of the burned area to determine changes in locations of experimental artifacts since the first phase, and recording of new locations and depths where needed. Rehabilitation of the fireline was also conducted as part of Phase 3 to collect additional data.

The results of the three phases of research are analyzed in Chapter 7. The concluding chapter of this document interprets the data and offers ways in which to integrate the results of this research into cultural resource and land management strategies of wildland fire management.

Significance

A substantial amount of previous field and experimental research (Traylor et al., 1990; Buenger, 2003; Sturdevant, 2009; Ryan et al., 2012a and references therein) has been compiled on how wildland fire directly impacts cultural resources. However, there are few publications that focus on impacts of wildland fire management practices (but see Traylor et al., 1990). Consequentially, much of the available training for wildland fire personnel and cultural resource specialists overlooks the operational effects of wildland fire management. A noteworthy exception is a current Forest Service training workshop for archaeologists, which includes the heading “Beyond Dozer chasing” on the syllabus. The purpose of the CRWFM Project is to gain an understanding of how wildland fire management engages with cultural resource management and to use the results of the experiment to provide knowledge to these professionals.

The effects of climate change are increasing the threat to cultural resources across North America. The size and intensity of wildland fires has increased dramatically over the past several years. This is due to many factors, including increased insect infestation, and decreased snow pack (Vose et al., 2018). Over the past thirty years, acreage burned has increased nearly fourfold (Vose et al., 2018). In the northwest- Idaho, Washington and Oregon- increased warming will further decrease snowpack levels and lead to a higher risk for wildfires and also extend the duration of the fire season (May et al., 2018). Megafires, those burning 100,000 acres or more, have become more common (Patel, 2018). Figure 1.1 below considers the total acreage burned in all megafires in Idaho (n=26), Oregon (n=17), and Washington (n=9) since 1999 using data from the National Interagency Coordination Center (NICC) and the National Fire and Aviation Management (FAM) Web Applications (2019). This data includes megafires occurring in both forest, grass, and sagebrush fuel types. It should be noted that included in this graph is the acreage of the 2007 Murphy Complex Fire, which occurred in Idaho and totaled 652,016 acres burned (NICC & FAM, 2019).

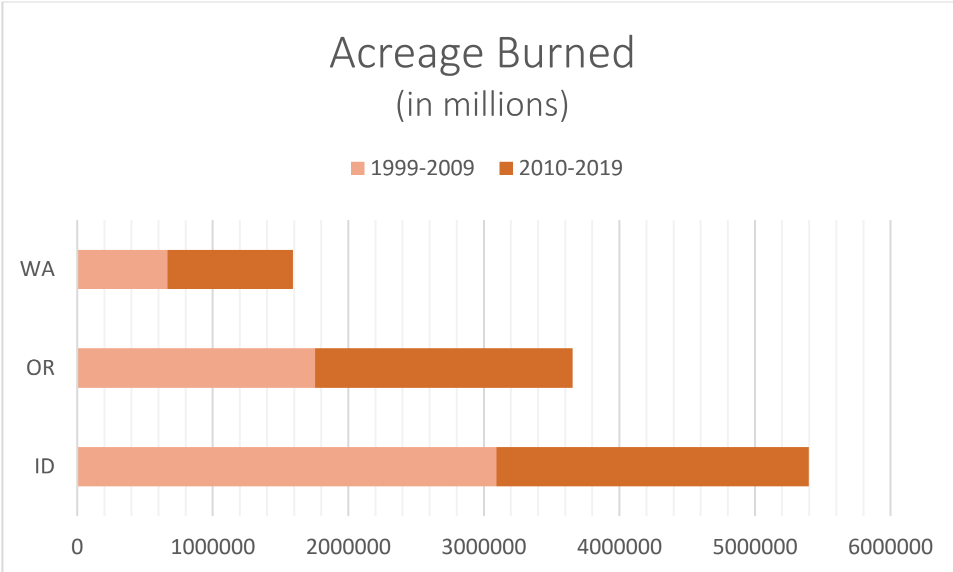

Figure 1.1: Total acreage burned in all megafires in Idaho, Oregon, and Washington over the last 20 years (NICC & FAM, 2019).

With climate change greatly increasing the length of the fire season and intensity of fires, it is inevitable that new fire management strategies will be developed. It is necessary to incorporate into these strategies the continued protection of cultural resources. Without a comprehensive understanding of how operational effects can impact cultural resources at all stages of fire management, I do not believe that these strategies will be effective. A comprehensive understanding of indirect fire impacts must go further than simply recognizing that they exist and that they are the most consistent and detrimental impacts to cultural resources (Ryan et al., 2012b). This must also incorporate understanding of how and at what stages of management impacts occur, so we may work to avoid them and recognize what they look like when they are unavoidable.

An understanding of how operational effects of wildland fire will affect cultural resources at each stage of fire management will allow all parties involved to implement informed, and therefore effective, decisions and actions that comply with legal regulations not limited to those laid out by the National Environmental Policy Act, and Section 106 of the National Historic Preservation Act. This will be beneficial to archaeologists, land managers, and incident management teams who work together to create comprehensive strategies for fire suppression and cultural resource management. A final report on the indirect impacts to cultural resources from wildland fire management methods, specifically prescribed burning, will aid the collaboration between cultural resource specialists and land managers. The report

(Appendix B, this volume) will be beneficial to archaeologists and fire personnel who work together in areas where wildland fire is prevalent.

Defining Cultural Resources

Cultural resources are defined and referred to in numerous ways. Though often used interchangeably, cultural, heritage, patrimony, and archaeological are terms that can imply different categories of elements in the human environment (Ryan et al., 2012b; King, 2013). Broadly, a cultural resource can be a material or non-material object such as a site, feature, artifact, or landscape. Numerous laws and regulations are in place to protect "'historic properties', 'archaeological sites', and 'Native American graves and cultural items'", however these are only a few general examples of what constitutes a cultural resource (King, 2013, p. 5). Elements of the human environment that are integral to a community's identity such as "social institutions, historic places and cultural sites, artifacts, documents, and traditional ways of life" can all be considered cultural resources (King, 2013, p. 382).

Cultural resources can be further understood as precontact, historic, and contemporary. In Americanist archaeology, "precontact"- also known as precolumbian or prehistoric- refers to the time in North America before a written record, and ends with Spanish contact (Ryan et al., 2012b). It follows then that "historic" refers to the time period after contact and at which time a written record was established, or approximately 1500 C.E. in North America (Ryan et al., 2012b). Contemporary cultural resources are those that are still used today, or have entered the archaeological record at least 100 years ago or became significant in at least the past 50 years (King, 2013). Furthermore, cultural resources can be described as tangible and intangible. Many are most familiar with tangible cultural resources, those that can be seen or touched. Intangible resources are often more difficult to identify. These are understood as "conceptual, oral, and behavioral traditions providing the social context for artifacts and sites" (Welch, 2012, p. 157). Intangible resources can also include language, performing arts, social practices, rituals, knowledge and practices, and traditional craftsmanship (King, 2013, p. 293 from UNESCO 2003 Convention). As one can see, cultural resources are not necessarily material objects.

Archaeological resources, specifically artifacts, are the focus of the CRWFM project. An archaeological resource is "any material remains or physical evidence of past human life or activities" and can include "the record of the effects of human activities on the environment" (Ryan et al., 2012a, p. 209). An artifact is any material that has been used or manufactured by a human; archaeologists study artifacts used by past peoples (Ryan et al., 2012a). Table 1.1 provides examples of each category of cultural resource. The specific categories of cultural resources involved in this study are discussed in greater detail in Chapters 3 and 4.

Table 1.1: Categories of cultural resources for the United States. (Adapted after Ryan et al., 2012b, p.9).

Category	Materiality	Tangibility	Examples
Archaeological	Material	Tangible	*Prehistoric:* stone tools, hearths *Historic:* iron cans, mining pits/trenches
Ethnographic	Non-material	Both	*Prehistoric:* salmon, camas root; traditional gathering or hunting sites
Landscapes	Both	Both	*Prehistoric:* sacred sites *Historic:* battlegrounds
Structure	Material	Tangible	*Prehistoric:* rock cairn *Historic:* train trestle

I have chosen to use the term "cultural resource" for three reasons, two of which are admittedly rather practical. First, the term resource is more familiar to the vocabulary of wildland fire managers than the term heritage; using a more familiar word allows for clear communication between archaeologists and wildland fire managers. Cultural resource is the term used by most federal and state land managing agencies in the United States (Ryan et al., 2012b). Secondly, many of the elements defined as cultural resources are thought of as non-renewable (Ryan et al., 2012b). Again, natural resource and land managers are familiar with the concept of non-renewable. Using this familiar term will aid in communicating the fact that as non-renewable resources, the value of cultural resources to society cannont be replaced when they are lost to impacts of wildland fire management. Finally, as a term that encompasses myriad categories of resources important to varying communities, cultural resource does not have an implied hierarchy and can be used as a more inclusive term for the numerous elements of the human environment that may have value to some cultures and communities but not to others.

Values of Cultural Resources

As stated above, cultural resources are non-renewable resources, and their value to society can be lost when they are themselves lost, destroyed, separated from their archaeological context, or even broken. A resource is valued because it is useful to an individual or community (Lipe, 2009, p. 41). Section 101 of the National Historic Preservation Act (NHPA) ratified the creation of the National Register of Historic Places. This gives the secretary of the interior the authority "…to expand and maintain a National Register of Historic Places composed of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, engineering, and culture" (National, n.d.). Section 106 of the NHPA requires the acknowledgment, by any federal or state agency using federal funds, of the effects of their management or other actions on any cultural resource "that is included in or eligible for inclusion in the National Register" (National, n.d.). Section 101 provides guidelines and four criteria for determining the eligibility of a cultural resource to be included in the National Register, including how to determine significance of a resource. Significance and eligibility of a resource as outlined in Section 101 are largely based in the values of heritage, aesthetic, and research. Table 1.2 below illustrates the four criteria for eligibility under NHPA.

Table 1.2: Section 101 of the National Historic Preservation Act criteria for consideration

Criteria	Category of Cultural Resource
A	Associated with an important event, set of events, or pattern of events.
B	Associated with the life of a significant person
C	Representative of a class, style, school of architecture, period of construction displayed in architecture, engineering, or artwork
D	Contains or may contain information. A building, landscape, example of engineering, or archaeological site.

Three additional values that people place on cultural resources have been illustrated by Lipe (2009). Preservation, educational, and economic values- in addition to heritage, aesthetic, and research as included in the NHPA- are important values of cultural resources. Preservation values are focused on conserving a site from excavation, looting, and vandalism (Lipe, 2009). This value is the main concern for many organizations, and federal agencies such as the Bureau of Land Management, Forest Service, and National Park Service, rely on volunteers to complete preservation projects (Lipe, 2009). Through the value of preservation, other values such as research and heritage can be realized (Lipe, 2009). Educational values of archaeological sites or cultural resources are based in their use to inform people of the past as well as what archaeology is (Lipe, 2009). This differs from the research value in that it is more accessible to the general public, for whom to which academic archaeology is responsible. Economic values of cultural resources lie in their ability to attract tourism and provide local employment (Lipe, 2009). In this way, cultural resources are similar to natural resources, such as lakes and timber. Effective management of cultural resources requires consideration of the values that various stakeholders may place on those resources (Lipe, 2009). This requires consideration of how others may use a cultural resource in ways different from oneself, and indeed in ways beyond those laid out in federal regulations. Archaeologists and land managers can contribute to the public good by working together to better understand the relationship between cultural resources and wildland fire management, and apply that understanding to preserving the use of cultural resources.

As the changing climate calls for adaptations in wildland fire management strategies, cultural resources must not get lost in the smoke. Experimental archaeology provides a framework from which to analyze and quantify the operational effects of wildland fire management to cultural resources. For this study, an archaeological site was simulated in the UIEF in northern Idaho. At the experimental site, mechanical fireline construction and rehabilitation, management practices associated with prescribed burning, were conducted. Knowledge gained through this research will contribute to the training of cultural resource specialists and wildland managers and fire personnel. The following chapter details how these two fields relate to one another in broad contexts as well as in the particulars of this study.

CHAPTER 2: UNDERSTANDING WILDLAND AND PRESCRIBED FIRE AND THE ROLE OF ARCHAEOLOGY WITHIN FIRE MANAGEMENT

Outside of academic and professional settings the terms wildfire and wildland fire might be improperly used as synonymous. Wildland fires are non-structure fires occurring on range or forest lands extending from the wilderness to the wildland-urban interface (WUI) (Ryan et al., 2012b). These can be intentionally started, such as prescribed burns, or unplanned fires started by natural or human causes. Conversely, wildfires are natural or human-caused wildland fires that are unplanned and unwanted, “where the management objective is to suppress or extinguish the fire” (Ryan et al, 2012b, p. 11). Wildland fire management is the actions taken to control both planned and unplanned fire, including fuels treatment and rehabilitation, and fire suppression on range and forestlands.

Wildland fires can have both direct and indirect impacts on cultural resources. Direct impacts are those incurred to resources by the fire itself. Indirect impacts refer to fire management actions that are dependent upon the occurrence of fire and change where a cultural resource is found (Ryan et al., 2012b, p.12). Operational effects are one type of indirect impact of fire management. Specifically, operational effects are indirect impacts that are associated with management activities such as mitigation, suppression, and rehabilitation (Ryan et al., 2012b, p. 14). Operational effects, as defined above, are the focus of this study. Specifically, fireline construction and rehabilitation, as well as methods employed by fire crews are the operational effects in the CRWFM study. The likelihood of erosion and/or vandalism occurring will increase as a result of operational effects therefore, these will be referred to as indirect impacts in this study.

Fire Basics

Fire occurs when three components- fuel, heat, and oxygen- coexist in appropriate amounts, allowing for combustion and successive ignition. A fire environment is determined by weather, terrain, and fuels. These three elements determine fire behavior, or how a fire burns fuels “in a given terrain with the prevailing weather conditions at the time” (Ryan & Koerner, 2012, p. 40). Temperature, wind speed and direction, humidity, precipitation, and sky condition are features of weather that impact wildland fire behavior (Ryan & Koerner, 2012). Slope, aspect, elevation, and drainage are the properties of terrain that influence fire behavior (Ryan & Koerner, 2012). Fuels are the source of energy for a fire and are comprised of both living and dead biomass "from the ground, the surface, and the canopy stratum" in a fire environment (Ryan & Koerner, 2012, p. 23). All of these factors influence fire intensity, and thus fire management decisions and actions. Fire intensity, the measurement of the amount of heat energy released in an area as it relates to the length and depth of a fires spread, is used to determine the difficulty of suppressing a fire (Ryan & Koerner, 2012). Low-intensity fires release minimal amounts of heat energy in proportion to the area in which they burn, and are easier to suppress.

Fire management involves a series of actions to control a planned or unplanned fire. Containment is the major goal and an early step in the process of managing wildland fire. Containment is the establishment of a barrier around a fire, creating a break in fuels available for a fire. Such a boundary can involve natural barriers as well as the manual or mechanical construction of a fireline (Fire Terminology, n.d.). Firelines look like trails, and function to create a barrier around a wildfire by removing fuels that would allow the fire to spread (Handcrews, n.d.). Suppression involves excluding, extinguishing, or confining a fire (Ryan et al., 2012a). Methods such as mop up and burnout can be employed as fire suppression. Mop up is when hand crews work using water or dirt to extinguish fire and hotspots between the fireline they constructed and the interior of the fire (Traylor et al., 1990). This process may also include the widening of the fireline, felling trees thought to create sparks that could jump the fireline to unburned vegetation, as well as digging up burning roots and chopping logs (Traylor et al., 1990). Burnout is another technique used in suppressing fires, predominantly by those on the ground, but helicopters can also be used to employ this method. Burnout involves "setting fire inside a control line to widen it or consume fuel between the edge of the fire and control line" (Fire Terminology, n.d.). Aerial suppression of fire involves dropping water or chemical suppressants or retardants onto fire so that crews may work on containment. Prescribed fire, discussed in more detail later in this chapter, is a method of fire management that can be used to mitigate the risk or severity of wildfires.

Rehabilitation of a burned area is an important post-fire task. The main focus of rehabilitation is to mitigate the effects of soil erosion, which is of heightened concern as a consequence of constructing firelines (Traylor et al., 1990). There are various techniques used in the process of rehabilitation. On a less invasive side, techniques can include reseeding and mulching, and on the more destructive side is the modification or construction of roads, trails, and culverts (Burned Area, n.d.). Because bulldozers cause the largest disruption of soils in the process of constructing firelines it is very important to rehabilitate the areas where they were utilized.

History of Wildland Fire Management in the United States

Long before European colonization of North America, indigenous peoples used fire as a means of shaping and managing the landscapes in which they lived. Across the continent indigenous peoples set fires for numerous purposes. These include clearing areas for agriculture, pest reduction, to facilitate travel, and improving habitat for subsistence sources including game and vegetation such as berries, nuts, and fungi (MacCleery, 1994; Norgaard, 2014). For example, the Karuk Tribe in northern California uses fire to promote production of plants for fiber to be used in basketry and for ceremonial purposes (Norgaard, 2014). Indigenous peoples regularly used short-interval and low-intensity fires to alter forest landscapes to meet their needs (MacCleery, 1994). Importantly, "in fire-prone ecosystems in the West, [American] Indian burning created an element of ecosystem stability that would not have existed without it" (MacCleery, 1994, p. 5). The use of regular, short-interval, and low-intensity fires not only promoted biodiversity from which humans could benefit, but it also decreased the risk and severity of high-intensity wildfire (MacCleery, 1994; Pyne, 2001). Human use of fire by indigenous peoples is not exclusive to North America, indeed it is a global phenomenon. The spread of colonization disrupted the culture of indigenous peoples, and by the late nineteenth century anthropogenic fire had faded from the North American landscape (MacCleery, 1994; Pyne, 2001). The loss of traditional ecological knowledge coupled with the initial aggressive exclusion of fire has left a lasting mark on both the North American landscape and the living descendants of many Native American Tribes.

The first agency to tackle firefighting in the United States was the Forest Service. Established in 1905, the Forest Service was first led by Gifford Pinchot (Egan, 2009). In the early 20th century, thoughts about what could be done about fire were minimally influenced by Western science in the way that they are today. The idea was that, "While nature could never be conquered, it could be tamed, tailored, customized" (Egan, 2009, p. 52). From this viewpoint, man was separate from and able to control nature. The 10 a.m. Policy, or ten o'clock rule, is an early framework for managing fire that has long since been abandoned. Created by the Forest Service in 1935, this policy established that from that date forward

"…any fire spotted in the course of a working day must be under control by ten o'clock the following morning" (Egan, 2009, p. 273). This policy was unrealistic as it required the same response to a fire regardless of the distance it was from firefighting resources (Pyne, 2015). By excluding fire from the landscape, the 10 a.m. policy, as was eventually realized, had actually done more harm than good.

The Forest Service monopolized fire control in the United States, and was the dominating agency around the globe into the 1960s (Pyne, 2015). Following its inception, the Forest Service managed sixty million acres (Egan, 2009). Today, the Forest Service manages 193 million acres of forests and grasslands and employs 10,000 firefighters (By the Numbers, 2013). Another agency that is dominant in fire control is the Bureau of Land Management (BLM). Established in 1946, the BLM currently manages 245 million acres of the land in the U.S. (Pyne, 2015; What We Manage, n.d.). The Weeks Act of 1911 established cooperation efforts in fire control between federal, state, and private organizations (The Weeks Act, n.d). As laid out in the Weeks Act, wildland fires are managed by federal, tribal, state and local, and private agencies and governments, and often by a combination of them. An agreement between the Departments of the Interior, War, and Agriculture the following year also contributed to cooperative efforts in managing wildland fire (Brett, 1912). Today, a complete interagency approach to wildland fire management is taken. The National Wildfire Coordinating Group (NWCG) in their publication of the Wildland Fire Incident Management Field Guide, and the Forest Service in publishing the National Fire Plan and various General Technical Reports provide management guidelines for all agencies in the U.S. The National Interagency Fire Center (NIFC) produces various manuals and handbooks, including the Red Book, for implementing fire management policy for use by all federal land managing agencies.

Over the course of the twentieth century, policies towards wildland fire management have ranged from exclusion, to suppression of fires that were not natural-caused, to active management that includes suppression and mitigation. The technology and resources used in wildland fire management have also changed remarkedly since 1905. In the early years of wildland fire management, technologies and resources were largely limited to men, hand tools, and pack animals when fire occurred in areas inaccessible to vehicles. Similar to many cultural resource management archaeologists today, past firefighters learned on the job. The first formal training of wildland firefighters did not occur until 1939, the same time that the concept of the fire crew was formalized (US Department of the Interior, 1939; Pyne, 2015). After WWII, aircraft was introduced as a viable resource with which to fight fire. Aerial tactics of firefighting such as using airtankers to drop retardants were in effect by the 1950s (Pyne, 2001, 2015). In 1962, a year after the first training course in fire behavior, a national fire training center was established (Pyne, 2015). Many of the same technologies and resources are used today, with some adjustments and additions. The chemicals used in fire retardants and suppressants have changed. Drone and Geographic Information Systems (GIS) technologies are also employed in wildland fire management to aid in monitoring fire behavior to guide management actions and for mapping fire suppression resource locations during an incident.

The removal of fire from the human landscape in North America by severely limiting or altogether ending traditional use of fire has had numerous negative consequences for indigenous peoples. In her study, Kari Marie Norgaard (2014) addresses the impacts of fire exclusion to the social, cultural, political, and physical wellbeing of the Karuk Tribe of the mid-Klamath River region. Through colonization and national fire policies that prevent the Karuk from practicing traditional burning, Tribal members cannot maintain spiritual practices that revolve around responsibilities to the Creator, their access to trade networks is inhibited, and their health deteriorates as access to traditional foods that historically composed 50% of their diets is severely limited (Norgaard, 2014). Ultimately the political sovereignty of the Karuk is threatened as they are unable “to continue the cultural practices necessary to maintain this legal standing” (Norgaard, 2014, p.86). Fortunately, land managers and foresters have begun to recognize the values of traditional knowledge and indigenous burning and their roles in fire regimes.

The Karuk and Yurok Tribes of the mid-Klamath River region in California and Oregon have been working to reinstate cultural burning for resource management, research purposes, and traditional use of fire (Lake et al., 2017). Recent workshops involving members of various Native American Tribes, agency forestry and fire managers, scientists, and students provide hope for effective collaboration and renewal of indigenous fire. A major outcome of these workshops as described by Lake and others (2017) is a call for consideration of both ecological and cultural benefits in fuel reduction strategies. These workshops have brought attention to difficulties in practicing traditional fire due to a lack of funding and legal restrictions on traditional lands (Lake et al., 2017). Additionally, the need to improve communication between fire managers and tribes is an important outcome of these workshops, as improving communication will allow for mutual trust and respect (Lake et al., 2017). The latter is particularly important in the West where much of the land is federally owned and where indigenous peoples were not removed from the land of their ancestors. Returning indigenous use of fire will not only benefit cultures by maintaining their traditional knowledge, thus maintaining their identity and sovereignty, it will also benefit the land and global climate.

Prescribed Burning as a Method of Fire Management

Fire mitigation through prescribed burning began at the national level in the 1960s. Prescribed burning is the "intentional use of fire under predetermined weather and fuel conditions [the prescription] to achieve specific objectives" such as disposing of slash or controlling unwanted vegetation (Ryan et al., 2012a, p. 217). This type of fire helps achieve the goals of "biomass reduction, preparation of an area for regeneration of conifers and shrubs, rejuvenation of shrubs and grasses, enhancing germination and growth of forbs, and suppression of in-growth species" (Timmons, deBano, & Ryan, 2012, p. 182). Prescribed burning takes place during the early spring or late fall when weather is most amicable for controlled burning (Ryan et al., 2012b). While beneficial to numerous ecosystem processes, prescribed fire is also an effective way to decrease the risk of wildfire in many environments.

There are several specialized tools used in prescribed burning, many of which are also used in fighting wildfires. Hand tools include shovels, Pulaskis, McLeods, and chainsaws. A Pulaski is a tool with a duel ax and adze head, and a McLeod has a duel rake and hoe blade. A Pulaski is effective for chopping and a McLeod is useful in digging and clearing fuels. Chainsaws are used to thin ground fuels and fell trees that pose the potential to fall and create a hazard to fire crews, or when they could cause sparks to jump a fireline. Mechanical tools used in prescribed burning can include bulldozers for use in constructing helispots, safety areas, or fireline. Firelines are dug to the depth of mineral soil to effectively remove fuels. When constructed using tools such as shovels and Pulaskis, firelines are called handlines, and when constructed using bulldozers they are called dozerlines. Handlines are used where the terrain is too steep (about 35% and greater slope) or where access is limited for a bulldozer;

dozers are used when the spread of a fire is rapid. The width of a fireline is dependent upon the physical environment- the terrain and fuels- and the tools used to construct it. A fireline can be from 12 to 36 inches wide when constructed using hand tools in area with light fuel loads (Handcrews, n.d.). Where fuels are heavier, the method of burnout might be employed to clear an area of 100 feet or more (Handcrews, n.d.). Burnout is when fire is intentionally lit adjacent to a fireline to clear a wider area of fuels available for fire to consume. Bulldozers are used to construct firelines in areas where fuel loads are heavy and can be from 6 to 36 feet wide (Traylor et al., 1990, p. 107; Handcrews, n.d.). To be effective, a fireline should be one and a half times as wide as the dominant fuel type is tall (Ryan et al., 2012a). To provide an additional barrier to the spread of fire, firelines are constructed with a berm on the edge furthest from the direction (head) of a fire's spread.

Drip torches are used to ignite fuels both in the prescribed burning and wildland firefighting technique known as burnout. Drip torches are 1 liter in volume metal cannisters with a wick that contain a flammable mixture. The mixture depends on the prescription and the type of burning one seeks to achieve, but often it is a four-to-one-part mixture of diesel fuel and gasoline. The wick is ignited and when the torch is angled downwards drips of the flammable mixture fall onto and ignite fuels as a firefighter walks across a landscape. When crews or individual firefighters with drip torches walk diagonally or at a right angle to a fire's head, they create a flank fire. This serves to reduce the amount of fuel available for an advancing fire to consume.

Prescribed fire provides a unique opportunity to study the operational effects of fire management because it takes place under controlled conditions. Unlike a wildfire incident this provides additional time to observe and monitor potential impacts to cultural resources, allowing for a better understanding of what impacts to expect. While the behavior of prescribed fire differs greatly from that of wildfire, similar management methods are employed in each setting. The CRWFM research allows for an understanding of these conditions that can be extended to wildfire incidents.

Archaeologist's Role in Fire Management

In accordance with the National Environmental Policy Act (NEPA), the National Historic Preservation Act (NHPA), and other state and federal laws, an archaeologist is often contracted to assist in the management and suppression of wildfires. In such situations the archaeologist takes on the position of cultural Resource Advisor, often referred to as the READ. Working with an Incident Management Team (IMT), the READ "…provides a key role during the management of an incident by providing professional knowledge and expertise for the protection of natural and cultural resources. A READ speaks for the resources… [and]… supports the IMT by providing information about impacted resources or potential hazards that allow the IMT to proactively craft response and mitigated [sic] actions that are sensitive to resources" (National Wildfire Coordinating Group, 2017, p. 3). It should be noted that while the READ has authority, it is the IMT that has the final say in how to carry out management and suppression (National Wildfire Coordinating Group, 2017). Understandably, wildfires are often unpredictable and occur in rugged terrain making certain protection measures unfeasible.

A Fireline Resource Advisor, or REAF, is another type of resource advisor position that an archaeologist could hold. REAFs work on wildland fires in "…federal or federal trust jurisdiction…" and are "…expected to have a deeper understanding of the hazards of the fire environment" (National Wildfire Coordinating Group, 2017, p. 8). When advising IMT leaders of management strategies to take in regards to cultural resources the READ or REAF should have knowledge of local politics and Land Use plans, the geographic area affected, regulations and concerns of the SHPO/THPO involved, and areas of potential eligibility for the National Register (National Wildfire Coordinating Group, 2017). Another important qualification of the READ is the "Ability to identify potential effects to natural and cultural resources as a result of the hazard and/or incident vs. those that may be/might have been caused by response activities" (National Wildfire Coordinating Group, 2017, p. 10). READs work to maintain compliance with NEPA and Sections 106 and 101 of the NHPA.

The National Park Service uses both READs and Cultural Resource Technical Specialists, or THSPs, in its preparedness and management plans for response to structural and wild fires within National Parks. On fire incidents, cultural resource THSPs collect and analyze information about cultural resources to make recommendations to the READ or IMT planning section chief (Fire Preparedness, 2020). However, unlike the READ they do not have the authority to make decisions for the protection or treatment of those resources (Fire Preparedness, 2020). In addition to advocating for the resources and developing ways to mitigate damage to them from fire suppression methods, the National Park Service includes

READs in the training of firefighting personnel in the identification of cultural resources (Fire Preparedness, 2020). “NPS Management Policies 5.3.1.2 (2006) requires that park and local fire personnel be advised of the locations and characteristics of cultural resources threatened by fire… Local fire crews are often the first responders to fires and have the first opportunity to protect cultural resources. Training local fire crews to recognize and avoid cultural resources helps to minimize unwanted effects of fire management” (Fire Preparedness, 2020). Part of this training includes the “Interpretation of the resources, as a value-added education opportunity to help firefighters to be better stewards of cultural resources in the park…” (Fire Preparedness, 2020). In accordance with Section 9 of the Archaeological Resource Protection Act (ARPA, enacted 1979), the NPS deems subsurface resources as sensitive thus keeping the locations of cultural resources in confidence until it is determined that providing that information is necessary to those responding to a fire (Fire Preparedness, 2020). On fires occurring on lands outside of the NPS System, the location of cultural resources is almost always kept in confidence. It is the responsibility of the READ to determine when and if the sharing of information of the location of resources is appropriate.

Resource advisors also play a role in rehabilitation after a fire. The Forest Service’s Burned Area Emergency Response (BAER) program, also implemented by other agencies such as the BLM, involves various professionals in developing rehabilitation plans which begin early during a fire incident (Burned Area, n.d.; After the Fire, n.d.). Rehabilitation is also employed at prescribed burns. Rehabilitation consists of various measures to attempt to return a burned area to its pre-fire state, and in the case of firelines, to prevent soil erosion. As a READ, an archaeologist can work on rehabilitation by mitigating additional damage to any cultural resources exposed when soil is replaced, for example when leveling a fireline berm.

Evidence of Fire Management in the Archaeological Record

As noted in the previous chapter, human activity on the environment is one type of archaeological resource. Common examples of this include hearths, mining trenches or prospecting pits, and even swaths of land that are plowed for agricultural use. Considering the operational effects such as fireline construction and felling trees, wildland fire management has the potential to become a cultural resource in limited circumstances.

While on the UIEF I have observed several pieces of evidence on the landscape resulting from operational effects. Most notably are changes in the landscape from manual and mechanical fireline construction. The first piece of evidence, from manual fireline construction, was found near the Flat Creek Cabin on the UIEF. In this case, a handline was cut around a slash pile created from gathering dry fuels in the area and igniting them to reduce risk of wildfire potential. The handline is evidenced by a shallow circular trench, approximately 20 cm wide and covering over 2 meters in diameter (see Figure 2.1). Although shallow, the handline was quite visible as it was only a year old, and charcoal from the slash pile was still visible on the surface. The mechanically constructed fireline I observed is located at Basalt Hill on the north end of the Flat Creek Unit of the UIEF. This fireline was evidenced by a small berm flanking a flat area about 1.5 meters wide. Though it is three years old, the visibility of this fireline is likely due to it not being rehabilitated. The reason for it not being rehabilitated is Basalt Hill is part of a research area and sections of it are burned roughly every three years.

Figure 2.1: Handline visible behind burnt stump where a slash pile had been burned

Lucas Hugie conducted thesis research on evidence of wildland fire management at Yellowstone National Park (2015). His research includes evidence of both manual and mechanically constructed fireline, as well as sawn timber and artifacts attributable to firefighters. Hugie looked at six fire sites, including those of the Lewis Lake, Kiewit, and North Fork fires. At the site of the 1943 Lewis Lake Fire, a non-rehabilitated dozerline was minimally visible on the landscape, however a wooden stake used to direct the dozer operator and saw-cut timber were still apparent (Hugie, 2015). Another non-rehabilitated dozerline at the Kiewit Fire site, that in the 60 years since its construction has been used as a hiking trail, and a wooden stake were visible at the time Hugie surveyed the area (2015). At the 1988 North Fork Fire both hand and dozerlines were created in addition to using existing roads and creating wet lines to contain and suppress the fire (Hugie, 2015). In the case of the North Fork Fire, firelines were still evidenced by collections of sawn timber gathered atop the fireline as a rehabilitation method, as well as rebar stakes used to direct the construction of the fireline (Hugie, 2015). Additionally, Hugie found two artifacts associated with fire management at the North Fork fire site. This includes one "roughhewn piece of lumber created by an Alaskan Saw Mill" that was likely related to camp activities, and an Orange Crush soda can dateable to 1988-1990 (Hugie, 2015, p. 96). At my research site I found one artifact attributable to the fire crews, or possibly to a recreationist on the UIEF. A plastic threaded bottle cap was found atop the berm of the fireline when I returned to my site to begin Phase 3. Various research activities take place on the UIEF, including those related to logging. As such, there is an abundance of sawn stumps that may or may not be specifically related to fire management.

If Hugie's findings can be applied to what I've seen on the UIEF it is possible that in 60 years the dozerlines will be difficult to identify and by 70 years they will have all but vanished to the untrained eye. It would likely take less time for the evidence of the handline to disappear. After such time, it is likely only possible through observing the profiles of an archaeological excavation unit could one identify these operational effects.

Having established a foundation of the relationship between archaeology and wildland fire management, the next chapter offers details on the experimental research area and influences behind studying the topic of operational effects of wildland fire management and their impacts to cultural resources. The archaeological practices and theoretical framework behind this research, as well as specific research questions, preliminary methodological steps of the study, and background on the experimental artifacts used in the study are also provided.

CHAPTER 3: PROJECT AREA AND METHODOLOGY

The physical remains of past human action are potent evidence through which one can experience another worldview. Furthermore, the ability to understand and connect to another way of being serves to know one's own identity. Growing up in southern Idaho, my summers were spent camping, horseback riding, and hiking on public lands from the desert to the forest. Many of the places I would explore held unique markers of human history, such as pictographs and historic structures. I do not recall a single summer in which wildfire had not consumed some part of my home state. The persistent smell of burnt sagebrush or conifers carried on smoke that lingers during the summer months is a nuisance to many, but nostalgic to me. Wildfire is of interest to me not only as an Idahoan, but because my father has worked in various roles in wildland fire management for over 40 years. His hard work and dedication have provided me the opportunity to enjoy, and find a passion in preserving, the history of the human past.

I am of the opinion that archaeology and wildland fire management can have a more cooperative and congenial relationship. A difference in values may inhibit work that is collaborative beyond the requirements of each position. Archaeologists will hold the archaeological record of higher import than will many wildland fire managers who have the goals of personnel safety and fire containment and suppression to accomplish. Though I am committed to preserving the material remains of the past, I understand that not everything can be protected when incidents occur and decisions need to be made quickly. I believe the intricacies of archaeology and of wildfire behavior prevent better understandings of each and the ability to see value in them across disciplines. I hope that the research presented here is only the beginning of my pursuit to resolve these differences and foster greater support for the management and use of human history. Beginning with the professionals who work to serve the public is only one step in this process. In agreement with Welch (2012), I believe wildland fire managers who have begun to see the forest in the trees can also begin to see the culture in archaeological sites.

Archaeology provides the opportunity to study and protect the past that has always inspired me. Merging the field with wildland fire management allows me to pursue my dual interests while contributing the futures of each. After deciding on this topic of research, I reached out to the University of Idaho College of Natural Resources and was put in contact with the manager of the University of Idaho Experimental Forest (UIEF). I attended a field day hosted by the UIEF in May 2019. The topics of focus at the field day were wildfire preparedness and forest stewardship. While attending the field day I learned more of the prospect of conducting my research on the UIEF. In addition to University of Idaho students, there were several private land owners in attendance. Seeing their interest in learning how to prepare for wildland fire on their property, I asked myself if they might also hold an interest in cultural resources. I suspect that many would. I even saw one older individual stop to pick up a sun-bleached vertebra, confirming for me that curiosity and interest in the "other" is held throughout many of our lifetimes.

Area of Study

The UIEF provides students and researchers access to field-based research and hands-on learning. As part of the University of Idaho College of Natural Resources, the UIEF consists of four management areas which include natural areas, two outdoor classrooms, and a tree farm. The UIEF also provides ample acreage for recreationists, including hunters. The majority of the research conducted on the UIEF relates to forest management, such as silviculture and timber harvest. The UIEF has also provided the research setting for studies relating to wildlife management, effects of prescribed fire on sapling physiology, and now archaeology.

The CRWFM Project was conducted within the Flat Creek Unit (see Figures 3.1 and 3.2 below) of the UIEF located approximately 33 miles northeast of Moscow, Idaho, off of State Highway 9. The Flat Creek Unit is located between 3,000-3,300 feet elevation. The forest within the Flat Creek Unit consists of mixed conifer- including Douglas and grand firs, ponderosa and lodgepole pines, and Western larch. Other vegetation includes ninebark and oceanspray shrubs, various grasses, berry bushes, and flowers such as Arrowleaf Balsam Root. Flat Creek and several of its tributary streams are located within the Flat Creek Unit.

The experimental site is located in the northwest of the Flat Creek Unit of the UIEF. In collaboration with the manager of the UIEF, an area within a prescribed burn unit was selected for the location of the experimental site. The site is situated between Basalt Hill and Brown's Meadow, approximately a half mile northwest on Brown's Meadow Road where it splits in Figure 3.1. The experimental site is located in Township 40N, Range 3W, Section 6.

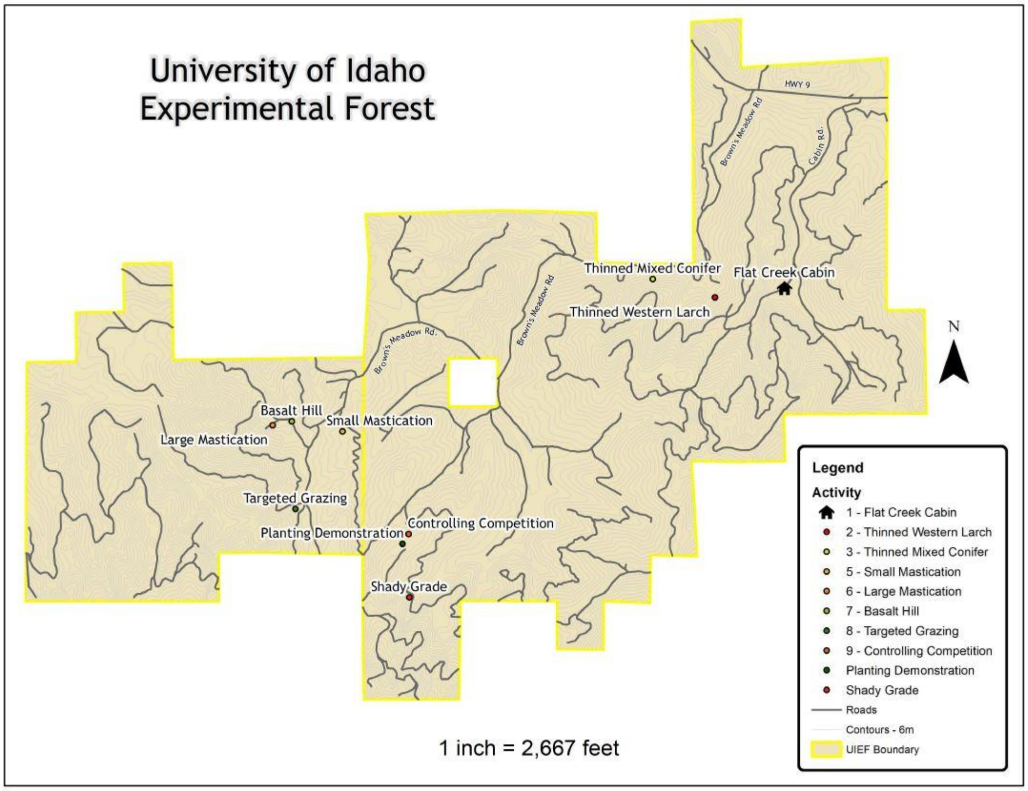

Figure 3.1: Map of May 2019 field day events on the Flat Creek Unit of the UIEF

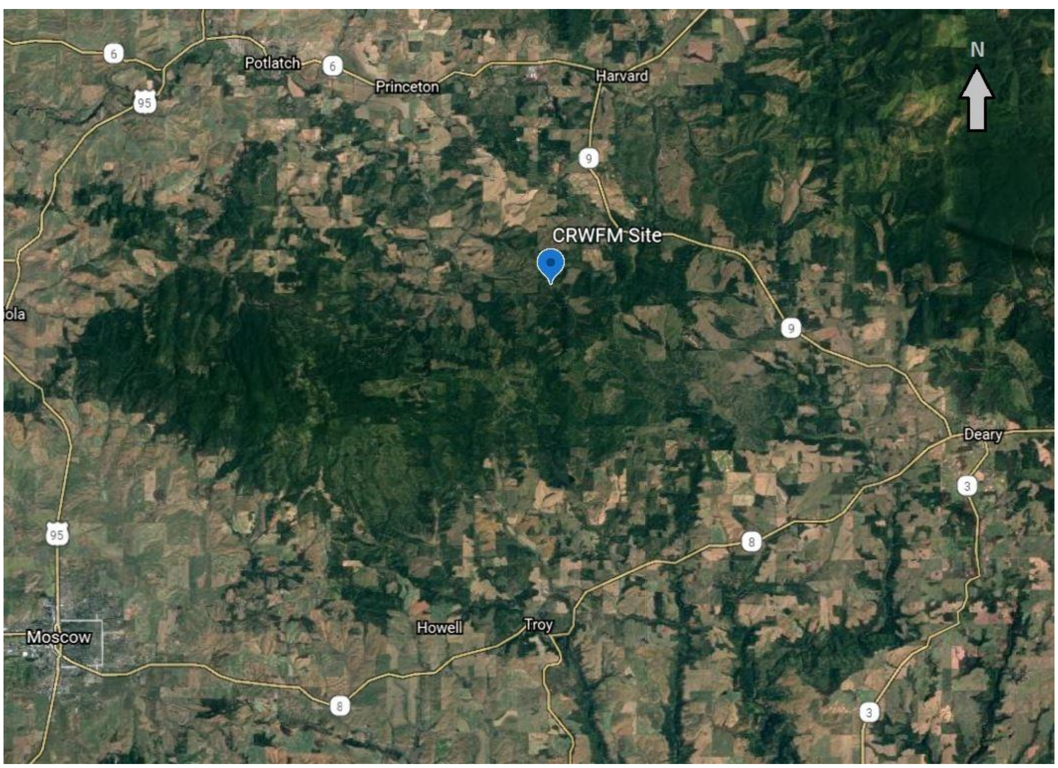

Figure 3.2: Regional map of experimental site location in proximity to nearby towns

The land occupation and ownership of the Flat Creek Unit has changed throughout time. Many of the areas included in the UIEF Flat Creek Unit were once owned by the Forest Service, and others have been donated by private land owners. Looking at the first map above one will see a blank square in the center of the map. This area is referred to as Brown’s Meadow, and is a 40-acre parcel of land that is privately owned. The CRWFM site is approximately half a mile northwest of Brown’s Meadow. Through researching patent records in the Bureau of Land Management’s General Land Office (GLO) records, the land north and west of Brown’s Meadow was purchased by Delilah Brown in April of 1893 (Brown, 1893). The land just north of Brown’s Meadow and where the CRWFM site is located was purchased by Joseph N. Brown in August of 1895 (Brown, 1895). The patent belonging to Joseph Brown was for a homestead on this land (Brown, 1895). Records show that in 1933 and 1937 the U.S. Forest Service acquired this land through the 1924 Clarke-McNary Act (Forest Development, 1937). There are no further records available in the BLM’s GLO for when the current private land at Brown’s Meadow was purchased from the Forest Service. In my family’s personal collection, an undated map published by the University of Idaho shows the site area under ownership of the Forest Service.

Archaeological Principles and Theoretical Framework of the Project

Most important to the execution of the CRWFM Project are the archaeological principles of site formation processes, stratigraphy, and provenience. Formation processes, or taphonomy, are the ways in which artifacts came to be buried, and what happened to those artifacts after their burial (Renfrew & Bahn, 2016, p.52). Archaeological site formation processes can be both cultural and natural. Cultural formation processes refer to the deliberate or accidental activities of humans, such as discarding refuse in a privy behind one’s home, the abandoned lithic debitage produced in the process of flintknapping, or the loss of an object while traveling across a landscape (Renfrew & Bahn, 2016, p.52). Natural formation processes refer to the environmental events that bury an artifact and impact the survival of the archaeological record (Renfrew & Bahn, 2016, p.52). For example, ash deposited from a volcanic eruption, erosion or deposition of soil carried by wind or water, or burrowing animals that shift sediment layers. Both cultural and natural site formation processes influence how artifacts are found in the archaeological record. Artifacts are found in surface or subsurface contexts. When in subsurface contexts artifacts are found in strata. Stratigraphy is the study and verification of the deposition of soil layers (strata) one above the other, in both vertical (time) and horizontal (space) dimensions (Renfrew & Bahn, 2016, p.111). Stratigraphy can be used as a relative dating method to interpret a site's chronology, as lower strata are understood to be deposited earlier than those above them (Ryan et al., 2012a; Renfrew & Bahn, 2016). Therefore, artifacts found further from the surface are typically older than those that are closer to the surface. Provenience is the location of an artifact in three-dimensional space in relation to stratigraphic layers. The term *in-situ* is used to describe the original position in which an artifact is found. Particularly concerning subsurface artifacts, this is believed to be the position of an artifact as it was deposited. Taken together, cultural and natural site formation processes affect the provenience of artifacts in stratigraphy.

Understanding site taphonomy is important because there has been a long-held assumption that what the archaeologist finds in the archaeological record is truly representative of a past human activity. To put it another way, it has been assumed that "the proveniences of artifacts in a site correspond to their actual locations of use in activities" (Schiffer, 1972, p. 156). The fault in such an assumption is twofold. First, this assumes that humans always deposited materials where those materials are primarily used. Second, this excludes the possibility for any natural of human force to influence materials in a site between the time of their deposition and the time an archaeologist digs them up. The former denies the potential for variation in human behavior, and scientists of various fields have long known the latter to be false. Many studies in experimental archaeology focus on site taphonomy to challenge these assumptions and better understand the multitude of variables that influence the creation of the archaeological record. One example is researching the amount of time it takes for materials like wood and textiles to disintegrate in specific soil conditions. This research can allow for an understanding of the extent of such changes and why such materials may be absent in archaeological contexts. Challenging assumptions of human behavior and studying natural site formation processes allows for more informed interpretations of the past.

Experimental archaeology falls under the purview of middle-range theory which is the bridge between the complex and untestable theorizing of causes of human behavior and the empirical studies separate from theory (Raab & Goodyear, 1984, p.265). Experimental archaeology, like any scientific experiment, begins with a hypothesis that is then tested, and the results of such testing can be replicated. In experimental archaeology, hypothesis revolve around past human cultural phenomena and "can be tested with authentic materials and in a range of environmental conditions that aim to reflect accurately 'real life' or 'actualistic' [sic] scenarios" (Outram, 2008, p.2). Unlike in laboratory settings, experimental archaeology allows for unpredictable phenomena to play out, which can improve hypotheses and archaeological interpretation (Outram, 2008, p.2). The CRWFM Project is one example of using authentic materials to reflect "real life."

Five categories of experimental archaeology have been outlined by Reynolds (1999), who notes that these are "complimentary and interdependent rather than exclusive" (p. 389). The first category deals with experiments in constructing at a 1:1 scale the structure of a building as hypothesized from evidence in the archaeological record (Reynolds, 1999). Process and function experiments are the second category, which seek to understand how something was achieved in the past (Reynolds, 1999). In the third category of experiment, simulation, "the objective is to understand elements of archaeological evidence by projecting backwards from the excavated site to the original or new state then monitoring the deterioration through time until the archaeological state is reached" (Reynolds, 1999, p. 391). This category, with some adjustment to Reynolds' description, best describes my experimental approach. This approach is described by Outram (2008) as "investigations into the formation processes of the archaeological record and post-depositional taphonomy" (p. 3). An example of the simulation category and explanation of how my approach both fits with and challenges Reynolds' and Outram's descriptions are discussed shortly. The fourth category, probability/eventuality trial, is a combination of the above categories (Reynolds, 1999; Outram, 2008). These are large-scale, long-duration experiments that can investigate phenomena such as agriculture economies (Reynolds, 1999; Outram, 2008). The final category, technological innovation, encompasses experiments with technologies for use in improving archaeological data acquisition (Reynold, 1999). Certainly, site formation processes are not the only focus of experimental archaeology. Experiments on the process and function category, such as lithic technologies experiments (see Crabtree, 1968), can indeed offer insight into the behavior of past members of cultural systems.

Returning to Reynolds' category of experimental archaeology that my approach might be likened to, the following is an example of site simulation. The Overton and Wareham Down Earthworks (see Bell et al., 1996) created in 1960 in England are two linear earthworks constructed with a chalk and turf bank and a ditch (Renfrew & Bahn, 2016, p.53). The purpose of the earthworks is to document erosion of the bank and ditch over a long period of time (Reynolds, 1999; Renfrew & Bahn, 2016). Additionally, materials including leather, textile, bone, wood, and pottery were buried in the earthworks to understand the impacts of natural site formation processes (Reynolds, 1999; Renfrew & Bahn, 2016). To understand impacts, sections of the bank and ditch are excavated at set time intervals, the next being scheduled for 2024 (Renfrew & Bahn, 2016, p.53). The experiment will be completed in 2088, 128 years after the creation of the earthworks. Significant results of the experiment so far include a 25 cm drop in the bank height quickly after construction followed by stabilization in the ensuing decade, minimal changes to pottery and leather materials after four years, and complete loss of textiles and wood located in turf soil after 16 years (Renfrew & Bahn, 2016, p.53). Studies in experimental archaeology such as these earthworks provide invaluable insight on the impact of natural site formation processes. By providing insight into non-cultural formation processes, such information can aid in archaeological interpretations by directing researchers towards identifying cultural processes.

The CRWFM Study as Experimental Archaeology

As scarce prior research has been conducted to offer more direction, the hypothesis of the CRWFM Project was simple; mechanical construction of fireline will remove artifacts from their *in-situ* context. Experimentation through establishing four test units to represent an archaeological record containing both surface and sub-surface artifacts, and having a bulldozer construct a fireline through those units, allows this hypothesis to be tested. The situation of a bulldozer razing an archaeological site or other cultural resource is not uncommon. Take for example the 1977 La Mesa Fire in Bandelier National Monument. Bandelier National Monument contains evidence of the life of the Ancestral Pueblo People (1150-1550 CE) in the form of cliff dwellings, volcanic tuff masonry, and petroglyphs. On the La Mesa Fire bulldozers with 12-foot-wide blades were employed in fire suppression measures including fireline construction and clearing of safety areas (Traylor et al., 1990). Though archaeologists were present during the construction of firelines and used flags to direct dozer operators away from sensitive sites, when these lines were widened this was not communicated and a total of 15 sites were impacted, eight of which were “totally leveled” (Traylor et al., 1990, p. 110). When archaeologists returned to the firelines they were “taken aback to notice that a site previously averted was now a scatter of rubble or entirely missing, with the flagging festooning a now uprooted tree" (Traylor et al., 1990, p. 110). The findings of the operational effects from the La Mesa Fire directed the formation of the above hypothesis.

The CRWFM Project involves simulation, however it rests on the peripheral of Reynolds' definition of simulation as a category of experimental archaeology. Rather than being interested in understanding how the archaeological record came into existence, I am interested in how it came to be undone. My approach, as described above, seeks to understand the *de*-formation processes of that record, rather than its formation processes. (The methods of the formation of the simulated record, and why it was formed in that way, are addressed in Chapter 4). In this sense, my research is not "projecting backwards" as much as it is projecting forwards to understand a hypothetical reality; this reality has proven to be all too real as evidenced by activities at the La Mesa Fire in 1977. It is through the experimental archaeology of the CRWFM Project that information regarding operational effects useful to archaeologists and wildland fire managers will be made available. Professionals can use the results of this study in development of management plans that prevent past negative situations from continuing to occur.

Methodology

The specific methodologies used for each phase of research are discussed in their respective chapters. Chapter 4 details the methodologies used in simulating the archaeological record and constructing the fireline. Chapter 5 provides information on the methodology of the prescribed burn. In Chapter 6 the methods for recovering experimental artifacts and rehabilitating the fireline are given.

Based on the hypothesis provided above, the research questions of the CRWFM study focus on the spatial displacement and physical impacts to experimental artifacts resulting from mechanical fireline construction and rehabilitation. Concerning spatial displacement, the horizontal and vertical displacement of experimental artifacts are of key interest. Specifically, research questions were devised to compare impacts on surface and subsurface artifacts and those located on various slopes. Research questions about physical damage, such as breaking, crazing, and staining, were also developed to determine the frequency of this impact to various artifact materials and contexts within the experimental site. The specific research questions can be found in Chapter 7 of this document. Further details on the site location and how it was selected are provided in the following chapter.

The methods for collecting data vary slightly between each phase of the study. In general, data collection entailed observing and recording in videos or photographs the methods and impacts of operational effects and prescribed burning. In Phase 1, the locations of artifacts were recorded with the total station, and maps of the experimental units were drawn by hand. Measuring tapes were used to draw hand maps of the fireline within each unit. A method of digging into and screening sections of the fireline berm was employed to collect spatial and physical data in Phase 3. Prepared field documents were used to prompt documentation of data such as where artifacts were encountered during the fireline construction. Use of these documents was limited as many unpredictable situations occurred while conducting the research, as will be discussed in Chapter 7 of this document.

An early step in the CRWFM Project prior to conducting experimental research was acquiring materials to use as experimental artifacts. I chose to include materials from both precontact and historic contexts. The first step of this project was to create a record of the experimental artifacts. To do that, I catalogued and photographed each object. Catalog data includes artifact material, sub-material, object name, part represented, complete description, surface features, measurements, and additional distinguishing information. Also included with each catalog entry is the experimental unit and context in which it was placed at the project site. For catalog purposes I also marked each artifact with white or orange India ink in a line across one surface as well as with a unique number. Figure 3.3 below provides reference. This step eased my identification of artifacts through referencing photographs taken in the field to my field notes. It is also possible that my use of India ink to mark artifacts helped convey the objects as part of research, rather than as part of the archaeological record. This could inform future researchers in the area, given that I was not able to recover all of the experimental artifacts. I thought it would also help to dissuade looters from taking the experimental artifacts. The surface on which the India ink line was made as well as the unique number are also included in the catalog.

Figure 3.3: Experimental artifact number 35 prepared for use in this study

Materials representing precontact artifacts include obsidian and chert. I collected flakes from a bucket of debitage in the University of Idaho Lithic Technologies Laboratory. Three types of obsidian, a vitreous volcanic glass, likely sourced from Glass Buttes in northeast Oregon were used. My knowledge of lithic materials is limited; therefore, I classified these types by color into the categories of standard for pure black, pure mahogany for pure mahogany type, and mahogany for material with coloring between the two. Two types of chert, a silica based sedimentary rock, classified by their color of grey or pink were also used. I selected flakes that had clear primary, secondary, or tertiary characteristics. These characteristics refer to the stage of flintknapping at which they were removed from the core. Primary flakes are those removed in the initial steps of flintknapping and have cortex, a weathered rind, on them. Secondary flakes can also have cortex on them in minimal amounts. Tertiary flakes do not have cortex on them, and might have two flaked surfaces as opposed to one. By choosing flakes with these characteristics I ensured that each flake was distinguishable from one another. Size was also considered in my selection of flakes. I chose flakes between 2 and 10 cm in length, the majority being between 3 and 5 cm. A total of 21 lithic flakes were used as experimental artifacts representing precontact artifacts.

While my access to materials representing precontact artifacts was limited to two lithic materials, the opposite was true of my access to historic materials. Fortuitously, artifacts from the Sandpoint Byway Project (2006-2013) were being deaccessioned from collections of the Archaeological Survey of Idaho Northern Repository housed in the Alfred W. Bowers Laboratory at the University of Idaho. I was provided the opportunity to give these artifacts a new purpose and value by using them in my research. As these materials were part of the archaeological record for approximately 100 to 125 years, I had the ability to get accurate data regarding how indirect impacts and operational effects can alter artifacts. The majority of the historic artifacts used in this research were incomplete when I obtained them; surface features were also present, most common were crazing of ceramic glaze and rust on ferrous artifacts. These are not seen as detriments to the research, rather they provide more reliable behavior and data. Partial objects or those that have crazing or are rusted are physical properties of artifacts that would be found in genuine archaeological sites. Therefore, physical damage that could be incurred in this study could be extrapolated to the same materials found in actual archaeological sites.

Table 3.1 below provides details of the precontact and historic artifacts used in this study. A total of 133 historic materials were used in this study. Ceramic artifacts used in the CRWFM Project are tablewares of either porcelain, stoneware, unrefined earthenware, or white refined earthenware. Seven colors of glass, in both container and tableware forms, were used. Synthetic or composite artifacts, such as building materials and light bulbs, were included as experimental artifacts. The majority of the metal artifacts in the CRWFM Project were iron. One steel and one copper artifact were also used. In total, 154 experimental artifacts were used in the experimental research of the CRWFM project.

Table 3.1: Experimental artifacts used in the CRWFM Project

Material	Count	Percentage of Total
Chert	7	4.5
Obsidian	14	9
Ceramic	50	32.5
Glass	46	30
Metal	29	18.8
Synthetic	8	5.2
Total	*154*	*100*

The following chapter details Phase 1 of field experiments in the CRWFM Project, beginning with the simulation of the archaeological record and the construction of the fireline. Greater detail on the artifacts used in this study is provided. Measurements of the fireline and supplementary data regarding erosion potential at the experimental site are also supplied.

CHAPTER 4: PHASE 1- BEFORE THE BURN

This chapter provides information regarding the experimental site of the CRWFM Project. Specifically, how the site was created and the methodology for simulating the archaeological record are discussed. Details on what artifacts were used, and expected impacts to those artifacts from operational effects are described. The methodology of fireline construction is illustrated, as well as preliminary results and data on the fireline construction. Finally, supplementary information on soil analysis for fireline depths and erosion data is provided.

Experimental Site Setting

The experimental site is within the Flat Creek Unit of the UIEF, between Basalt Hill and Brown's Meadow. The location of the site was chosen due to it being situated within a prescribed burn unit, where a fireline was planned to be constructed. This fireline is referred to as the midline, as it functioned as the boundary between two sections of the burn unit. The midline connects the access road for Basalt Hill to a 4-wheel drive road to the south. The experimental site is located at the northern end of the midline, approximately 380 feet south of the access road that branches off of NF 4713. The entire experimental site covers approximately 200 feet. The northern end of the site is situated on a flat hilltop with an elevation of 3,100 feet. Moving south, the site extends across a 10% slope change and concludes at an elevation of approximately 3,060 feet.

Multiple areas within the Flat Creek Unit were surveyed for their potential to serve as the location of the CRWFM Project. This includes various areas along the planned midline. I selected the location described above because it best offered the opportunity to consider how impacts to cultural resources might vary across different slopes (see Figure 4.1 below). The site location is also representative of an area where one would expect to find cultural resources. Standards in archaeological survey used by private, federal, and state agencies characterize the probability of the presence of artifacts on certain slope percentages. For example, the Bureau of Land Management and Idaho State Historic Preservation Office consider areas of 30% or greater slope to be low probability for archaeological sites (State Protocol Agreement, 2014). The location of the experimental site was also influenced by my choice to use a total station to collect data for the locations of experimental artifacts in this first phase of the project, as well as in Phase 3. The experimental site provides an area within which I could establish a single datum for the total station that could be used to record data across the varying slopes of the 200-foot-long site.

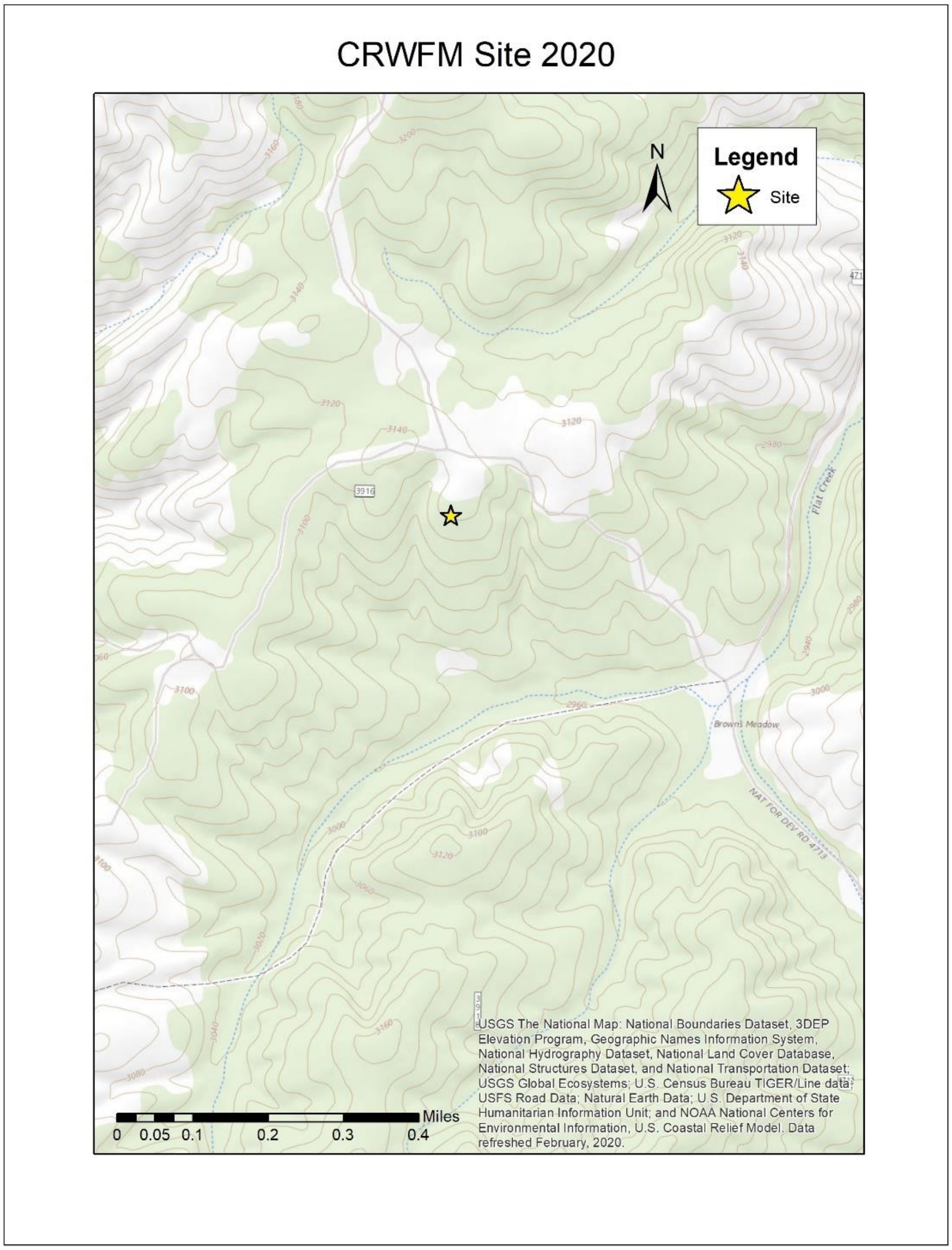

Figure 4.1: Topographic map of the CRWFM site

The experimental site consists of four experimental units. The first of the units, Unit 1, is a roughly 4x4 meter unit situated at the north end of the experimental site, near the northernmost end of the midline. Vegetation at Unit 1 consists of grass, oceanspray and ninebark shrubs, and saplings of various coniferous tree species. Units 2-4 are each approximately 2x2 meters in size and are located south of Unit 1. Here the slope ranges from

5-10% and the vegetation associated with these units is of grass, a small bush, and Douglas fir and ponderosa pine trees. The location of Units 2-4 in relation to their north-south orientation and relationship to Unit 1 follows a descending order (see Figure 4.2 below); Unit 2 is south of Unit 1 and north of Units 3 and 4, Unit 3 is south of Units 1 and 2 and north of Unit 4, and Unit 4 is south of Units 1-3. There are approximately 23 meters between the south end of Unit 1 and the north end of Unit 2. Between the south end of Unit 2 and the north and of Unit 3 there are approximately 3.5 meters. There are approximately 11.5 meters between the south end of Unit 3 and the north end of Unit 4. Figure 4.1 provides a view of the site at a smaller scale for reference to the road and topography. Figure 4.2 below is the large-scale map of the experimental site at the midline.

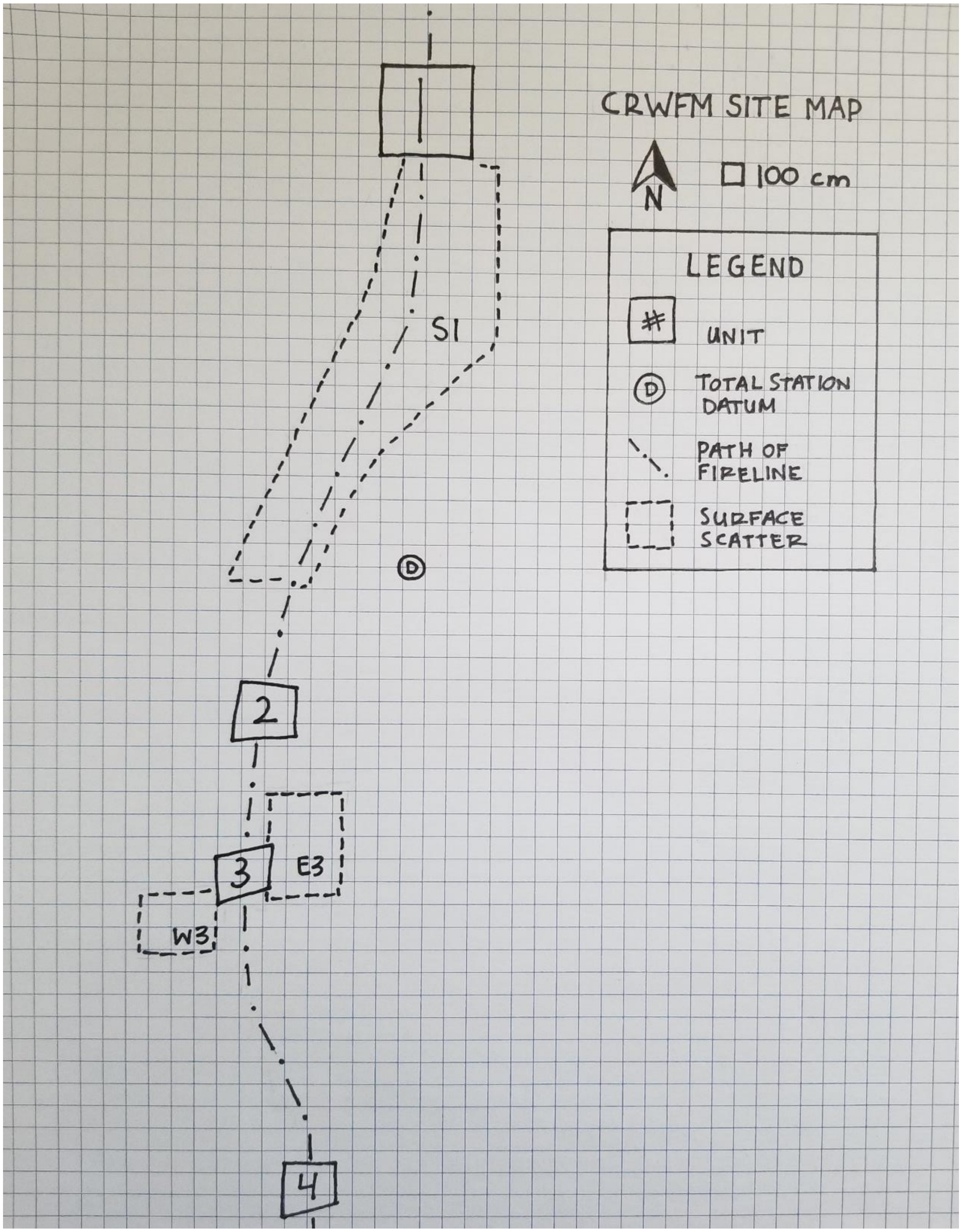

Figure 4.2: Map of the CRWFM experimental site and experimental units

Methodology: Establishing the Experimental Site

When considering what size my experimental units should be, I had several options though I was constrained by two factors. One of these factors is the size of the blade of the bulldozer that would be used in constructing the fireline. A unit 1x1 meters in size would have been too small, as the dozer blade is 2.43 meters wide. With such a small unit the dozer operator could have missed nearly half if not more of the experimental unit. I chose a minimum size of 2x2 meters to ensure that a larger fraction of my unit was impacted. The second factor influencing my decision for experimental unit sizes was that I established the experimental site on my own. Thus, a unit measuring 5x5 meters in size was too large for one person to establish themselves especially considering factors of terrain and vegetation. I could more easily create a 4x4 meter unit by myself therefore, that is the largest unit size I used. This size also provides assurance that the fireline construction would impact the majority of the unit as well as the potential for some area to be left undisturbed. For the sake of controlling the size of the area where artifacts would be impacted by fireline construction, experimental unit dimensions were chosen however, the dimensions are approximate. Their dimensions were chosen to be approximate in order to more accurately replicate the archaeological record. Due to the presence of trees and the orientation of where the fireline would be constructed where Units 2-4 were established, 4x4 meters would have been too large to be able to record experimental artifacts with the total station. Therefore, 2x2 meters was chosen as a sufficient size for these units.

I established the experimental site on October 5, 2019. Establishing the one 4x4 meter unit and three 2x2 meter units was done by using two tape measures, pin flags, line, and nails. Prior to establishing the units, I confirmed that each would be visible from the area where I chose to place the total station datum. I chose the location of Unit 1, a flat clearing, and selected a place to represent the northwest corner of the unit. I put a nail and pin flag in this place and measured out from it moving east and south with tape measures to visualize the unit. I then placed pin flags at the ends of the measuring tape where it read four meters, those being northeast and southwest of the first pin flag. I used one measuring tape to measure one meter east of the northwest corner, where I then placed a pin flag. From this pin flag I again measured one meter east and placed another pin flag. I continued this process until I had measured out to four meters. I continued this process moving south from the northwest corner, and again moving east from that corner and then south from the northeast corner until I had established a roughly square unit. I used line and the nails to mark the boundary of the unit. The same process was followed for each of the three 2x2 meter units to the south of Unit

1. Though the 2x2 meter units are on different percentages of slope, the measurements for the boundaries of these units did not account for the varied slopes.

Figure 4.3: Experimental Unit 2, looking north, prior to simulating the archaeological record

After cataloging, marking, and photographing each experimental artifact I began to divide them into groups to be used in the four experimental units. I did this prior to establishing the experimental units, therefore I chose total counts for each unit that would be sufficient for a 4x4 meter unit. I selected a minimum of 40 experimental artifacts to be used in each unit. I decided to use no less than 15 but no more than 20 artifacts to be placed on the surface, and no less than 10 but no more than 20 artifacts for below the surface. This allowed a buffer, should the size of my units at the time of my creating them call for fewer artifacts. I labeled two bags for each unit, one for each context (surface and sub-surface). I did my best to randomly select artifacts from the assemblage without bias while also ensuring there was a representative sample of each material type in each unit. I selected artifacts so that there would be a wide range of artifact size in each unit. Experimental artifacts that resembled each other were sorted into separate units. I had four artifacts that could cross mend with another making a total of two artifacts. I chose to place the pairs of artifacts that could cross mend in the same unit but in different contexts. When dividing experimental artifacts by planned context I chose to place ceramic artifacts greater than 12 cm in length and glass and metal artifacts greater than 18 cm in length on the surface. This was done to minimize the number of large holes I would need to dig. I also selected artifacts to use to replicate a surface scatter in three areas (see Figure 4.2 above). The majority of these were small, 2 to 5 cm in length, ceramic or glass sherds or lithic flakes, as well as some metal and synthetic artifacts of various sizes. The three surface scatters consisted of 13, 11, and 10 experimental artifacts.

After marking out each experimental unit I then selected areas within them to dig holes for placing experimental artifacts below the surface. I based the number of holes to dig off of the number of artifacts chosen for each unit as well as by the dimensions of the units. Unit 1, the 4x4 meter unit, was large enough for me to dig all 20 holes for the artifacts I selected to place below the surface. The 2x2 meter units proved too small to dig more than 13 randomly placed holes without overlapping artifacts or placing them in very close proximity to one another. I wanted to measure impacts to artifacts throughout the units, so I avoided placing artifacts close together or more than one artifact within one hole. Using a shovel, I dug holes in randomly selected locations within each unit, measuring between shoveling to ensure that I dug to at least 10 cm below the surface. In their 1990 report on the study of wildland fire management activities at the La Mesa Fire, Traylor, Hubbell, Wood, and Fiedler report that firelines were often a foot or more deep (p. 107). The firelines on the La Mesa Fire were created using bulldozers much larger than the one used at my site therefore, while a depth of 12 inches (30.48 cm) could be possible, I thought it was not likely at my site. I chose the depth of 10 cm below the surface because this is the maximum depth that I thought an artifact could still be impacted by the fireline construction.

Just as the vegetation varied between Unit 1 and Units 2-4, the fuels present and soil texture and color were found to vary by experimental unit and even within each unit. At the time of my establishing the experimental units, the weather had been relatively mild. Temperatures ranged from low to mid 50° Fahrenheit and there was no recent precipitation within the past five days of establishing the units. The soils I encountered were mostly dry or slightly damp. Overall, the soils were relatively compact while some areas were more or less compact than others. When encountering softer soils, I often dug to a depth of at least 10 cm, often more, with just one use of the shovel. The surface vegetation and fuels in Unit 1 were mostly comprised of grasses and a small oceanspray shrub was located in the center of the unit. In some places soil was visible through the vegetation. Other fuels include a punky (dry rotted) stump located in the northeast corner of the unit, and a branch approximately one meter long in the southwest corner. A large rotted log was located outside of the unit at the southeast corner. Table 4.1 below describes the vegetation, soil, and slope for Units 2-4. All soils were of a fine silt texture.

Table 4.1: Vegetation, soil, and slope for experimental units 2, 3, and 4, prior to construction of the fireline

Unit	Artifact Number	Vegetation and fuels	Munsell Dry	Munsell Wet	Soil Notes	Slope
2	114	Grass, dried p. pine needles	7.5YR 5/2 Brown	10YR 3/3 Dark Brown	10YR 3/6 (brownish yellow) dry inclusions, compactness varied	5-10%
2	133	Grass, dried p. pine needles, 3 cm deep duff layer, branch	7.5YR 4/4 Brown	10YR 3/2 Very dark greyish brown	Organic inclusions	5-10%
2	128	Grass, dried p. pine needles	7.5YR 5/2 Brown	10YR 2/1 Black	Some Organic inclusions	5-10%
3	123	Grass, dried p. pine needles	7.5YR 5/2 Brown	10YR 2/2 Very dark brown	Compact, charcoal inclusion	5-10%
3	81	Grass, dried p. pine needles	10YR 6/6 Brownish yellow	7.5YR 3/2 Dark brown	Compact, visibly lighter than others when dry, potentially 10YR 3/3 wet	5-10%
3	94	Grass, dried p. pine needles	7.5YR 5/2 Brown	10YR 2/2 Very dark brown	Compact	5-10%
4	62	Grass, bushes, p. pine cones and dried needles, broken branches	7.5YR 4/4 Brown	10YR 2/2 Very dark brown	Soft, many woody organic inclusions	5%
4	69	Grass, bushes, p. pine cones and dried needles, broken branches, 10 cm deep duff layer	7.5YR 5/2 Brown	10YR 2/2 Very dark brown	Soft, many woody organic inclusions	5%
4	4	Grass, bushes, p. pine cones and dried needles, broken branches	7.5YR 5/2 Brown	10YR 2/2 Very dark brown	Soft, many woody organic inclusions	5%

I collected samples of soil from Units 2-4 to record their texture and Munsell colors prior to constructing the fireline to determine if the fireline would be constructed to a different stratigraphic layer. Also, with Units 2-4 being on varying percentages of slope I wanted to consider the effects of and potential for erosion. This information is discussed in depth at the end of this chapter and analyzed in Chapter 7.

Figure 4.4: Surface and near-surface fuels within experimental Unit 4

After establishing each unit and digging holes for experimental artifacts in the units, the next step in creating the experimental site was establishing the total station datum. I chose to use a one foot long piece of steel thread-all with a half inch diameter to serve as my datum. After reconfirming that I could see each unit from the location I selected, I hammered the thread-all into the soil. Using a wide mouth canning jar lid liner as a more visible marker than the thread-all, I wrote in permanent ink "CRWFM19 DATUM" on the interior surface of the lid liner and placed this side face up centered over the thread-all. The datum is 5.1 meters east of a ponderosa pine tree. This tree is southwest of the southwest corner of Unit 1 and north of the northeast corner of Unit 2 at the boundary of the flat clearing and forest.

Returning to the experimental site with a peer on October 6th, I began the process of placing experimental artifacts within each unit. Unlike establishing the experimental units, two people were needed to complete this stage because I was using a total station. I chose not to place experimental artifacts on the day that I dug the holes as I was unsure when I would next be at my site. First, I set up the total station and created a job in it to use for the entire project. The northwest corner of Unit 1 was chosen as the reference point with coordinates northing (N) 10,000, easting (E) 10,000 and elevation (Z) 1,000. Myself and a peer first placed the artifacts I had chosen to have below the surface within each unit. These were placed randomly so as to have each artifact type represented throughout the unit. After they were placed and their location recorded with the total station they were buried. Next the surface artifacts were placed, again randomly, and their locations were recorded using the total station. The locations of artifacts were mapped by hand as well. Placing experimental artifacts in the four experimental units was complete on October 7, 2019.

In addition to the experimental artifacts within the experimental units, I included three areas to simulate a surface scatter. These are located outside of where the fireline would be constructed in order to gather data on impacts from non-mechanical fireline construction activities and other indirect impacts and operational effects. The manual fireline construction activities are discussed in detail later in this chapter. The surface scatters (see Figure 4.2) were created on October 16, 2019. Again, the locations of the experimental artifacts used in the surface scatters were recorded using the total station. The first surface scatter was placed east of where the midline would be and south of Unit 1. I named this surface scatter S1. In S1, four artifacts were placed where the midline would be constructed in close proximity to large fuels including logs and punky stumps. This was done to measure how fireline construction would impact artifacts near them. The second surface scatter, named E3, is located east of Units 2 and 3, south of the datum. The final surface scatter, named W3, is located southwest of Unit 3 where a small group of saplings is located. I chose to not define dimensions to control the size of the surface scatters, rather experimental artifacts where placed where it seemed likely they would be impacted. With this said, E3 and W3 are confined to an area of approximately 4x4 meters. As noted, in S1 artifacts were placed near heavy fuels south of Unit 1 as well as to the southeast of where the midline would be constructed. S1 then covers an area larger than 4x4 meters.

Experimental Artifacts Involved

As discussed in the previous chapter, a total of 154 experimental artifacts were used in this project. Ceramic, glass, metal, synthetic, and composite materials were chosen to represent historic artifacts. Experimental artifacts representing pre-contact artifacts include three types of obsidian and two types of chert. Table 4.2 below shows the number of total artifacts within each experimental unit or surface scatter, separated by context.

Table 4.2: Total number of experimental artifacts within each experimental location by context

Location	Experimental Site Surface	10 cm Below Experimental Site Surface	Total
Unit 1	20	20	40
Unit 2	15	13	28
Unit 3	15	12	27
Unit 4	15	10	25
Surf Scatter S1	13	-	13
Surf Scatter E3	11	-	11
Surf Scatter W3	10	-	10
Total	*99*	*55*	*154*

A total of 120 experimental artifacts were used within the experimental units; 55 of these were placed at least 10 cm below the surface and 65 of these were placed on the surface. An additional 34 experimental artifacts were included to represent three surface scatters and measure indirect impacts and operational effects other than mechanical fireline construction. Table 4.3 below shows the number of total artifacts for each location divided by material type. Table 4.4 illustrates the number of total artifacts for each experimental unit by context and material type.

Table 4.3: Number of experimental artifacts within each experimental location by artifact type

Location	Ceramic	Glass	Metal	Synthetic	Lithic	Total
Unit 1	11	14	8	2	5	40
Unit 2	8	9	6	1	4	28
Unit 3	8	7	6	1	5	27
Unit 4	7	7	5	2	4	25
Surf Scatter S1	4	4	2	1	2	13
Surf Scatter E3	3	4	2	1	1	11
Surf Scatter W3	9	1	-	-	-	10
Total	*50*	*46*	*29*	*8*	*21*	*154*

Table 4.4: Number of experimental artifacts within each experimental unit by unit context and artifact type

Location	Ceramic	Glass	Metal	Synthetic	Lithic	Total
Unit 1 Surf	5	6	4	1	4	20
Unit 1 Sub-surf	6	8	4	1	1	20
Unit 2 Surf	6	4	3	-	2	15
Unit 2 Sub-surf	2	5	3	1	2	13
Unit 3 Surf	5	3	3	1	3	15
Unit 3 Sub-surf	3	4	3	-	2	12
Unit 4 Surf	4	4	3	1	3	15
Unit 4 Sub-surf	3	3	2	1	1	10
Total	*34*	*37*	*25*	*6*	*18*	*120*

The most frequent material type used in the experimental units was glass, followed by ceramic, metal, lithics, and synthetics. Due to a low number of synthetic materials acquired prior to Phase 1, more were not included in this study. When considering the materials placed in the surface scatters in addition to those in the experimental units, ceramics were used most frequently, followed by glass, metal, lithics, and synthetics.

Expected Indirect Impacts

Previous findings show that exposure and damage are common indirect impacts to cultural resources resulting from wildland fire management. Exposure and damage can result from various management activities. Moreover, fire management activities can indirectly lead to increases in the erosion and vandalism of cultural sites. Exposure of a cultural resource typically results from fireline construction, both manual and mechanical. An example of handline construction on the 1977 La Mesa Fire in Bandelier National Monument shows that handline construction exposed subsurface middens and displaced surface finds (Traylor et al., 1990, p. 103). The authors of the 1990 report on the La Mesa Fire also observed that manual and mechanical fireline construction often buried surface artifacts or reburied those that had been exposed under piles of brush or dirt (Traylor et al., p. 103, 113). In either of these scenarios, burial of cultural resources is damaging to the integrity of their context. Like exposure, this can inhibit the interpretation of a site from which those artifacts originated.

Previously unknown sites or resources can also be exposed through fireline construction. For example, the 2007 Bugaboo Fire was a complex of fires burning in Okefenokee National Wildlife Refuge, Osceola National Forest, and in surrounding areas of the states of Georgia and Florida (Timmons et al., 2012). On the Bugaboo Fire, firelines were constructed both manually and mechanically on hundreds of miles of land (Timmons et al., 2012, p. 175-6). In the Osceola National Forest alone, more than 100 previously unknown sites were discovered on 253 miles of fireline (Timmons et al., 2012, p. 175-6). Exposure of an unknown site or cultural resource is important to consider as a potential indirect impact or operational effect. However, this type of exposure did not occur at my experimental site. While surveying the area and deciding where to establish my experimental site, I did not encounter evidence of cultural resources. Other than the contemporary plastic bottle cap mentioned in Chapter 2, no unknown cultural resources were encountered during this study.

Oftentimes the exposure of a cultural resource also results in damage to that resource. One example of this is the 2001 Highway 88 Fire in California, where a dozerline exposed a large bedrock mortar; either while the blade was removing the soil over it or from the weight of the machine itself, one edge of the mortar was broken off (Timmons et al., 2012, p. 175). Damage to a cultural resource can also occur from fire management without it first being exposed by management activities. Damage can include physical effects such as breaking, cracking, and staining the surface of a resource. The latter two are not specifically associated with fireline construction but should be noted. Using water on artifacts that have been super-heated as a result of being exposed to fire can result in their cracking (Haecker, 2012). Chemical fire retardants or suppressants are colored with either an iron oxide or a fugitive color that is made to fade with exposure to the sun (Gerow, 2013; Seifkin, n.d.). The purpose of the color is for aircraft pilots and crews on the ground to know where the suppressants have been applied. Staining of cultural resources from chemical suppressants has been observed in numerous places and fire incidents (see Traylor et al., 1990; Timmons et al., 2012; Gerow, 2013). Though water and chemical suppressants were not used at my site, their use is a notable operational effect of wildland fire management. My principal concern was the physical damage that fireline construction can cause to cultural resources. At one Puebloan site in Bandelier National Monument, a dozerline had been cut through the edge of the site and broke building blocks and displaced ceramic artifacts (Traylor et al., 1990, p. 38). Additionally, 11 instances of building broken blocks were recorded at the three dozerlines created during the La Mesa Fire (Traylor et al., 1990, p. 101). These findings led me to expect that some of my experimental artifacts would break as a result of the fireline construction.

The impacts discussed above can have compounding effects as erosion and vandalism increase as a result of site disturbance. Soil erosion can be caused by both wind and water. Erosion can impact a cultural resource or archaeological site by removing exposed artifacts from their provenience even further. Erosion can also impact cultural resources, such as structures, by exposing them to increased amounts of runoff (Timmons et al., 2012). At Bastrop State Park in Texas, numerous culverts received damage to their sandstone faces as a result of increased erosion following a heavy storm after a large fire in the Park in 2011 (Gerow, 2013, p. 24). These culverts were created by the Civilian Conservation Corps and are faced with local sandstone (Gerow, 2013, p. 24). The culverts are a factor of significance in the National Historic Landmark nomination of Bastrop State Park (Gerow, 2013). Erosion is certainly an expected indirect impact of this study, particularly at Units 2-4 as they are located across a slope of 5-10%.

Exposure of cultural resources makes them vulnerable to vandalism in the forms of damaging or defacing a resource, or in looting artifacts. On the La Mesa Fire, artifact collection was the most common impact associated with hand crews, as evidenced by small piles of artifacts next to trash from these firefighters' lunches (Traylor et al., 1990, p. 103). On one occasion, crews were mistakenly dropped by helicopter at the Pueblo of the Stone Lions ruin; while waiting to be relocated, pocketing of artifacts was observed (Traylor et al., 1990, p. 105). Luckily, "line archaeologists informed the crews that cultural material should be left where it was found. Later, one of the archaeologists gave an impromptu talk about the site and Bandelier archaeology. Many small piles of artifacts later appeared around the ruin" (Traylor et al., 1990, p. 105). The high rate of artifact collection was attributed to the increased number of people present within the Monument as a result of fire suppression efforts (Traylor et al., 1990). To some extent vandalism was also an expected indirect impact in the CRWFM study. The UIEF provides numerous recreational opportunities, including hunting, meaning that people unfamiliar with my research could have come into contact with it. As my research was conducted in the fall, I frequently saw hunters while on the UIEF, though I never saw any at my site. The UIEF employees and University of Idaho students who were involved in Phase 1 and Phase 2 of my research could have also posed a threat of vandalism at my site. However, I expected this to be minimal as I was present at the times they were, and they understood that I was conducting experimental research. As to not influence the potential for vandalism to occur as an indirect effect in my research, I chose not to address the topic of vandalism with the UIEF employees and fire crew.

Methodology: Fireline Construction

Prior to the construction of the fireline I created a buffer zone around each 2x2 meter experimental unit to direct the bulldozer operator. This entailed marking every 50 cm for one and a half meters east of the northeast and southeast nails of Units 2-4 and the same amount west of the northwest and southwest corners of these units. This ensured that should the operator need to adjust the course of the midline they would still impact at least 50 cm of the units. A buffer zone was not created at Unit 1 due to it being large enough for the majority of it to be impacted even if the dozer operator had to adjust the direction of the fireline. Due to Unit 1 being on a flat clearing it was not expected that the dozer operator would need to adjust the orientation of the fireline. Also prior to the fireline construction I removed the line that had demarcated the boundary of each unit, as this was expected to be pulled out when the bulldozer came through.

The fireline was constructed on October 24, 2019. For both practical and safety reasons the fireline was constructed prior to the prescribed burn. Having a fireline constructed before the burn allowed for a controlled area within which burning could occur safely, should weather or other factors alter the behavior of the fire unexpectedly. The bulldozer used to construct the fireline is a Deere model 550b bulldozer. The dozer blade is 2 meters and 43.5 cm wide. According to the recent standards published by the Equipment Technology Committee of the National Wildfire Coordinating Group (NWCG) in December 2019, this dozer falls into the Type 4 category. Dozers of this type would be used most frequently on wildland fires where logging slash fuels are minimal (Seifkin, n.d.). The midline was constructed to extend from the access road northeast of NF 4713 that is north of the experimental site to an unnamed four-wheel drive road located to the south. It is standard for the berm of a fireline to be constructed opposite of the direction of the head of a fire. Due to a section of the prescribed burn unit being on either side of the midline, the berm was chosen to be constructed on the east side of the midline. The operator of the bulldozer began the construction of the midline from the north access road. The process of the fireline construction was video recorded for reference during data analysis.

During the construction of the midline I remained east of the bulldozer to observe and record the methods, following along the experimental site for the duration of the process. The path of the fireline is included in Figure 4.2 provided earlier in this chapter. At Unit 1 the dozer operator made one continuous pass through the entire unit. An area 70-90 cm wide at the length of the west edge of Unit 1 was not impacted by the bulldozer, therefore this area remained outside of the fireline. South of Unit 1, the dozer operator made one cut into the soil, then lifted the blade and reversed the dozer to then go forward with the blade lowered again. This allowed them to make a second cut to produce more soil for the structure of the berm. At each of Units 2-4, two cuts were made to expose mineral soil. Figure 4.5 below shows the fireline construction at Unit 2 during the second cut through that unit.

Figure 4.5: Construction of the fireline at Unit 2

After one initial pass of the length of the entire midline, the dozer operator was instructed to retouch some areas where additional berm strength was needed or where the fireline surface needed to be evened out. One continuous pass was made with the blade lowered, beginning at Unit 4 and concluding approximately 3 meters north of Unit 1. At that location the blade was raised and the mechanical construction of the midline was completed. This final pass did not involve the dozer blade being used to cut deep into the soil, rather it directed already loosened soil across the surface of the midline and into the berm.

While the midline was being constructed mechanically with a bulldozer, three individuals used hand tools to clear an area of 10 to 15 feet west of the fireline. They used chainsaws and Pulaskis to remove large fuels, such as rotted timber, as well as to shorten the height of fuels such as ninebark and oceanspray shrubs. This process adds an extra layer of strength to a fireline by minimizing the potential for large fuels or flames to cross over the fireline. This method is commonly practiced by federal and state agencies who manage wildland fire. A chainsaw was taken to large fuels to break them into smaller pieces that could be moved aside further west of the midline. A Pulaski was also used to break up punky, or rotted, fuels to spread them out across a larger area and further from the midline. Chainsaws helped decrease the height of small bushes. The cuttings from this method were left where they fell. The hand crew cleared fuels for the length of my experimental site, west of each unit and the midline. These activities occurred in part of surface scatter S1 and in all of surface scatter W3.

There are some notable observations of the fireline construction that should be addressed before continuing this discussion. First, soils were being moved from the north to the south for anywhere between 5 to 10 meters before they were deposited. Additionally, as the dozer blade would remove soil that soil would sometimes roll over itself as it was being pushed forwards, resulting in spirals of soil forming the berm in some places. The berm was particularly high at these places. Other times the soil would be pushed up the height of the dozer blade where it would then crumple down and fall forwards rather than roll. See Figure 4.6 below for examples of both, and Figure 4.7 for a view of the completed fireline in Unit 2. After the fireline was constructed, a total of 12 experimental artifacts were visible on the site surface, in the midline, or within or on top of the berm. These were found in Unit 1, S1, E3, W3, and between Units 2 and 3. These artifacts were photographed but not flagged, as it was decided to recover them during Phase 3. The entire process of constructing the midline at the CRWFM site took approximately eleven and a half minutes. The mechanical construction took approximately four and a half minutes and the hand crew worked for approximately seven minutes on manually clearing fuels west of the midline. The final step in Phase 1 was to take measurements of the fireline and collect soil samples.

Figure 4.6: Fireline berm at Unit 2 with spiral of soil on the left, and crumpled soil on the right

Figure 4.7: View of Unit 2, looking north, after the fireline was constructed

Fireline Measurements

After the fireline had been constructed, measurements of the fireline were taken for each unit as it transected a unit. There was some variance between the width of the fireline at each unit; however, it was frequently between 1.9 and 2.1 meters wide. As noted above, the western edge of Unit 1 was not impacted by the bulldozer. Considering the width of the fireline, this meant that approximately half of Unit 1 was exposed soil. In Units 2-4 the amount of exposed soil was closer to 80% or 90% of the total unit area. What is considered here to be exposed soil is the width and length of the fireline. The berm is not considered an area of exposed soil within the experimental units as the berm often covered some portion of what had been the surface of the units. The width of the berm varied within and between experimental units, as did the depth of the fireline. Average depths of the fireline on the west side of the units were from 24 to 30 cm. As discussed previously, firelines are dug to the depth of mineral soil. It should be noted that these depths vary in different regions of the country. In very arid regions mineral soils can be located on or near the surface, and in temperate areas these soils are found at greater depths (Seifkin, n.d.). Therefore, the depth needed to construct an effective fireline will be context dependent. Northern Idaho is a fairly temperate region, and in a mixed conifer forest such as the UIEF mineral soil is found below a layer of duff.

The following table provides the ranges in the measurements of the fireline as it transected each of the experimental units. The measurements of the fireline depth on the west of the unit were taken by measuring from the surface of the area at the west edge of the unit. Depths on the east were measured from the top of the fireline berm, therefore both the fireline depth and berm height are considered. These are provided separately in Table 4.5. All measurements are given with meters as the unit of measurement. Note that for Unit 1, a 70-90 cm wide section on the west side for the length of the unit was not impacted by the fireline construction.

Table 4.5: Range of the measurements of the midline for each experimental unit

Unit	Fireline Width	Fireline Depth on West of Unit	Fireline Depth on East of Unit	Berm Width	Berm Height
1	1.8-2.2	0.22-0.32	0.36-0.77	0.50-1	0.14-0.45
2	1.4-1.6	0.23-0.28	0.31-0.54	0.30-0.50	0.08-0.26
3	1.9-2.1	0.20-0.28	0.28-0.43	0.20-0.40	0.08-0.15
4	1.6-1.9	0.28-0.32	0.27-0.81	0.20-0.50	0.09-0.49

Soil Data

Earlier in this chapter I noted that soil samples were collected from Units 2-4 both while establishing the units and after the fireline had been constructed. This was done to help distinguish between depths of the fireline within those units. Also, because these units are situated on a slope ranging between 5-10%, I wanted to see how this influenced the fireline construction, as well as soil erodibility. To determine the latter, I created a soil map using the USGS Web Soil Survey (WSS). The soil map and soil data document are included as Appendix C in this document. I have compared the results of the WSS to the samples I gathered in the forest. Returning to the experimental site in the spring will allow me to observe and document any impacts of erosion incurred over the winter.

The WSS map (see Appendix C) shows that the soil type found at my experimental site is the Carrico-Carrico, dry-Kruse complex, or Cr4. A complex is a soil composed of two more soils that are intricately mixed in a small area. Cr4 is found in areas of 5 to 35 percent slopes (Appendix C). The WSS map states that the study area is 40% Carrico, 25% Carrico, dry, and 20% Kruse, and the remainder are similar soils. Cr4 is described as having an ashy silt loam texture. Though the WSS does not provide Munsell colors as part of the soil data, these can be used in tandem with the data of the typical profile for the soil complex. Differentiating between soil colors using Munsell Soil Color Charts helps to define changes in soil profiles, and thus differentiates amongst stratigraphic layers. Table 4.6 illustrates the typical profile of each soil in the Cr4 complex. Note that each profile varies in depth, and that the third soil horizon for Kruse is BA rather than AB.

Table 4.6: Typical profile of Carrico-Carrico, dry Kruse soil complex

Soil	Oi Depth	Property	A Depth	Property	AB Depth	Property
Carrico	0 inches	Decomposed plant material	0 to 6 inches	Ashy silt loam	6 to 8 inches	Ashy silt loam
Carrico, dry	0 inches	Decomposed plant material	0 to 6 inches	Ashy silt loam	6 to 8 inches	Ashy silt loam
Kruse	0 to 1 inch	Decomposed plant material	1 to 10 inches	Ashy silt loam	BA 10 to 14 inches	Silt loam

I chose to list here only the profile data of Cr4 for depths at which my experimental artifacts were buried and at which the midline was dug to. All of the soils I collected were a fine silt texture both before and after the fireline was constructed. The most common Munsell soil color in Units 2-4 before the fireline was constructed was 7.5YR 5/2 (brown) when dry and 10YR 3/3 or 2/2 (dark brown or very dark brown) when wet. Units 2 and 4 contained another soil color, 7.5YR 4/4 (brown) when dry which would appear as 10YR 3/2 or 2/2 when wet (very dark greyish brown or very dark brown). Unit 3 had an additional soil color unique to the unit which was 10YR 6/6 (brownish yellow) when dry and 7.5YR 3/2 (dark brown) when wet. To limit misidentification of soil colors, I measured all of the soil colors myself in a controlled area under fluorescent lighting. The soil samples collected after the fireline was constructed are discussed in Chapter 7. An analysis and comparison of the soils before and after the fireline was constructed can also be found in Chapter 7 as Table 7.2.

With the experimental site established, and the midline constructed, Phase 1 of the CRWFM study was complete. The main finding in this phase of the study is the rapid reduction of artifact visibility at the experimental site. Artifacts that were on the surface of experimental units were quickly displaced during the mechanical construction of the fireline. Experimental artifacts that had been buried remained hidden even after the fireline had been cut to depths greater than those at which artifacts were placed. The variation in fireline width and depth across the differing slopes led me expect differences in impacts to artifacts based on slope. Significant erosion was expected to occur at Units 2-4. The next step in the study, Phase 2, was to conduct the prescribed burn. The methods of prescribed burning, the fire data, and observed impacts to experimental artifacts are provided in the following chapter.

CHAPTER 5: PHASE 2- THE PRESCRIBED BURN

This chapter provides data on the prescribed burn conducted at the experimental site of the CRWFM Project. Information on the burn prescription, fire data, and expected impacts of prescribed burning to cultural resources are discussed. Details on the methodology of the prescribed burn follow. Concluding the chapter is a brief note on the relationship between wildfire and prescribed fire on the UIEF.

Various prescribed burns were taking place across the Flat Creek Unit in the Fall of 2019. The prescribed burn unit with which the CRWFM Project is associated is the B3 Unit. The B3 Unit was comprised of five burn units of varying sizes totaling 191 acres. The B3 Unit extends from Brown's Meadow to Basalt Hill and beyond, thus the name B3. Burn units D and E of B3 flank the midline, on the west and east respectively, and are therefore associated with my experimental site. Burn unit D of the B3 burn was 35 acres and burn unit E was 17 acres. Figure 5.1 below is the map of the entire B3 prescribed burn. Burn units D and E are located in the top right of the map.

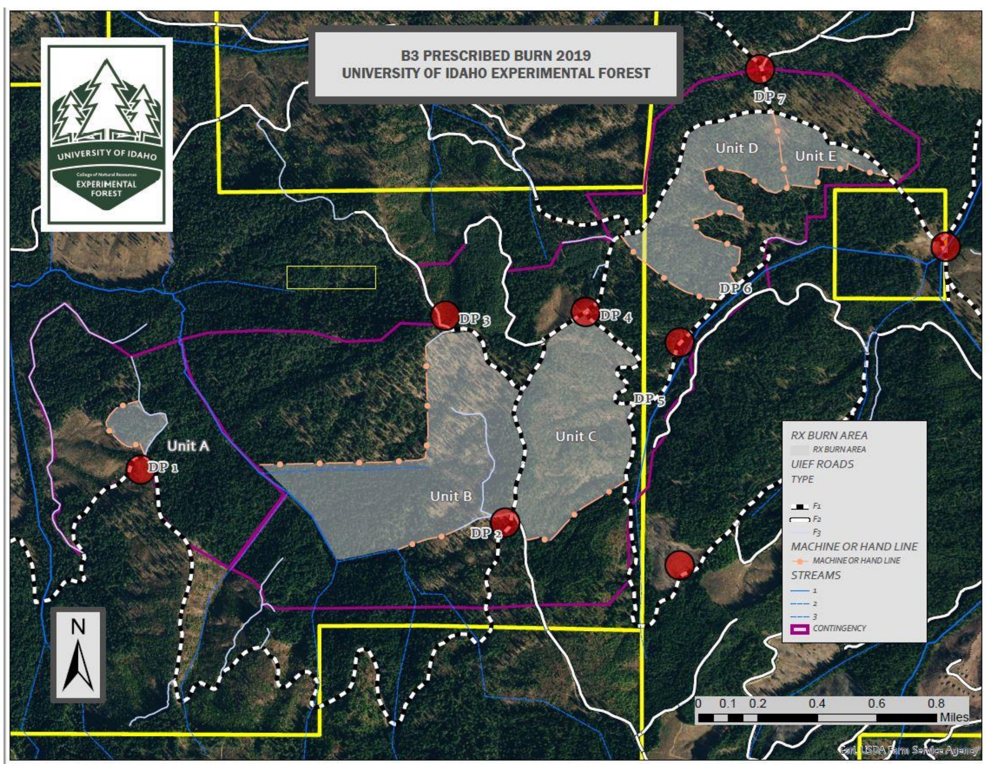

Figure 5.1: Map of B3 Prescribed Burn on the Flat Creek Unit of the UIEF, 2019 (Map supplied by Rob Keefe)

The objective of the B3 prescribed burn was to reduce understory fuel loads. Understory fuels are those found between the litter and shrub fuel bed strata. A main prescription goal was a fuel and silviculture treatment to reduce fuels and improve forest growth and productivity. The goal was to improve the health of the forest and reduce threat of wildfire without losing timber value. Unless these were located close to a live tree, fuels of dead biomass, such as rotted stumps and logs, were targeted. Prior to the burn a slash pile of fallen branches from snags had been created. This slash pile was burned on the day of the prescribed burn. Each of these actions served to decrease the likelihood of wildfire on the UIEF.

Prescribed Burn Data

Burn unit B3 units D and E were burned on October 26, 2019. A crew of 11 conducted the burn. This included employees of the UIEF, some of which are also students of the University of Idaho, as well as forestry students and those in the Prescribed Burn Course. As noted in Chapter 2, weather is one of three factors that influences fire behavior and intensity. This day provided a good day to burn due to a combination of a low temperature, dry conditions and relatively low wind speed. Prior to October 26th there were few windows in which to burn due to temperatures near 60° Fahrenheit, episodes of rain, or wind speeds over 20 MPH, or a combination of these factors. When the fuel moisture (also known as relative humidity or RH) was first measured on the burn day it was very low, meaning the fire behavior would be low. This would make achieving the goals of the burn prescription difficult. We waited for the temperature and sky condition to improve to raise the RH. The UIEF burn crew predicted that the litter fuels (needles and twigs) would light easily but the wind would be needed to carry the fire. Terrain and fuel factors also influence the behavior and intensity of a fire. Within burn unit D the terrain varied from flat areas to large sloping areas with a southerly or westerly aspect. Burn unit E is flat with a slight easterly aspect. The fuels at burn units D and E were surface fuels. This includes litter, woody fuels such as rotted stumps and branches from snags, low vegetation such as grasses, and shrubs including oceanspray and ninebark. Table 5.1 below provides the burn data for units D and E on October 26, 2019.

Table 5.1: Fire data for Units D and E of prescribed burn unit B3 of the Flat Creek Unit of the UIEF, October 26, 2019

Fire Variable	Data Collected
Weather	Temperature- 40° F; Sky Condition-Cloudy
Wind Speed; Direction	4-7 MPH; direction varied from northerly to westerly
Relative Humidity (RH)	35-45
Terrain	Class 2 Riparian
Fuel type	Surface- litter, grass, woody fuels, shrubs
Behavior/Intensity	Low
Duration	6 hours
Acreage Burned	Approximately 28

Expected Impacts

In Chapter 4, I described how I had simulated three surface scatters at my experimental site to gather data on the non-mechanical construction of the fireline. I also discussed various expected impacts to cultural resources that would occur during Phase 1. Though the purpose of the CRWFM Project is not to understand direct impacts of fire to cultural resources, the locations of these surface scatters meant that they would be exposed to and impacted by fire. Therefore, some examples of expected fire impacts are provided.

The majority of the artifacts used in the surface scatters were of ceramic, glass, and ferrous metal (iron). Fire can impact these artifacts through flame, smoke, or heat buildup. Some fire impacts that could be expected on these include temporary or permanent discoloration and crazing to the surface of ceramic and glass artifacts (Haecker, 2012). Discoloration can result from burning of the material or the buildup of combustive residue (soot). The severity of these impacts is dependent upon factors such as the proximity of the artifact to the fire's point of origin, as well as the size of the fuel load (Haecker, 2012, p.138). These factors also influence the degree of impact to metal artifacts, which commonly become alloyed. This is when a metal with a low melting point is heated by fire and contacts metals with higher melting points (Haecker, 2012). When these metals come into contact, they melt, resulting in an alloy with a melting temperature lower than that of even the lower-melting-temperature metal (Haecker, 2012, p.140). Iron has a high melting point, approximately 2,795° Fahrenheit (Haecker, 2012, p.140). As I did not use non-ferrous artifacts in the surface scatters and the fuel loads were small, alloying was not expected. Due to a low fuel load comprised of both green and dried grass and dried pine needles, the experimental artifacts were expected to be minimally impacted by fire. The prescribed burn temperatures were not recorded.

An indirect impact of fire that can severely affect cultural resources is the burnout of stumps. Stump burnout can negatively impact cultural resources by destroying the stratigraphy of a site or feature. Trees often grow adjacent to archaeological features, and can even be found within features as the roots expand over time (Timmons et al., 2012). This is due to the high organic constitutions of hearth features and middens. A stump can be created either naturally or through logging activities, and as it decays it transforms into a "fuel capable of sustained flaming and smoldering" (Timmons et al., 2012, p. 184). The burning of a stump visible on the surface continues into the subsurface root system. As the roots burn and disintegrate, the soils and potential artifacts or features within them that are held in place by the roots collapse (Timmons et al., 2012). This redistribution of cultural resources is a loss of stratigraphy, meaning that reliable dating of the site or feature may be difficult. At a prescribed burn in northwestern Montana, 80-year-old stumps created through logging resulted in burned-out stump cavities one and a half meters in diameter and depth with 5-meter-wide root cavities (Timmons et al., 1996 cited in Timmons et al., 2012, p. 183). Additional research in Montana has shown that the age of a stump can influence how it will burn; stumps 45 years old were dryer than 30-year-old stumps and were more likely to burn completely in a single event (Hemry, 1996 cited in Timmons et al., 2012, p. 183). These studies were conducted within a forest of Douglas fir and ponderosa pine, the same type as the CRWFM experimental site. Burning stumps also pose the potential to thermally alter subsurface artifacts, as burning roots can reach depths greater than 15 cm (Oster et al., 2012, p. 145). Even at high intensity wildfires, a minimum of 5 cm of soil can insulate artifacts from heating; it is where stump burnouts occur that impacts to subsurface materials are most severe (Oster et al., 2012; Timmons et al., 2012). There were no stumps in an area within my experimental site where I could test the impacts of stump burnout to cultural resources and measure the effects with the total station. However, observations of the burnout of a stump south of the experimental site provide relevant data. A portion of this data is discussed later in this chapter, and in more detail in Chapter 7.

The surface scatters functioned to provide data on operational effects of non-mechanical construction of fireline. They also served to provide data on behavior of the fire crew in Phase 2. Movement of the fire crew across the landscape during prescribed burning methods was expected to impact the surface scatters. Due to the presence of several individuals participating in the prescribed burn who did not know of the surface scatters, it was expected they would be impacted. Specifically, walking on or over the experimental artifacts in the surface scatters was thought to result in disturbance to their locations.

Methodology: Prescribed Burning

Prior to the burn a briefing was held to address prescription goals and safety. At this time some of the data in Table 5.1 was gathered, and roles were assigned. This included a burn boss and a holding boss. The former role involves directing crew members with drip torches where and how to ignite. Again, drip torches are metal cannisters with handles that are filled with a flammable mixture, in this case a four to one mixture of diesel fuel and gasoline. Drip torches have a wick at the end of a spout; the wick is lit and as fuel exits the end of the spout it catches fire and drips to the ground, igniting fuels below. The role of holding involves monitoring fire behavior and direction of spread from one area, “holding” the control line to act appropriately should spot fires occur. The roles of the other crew members were assigned to one of these tasks. Two individuals were selected to go ahead of the burning on the midline to fell dead trees known as snags. Snags are hazardous due to their greater potential risk of falling or losing limbs in high winds or when ignited, causing not only the potential for fire to spread to unwanted areas but also a hazard to the safety of fire crew members.

Part of the briefing before the burn addressed safety. Everyone participating in the prescribed burn was wearing appropriate clothing and equipment. This included Nomex fireproof pants and shirts, leather gloves, Vibram soled boots, and hard hats. Additionally, everyone was equipped with line gear including a pack containing a fire shelter and water, and a tool for digging and cutting, such as a Pulaski. Most everyone had a radio, those who did not stayed with someone who did. The radios facilitated communication amongst the crew members, as we were spread several acres apart at times. The radios could also be used to contact the Idaho Department of Lands in case of an emergency. Many of us also had cellular reception at the location of the burn. As someone with no prior experience on a fire, I was always accompanied by at least one member of the fire crew. The red dots on the map in

Figure 5.1 signify the designated safety areas for the B3 unit. These were identified during the briefing, as well as other equipment that could be used if needed. This includes two four-wheel drive engines each equipped with 850 liter capacity tanks from which water can be pumped, a 2,250 liter capacity water tender truck, and the Deere bulldozer used in Phase 1.

Research on the physiology of ponderosa pine saplings impacted by prescribed fire was being conducted north of my experimental Unit 1 within burn unit E. Data for this research was being collected during the prescribe burn. An additional dozerline was established around the area within burn unit E to allow for data collection for this research and the prescribed burn to be conducted safely. This dozerline connected the access road northwest of road NF 4713 and the midline. During the construction of the new fireline, part of the berm of the midline was cut into (see Figure 5.2 below). The berm south of experimental Unit 3 and north of Unit 4 was removed to create the new fireline. Similar to the midline, the berm for the new fireline was constructed on the east side of the line, as the area being burned was located to the west.

Figure 5.2: Where midline was cut into between Units 3 and 4

Beginning at the north end of burn unit D and west of the midline, the burn boss and fire crew began to ignite fuels using drip torches. The crew employed the method of strip burning, where they created a flank fire by walking parallel to each other and moved west across the flat clearing and down a draw, lighting as they walked. This method, whereby the lines of fire are lit into the direction of the wind, causes fire to burn at a right angle to the direction of the wind. In addition to the wind direction these lines were perpendicular to the slope's axis, which allowed the fire to spread. Due to relatively low windspeeds and a somewhat high fuel moisture the fire intensity was low. My role during this time was to help hold the line. At experimental Unit 1 the fire had burned quickly and in patches on both the west and east sides. Recalling from Phase 1 that a dense concentration of dried pine needles was present on the surface at Units 2 and 3, the fire had burned evenly west of these units. The east side of Units 2 and 3 were within the burn unit E, and the fuels burned thoroughly and somewhat quickly. West of the midline was burnt at Unit 4 however it did not spread more than 1 to 2 meters outward. The east side of Unit 4 was not burned.

Figure 5.3: Patchy burned spots and experimental artifacts in Unit 1

As one part of the fire crew continued west of the midline in unit D, I assisted with the burn in burn unit E, east of the midline. Here I worked to "black the line". This involved walking within the dozerline and burning the fuels along the west edge of it to create an additional break in fuels. While I did this two fire crew members worked within burn unit E conducting strip burning. Here there was a slight easterly aspect so they walked at an angle from northeast to southwest. Both here and west of the midline, after a transect was lit the crew members would use the drip torches to burn a line connecting the parallel lines. Similar to blacking the line, this is to create a boundary of a break in fuels to contain the fires spread. After the new fireline had been blackened, I helped burn within burn unit E, walking in a transect and burning parallel to others in strips.

From my observations and own experience during the prescribed burn, the fire crew had limited time to vandalize the experimental site by collecting artifacts. The majority of the time was spent by focusing on where drip torch fuel was placed, and where one was walking. There were brief moments where ignition was paused to observe the fire behavior. This was done to determine what actions should be taken to meet the prescribed burn goals. Therefore, even during moments of pause between strip burning, attention was focused on the prescription goals, rather than on the experimental site. Another observation is the difference between how the fire crew and myself looked at the landscape. Though I can only confidently speak for myself it is highly probable that the members of the fire crew were looking at the experimental site and burn units differently than I was. Out of habit as an archaeologist, when I was not looking ahead to where I was burning, I paid close attention to the ground directly in front of me. As the behavior of fire is dependent upon multiple factors, I doubt that the fire crew members were solely looking at the litter fuels, and ignoring the surrounding fuels and terrain. Vandalism of the experimental site was not expected to occur, due to my being present and the fire crew knowing that I was conducting research. I would predict that looting might be frequent in situations in which fire personnel are not expecting to encounter cultural resources. Additionally, situations in which fire fighters are not focused on ignition and are located in close proximity to cultural resources, one might expect higher instances of vandalism.

The wind direction changed frequently, which made conducting the burn more difficult. Just as the crew would adjust the direction of their burning so as to have the wind carry the flames, the wind would again change direction. There was some success with burning the surface fuels however there was more success with the stumps. The duration of the burn as listed in Table 5.1 includes both the time spent by the crew in conducting the burn as well as the continuous burning of large fuels on October 26th. The fire crew burned for approximately 4 hours, however many fuels within the units continued to burn or smolder for several days, in some cases weeks. In particular, I observed that stumps could still be flaming for 24 hours, and smoldering for 13 days. Occurring after the flaming combustion phase of fire, smoldering is a phase characterized by a glowing combustion (Ryan et al., 2012a, p. 219). Smoldering is typically flameless but can involve scattered flaming and is a slow spreading fire that produces a large amount of smoke. One stump in particular, located south of my experimental site and west of the midline, continued to smolder for at least thirteen days but likely longer. After six days the stump was largely burned out and still smoldering and flaming from the root system. At a study in northwestern Montana, a tree root was seen burning 3 meters away from its stump a week after a prescribed burn (Hemry, 1996 cited in Oster et al., 2012, p. 147). As stumps are a large surface fuel that is connected to larger subsurface root systems, they can produce flames and smolder for long periods of time after initial ignition. The next time this stump was revisited was 22 days after the prescribed burn, at which time it was seen to have been completely burned out.

On October 27, 2019, I returned to the UIEF to help three other individuals conduct more prescribed burning within burn unit D of the B3 burn. On this day we did not burn near my experimental site at the midline. The fire behavior on the 27th was much better. That day the temperature was still close to 40° Fahrenheit however, it was sunny and the humidity was low. The fire carried much better than it had on the previous day. I mention above how there were limited windows in which to burn due to various weather factors. It was a good thing that burn units D and E of the B3 unit were burned when they were, because it snowed on October 28th. Due to the low fire behavior at the midline in burn unit D, two employees of the UIEF returned to the area on November 1, 2019 to complete the prescription goals. Snow was still present in shady areas on November 1st. With approximately 80% of the acreage successfully burned at burn units D and E of prescribed burn unit B3, Phase 2 was completed.

Wildfire on the Experimental Forest

An interesting and coincidental situation occurred on the Flat Creek Unit of the UIEF in early October, two weeks before the prescribed burn at my site. The Flat Creek Unit is bounded by private property, as well as state and federal lands. During the fall it is common practice for homeowners to collect yard and garden refuse into slash piles and dispose of these by burning them. This practice is also common in wildland fire management such as prescribed burning. A few days after a neighboring homeowner had lit a slash pile and left it to burn, it had spread onto the UIEF as a wildfire. Warmer weather and increased solar radiation allowed the slash pile that was still in the glowing combustion stage of fire to spread. I found out about this incident when leaving my experimental site one day when the manager of the UIEF pulled up and said he saw smoke in the area. The smoke was not visible where we were, so he went down an access road to locate its source. As I was leaving, I could see a tall plume of white smoke at the edge of the forest and private property. When the manager of the UIEF got to the scene, he found that the fire behavior was much like the kind that he was aiming for with the prescribed burns throughout the Flat Creek Unit. The fire was only consuming the surface fuels and not spreading into the canopy. Fortunately, the situation resulted the way that it had and no one was harmed.

This incident serves as a valuable lesson in fire behavior and a reminder that though flames are absent a fire can continue to burn and pose the potential to spread. The property line of the UIEF is about one half mile north of the CRWFM site. Had the off-property fire reached my experimental site and emergency action been taken to respond to the incident, the results of my research could have been altered.

Observing and participating in the prescribed burn offered for insight into both the operational effects associated with this wildland fire management activity and the direct effects of fire. Some experimental artifacts were briefly exposed to direct fire during the prescribed burn. The implications of the movement of the fire crew weigh heavier on the experimental artifacts than those of fire. Overall, both the spatial displacement and physical impacts were less severe than anticipated. I did not observe any artifacts being moved by the fire crew, either by their movement across the experimental site or deliberate touching or picking up artifacts. The impacts of the fire management methods in Phase 3 of this study, discussed in the following chapter, are quite dissimilar.

CHAPTER 6: PHASE 3- RECOVERY AND REHABILITATION

The purpose of Phase 3 was to gather data on the indirect impacts and operational effects on the experimental artifacts incurred during Phases 1 and 2. Rehabilitation of the fireline was also included in Phase 3 as well as data on the impacts of this activity. Experimental artifacts were recovered at this stage. The methodologies of recovering experimental artifacts differed slightly before and after the fireline was rehabilitated, therefore they are discussed in different sections here. Phase 3 began on November 2, 2019 and was completed on November 20, 2019.

Methodology: Recovering Experimental Artifacts

Weather had been a very influential factor in the timeline and success of much of the CRWFM Project, and it was again in Phase 3. At the end of October, it had snowed on the UIEF, including at my experimental site. As noted at the end of Chapter 5, snow was still present in shady areas on November 1st. Concerned that snow would continue to fall in the coming weeks I chose to not wait any longer to begin Phase 3.

Throughout this chapter and in the following chapters I will be referencing various areas of the experimental site using terms that have not been used previously. Figure 6.1 below is a map of the CRWFM site to help the reader understand the locations of these areas in relation to the experimental units.

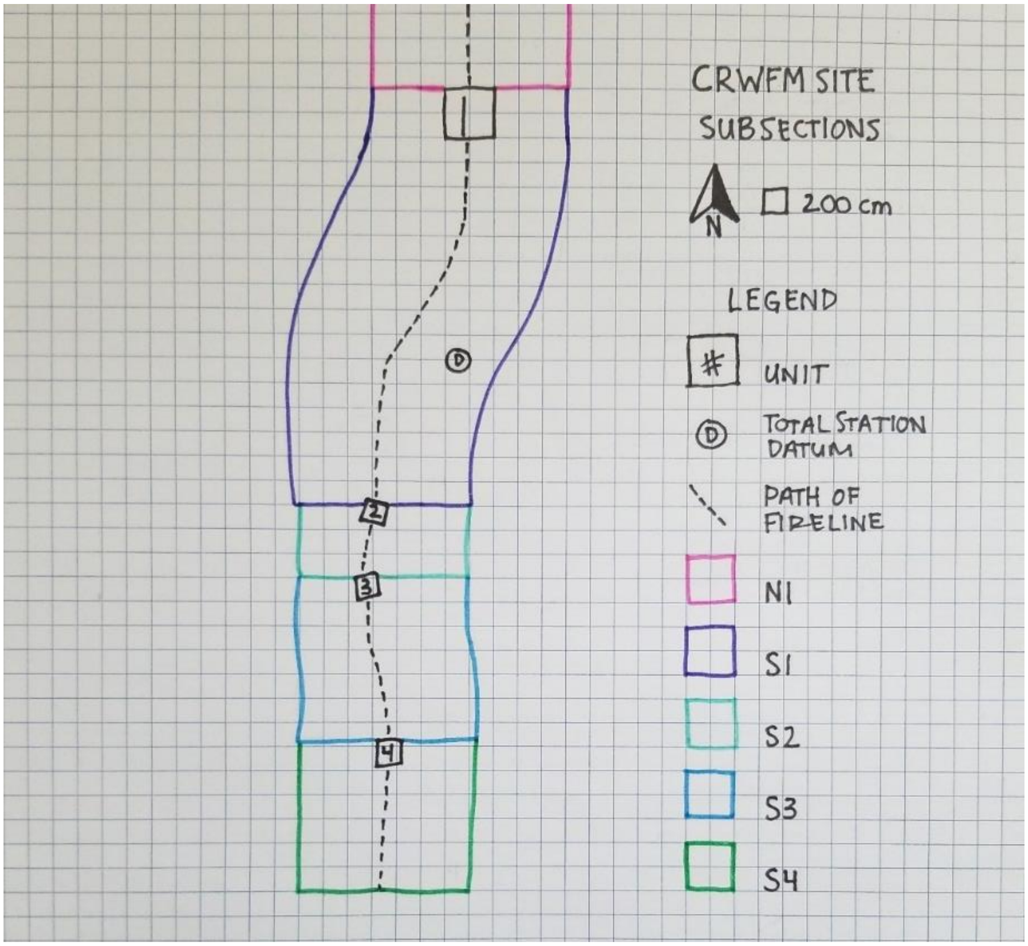

Figure 6.1: Map of experimental site with secondary locations used in artifact recovery

The first step in recovering the experimental artifacts was to conduct a pedestrian survey of the site and flag visible artifacts. Myself and a peer conducted the survey, looking within the midline, on the berm, at the west and east edges of the midline, and where the surface scatters were originally located. Some snow was still present at Unit 1, but we were able to brush it aside during our survey. There were minimal amounts of snow at Units 2-4. After flagging the experimental artifacts that were visible, we began to collect them, beginning at Unit 1, surface scatter S1, and the surrounding area. This involved marking a plastic bag with the location of the artifact within the site, either by unit number or surface scatter number. The location of each experimental artifact was taken with the total station, and the coordinates documented. A piece of paper was put within each bag to keep track of more specific locations of artifacts. This included if it was in an experimental unit or outside of the unit and in what direction, and if located in the unit and berm how many centimeters south of the northeast nail of the unit the artifact was recovered. Additionally, it was recorded if the artifact was recovered from within the berm or surface of the berm, or the surface within or outside of the fireline. On November 2nd, a total of eight individual artifacts were recovered from nine different locations at Unit 1, surface scatter S1, and a new location, N1, north of Unit 1.

Due to a low number of artifacts visible on the surface of the site immediately after fireline construction, I decided to screen sections of the midline berm. I based this decision off of my observations of the fireline construction in Phase 1, in particular how the dirt was moved from north to south and how the dozer blade caused the soil to roll over itself. Unsure of how successful this method would be and due to the height of the berm in some places I chose to screen sections of the berm, each 30 cm wide, every 50 cm within the experimental units, as well as every 50 cm for 1-3 meters after each unit. Since the dozer moved dirt from the north to the south when constructing the midline, I chose to look south of experimental units in an attempt to locate artifacts. Screening the berm involved shoveling the soil of the berm in sections from the top down and placing that soil into a five-gallon bucket. When the bucket was three quarters of the way full the dirt was then screened through a 1/8-inch screen. The berm was thought of like an archaeological excavation unit; digging into the berm in even sections from the top down was done to preserve the artifact location as deposited by the fireline construction. Before shoveling dirt into the bucket, an elevation measurement of the height of the berm was taken using the total station. After each full bucket another elevation measurement was taken, as well as a concluding elevation after the section had been entirely screened. The base of the berm, where we stopped digging, was determined by contacting the surface vegetation that the berm had been covering. Since the berm of the fireline was going to be rehabilitated, we screened over the fireline and left the screened dirt in place.

We began our screening at Unit 1. Due to the recent snow and ensuing cold temperatures, the soil was frozen and digging into the berm and screening the soil was difficult and slow. In one day of screening we only made it halfway through Unit 1. All of the screening on this day was sterile, meaning that no experimental artifacts were recovered. The following day myself and three others returned to the experimental site to repeat the process of screening and recovering artifacts. We collected more experimental artifacts from the surface at S1, then completed screening the berm within and three meters south of Unit 1. Eight sections were screened within Unit 1, and four sections were screened south of Unit 1.

Two artifacts were recovered from screening the berm the second day at Unit 1 and S1. Next, we moved on to Unit 2 to screen the berm. Thankfully the soil in the berm at Unit 2 was slightly thawed. This factor and the smaller size of the unit made screening somewhat quicker; having additional hands also helped greatly. A total of three 30 cm wide sections of the berm were dug and screened within Unit 2, all of these were sterile. See Figure 6.2 below for what Unit 2 looked like after screening. Two meters south of Unit 2 (in S2), two sections were screened 50 cm apart, one artifact was recovered from within the berm during this process. Before moving on to Units 3 and 4, I chose to collect the experimental artifacts that had been relocated at the surface scatters. Six artifacts were recovered from S1, seven artifacts were recovered from E3, and six were recovered from W3. A final artifact, located on the surface where the midline had been split to create an additional fireline during Phase 2, was located in S3 and was recovered the second day of Phase 3.

Figure 6.2: Unit 2, looking east, after screening the berm

The process of screening to recover artifacts at Units 1 and 2 influenced the methodology for Units 3 and 4. It was decided that three 30 cm wide sections of the berm within these units and two sections of the berm just south of the units would be dug and screened. On November 4th, the third day of recovering experimental artifacts, myself and a peer began at Unit 3. We repeated the process of digging sections of the berm from the top down and screening those. In all five sections screened at or south of Unit 3 a total of two artifacts were recovered from the berm. As described in Chapter 5, the berm of the midline between Units 3 and 4 was cut into to create an additional fireline for unit E of the prescribed burn. This area was surveyed and the southern section, where an artifact had been recovered from the surface the previous day, was screened. Screening here was sterile. We concluded the recovery of artifacts from the experimental site at Unit 4. All five sections of the berm that were screened within and south of Unit 4 were sterile. Two experimental artifacts were located on the surface of the berm at S4. When collecting these artifacts an additional artifact was located sticking out from the middle of the berm and was also collected.

In summary, a total of 35 individual artifacts were recovered from the experimental site during a period of three days. There were four general locations from where artifacts were recovered; where they had been placed in Phase 1, on the surface of or sticking out from the berm, buried in the berm not visible during survey, and, in the fireline. Excluding those artifacts that were recovered from where they were placed in Phase 1, the most frequent location that artifacts were recovered was the surface of the berm or sticking out of the berm. Buried within the berm was the next most frequent location of artifact recovery. Only five of the 35 artifacts were recovered from the process of screening the berm. When each of these five artifacts were recovered, they were found intact in the berm rather than in the screen. This reflects a low potential for recovering broken artifacts prior to rehabilitation. These five experimental artifacts were not visible prior to conducting the process of shoveling the berm. Six artifacts were visible on the surface of, or sticking out from, the berm. Across the entire experimental site, only two artifacts were recovered from within the midline. Of the 34 artifacts used in the three simulated surface scatters, a total of 21 were recovered. These were recovered from the surface scatter locations they were placed in, as well as in the berm and fireline.

A total of two experimental artifacts were broken. The broken pieces from one of these artifacts could not be relocated. Pieces of the other broken experimental artifact were found in two separate locations within the berm, separated by a distance of 3 meters. Three artifacts recovered from Unit 1 were within the western section of the unit that had not been impacted by the construction of the fireline. As these 35 experimental artifacts were recovered prior to rehabilitation of the fireline, data regarding their displacement and physical impacts can be directly attributed to fireline construction. This information is discussed separately in detail in the following chapter. Table 6.1 below provides information for the total count of artifacts recovered from each location on the experimental site over the course of Phase 3, both before and after the midline was rehabilitated. Note that the counts in the table are not for individual artifacts, rather they are for locations of artifacts. This is because one experimental artifact that was broken was found in two distinct locations, separated by 3 meters. This distance is considered significant.

Table 6.1: Recovery location counts of experimental artifacts recovered before and after the midline was rehabilitated by area of the experimental site

Site Location	Phase 1 Count	Artifact Locations Before Rehabilitation	Artifacts Locations After Rehabilitation	Total Artifact Locations
N1	-	1	-	1
Unit 1	40	5	2	7
S1	13	9	3	12
Unit 2	28	1	1	2
S2	-	1	1	2
Unit 3	27	2	-	2
S3	-	1	3	4
E3	11	7	-	7
W3	10	6	-	6
Unit 4	25	-	-	0
S4	-	3	5	8
Total	154	36	15	51

Methodology: Fireline Rehabilitation and Recovering Experimental Artifacts

Rehabilitation of a fireline, especially one that is mechanically constructed, is common practice for many state and federal agencies who manage wildland fire. In part because fewer artifacts were recovered than expected by the processes of pedestrian survey and screening, and because it is standard practice, I chose to include fireline rehabilitation in Phase 3. This was done mechanically with a small excavator, a CAT model 305.5 E2 CR, operated by the manager of the UIEF.

During their post fire survey at Bandelier National Monument, Traylor et al. (1990) discovered that fireline rehabilitation increased the damage to already impacted sites. The authors observed that firelines were widened as bulldozers were used to push the removed soil back into the lines (1990). This would not only displace or break artifacts but would also bury them (Traylor et al., 1990, p. 113). At one dozerline, evidence of a site seen during the construction of the line was lost during rehabilitation, making relocation of the site impossible (Traylor et al., 1990, p. 113). Though the equipment and methods of rehabilitation employed after the La Mesa Fire were different from those at my site, this information led me to expect that some experimental artifacts at my site would be both exposed and reburied.

The midline was rehabilitated on November 16, 2019. Observation of the fireline construction in Phase 1 and where artifacts were recovered from earlier in Phase 3 led me to decide to have the berm rehabilitated from 5.5 meters north of Unit 1, through the entire experimental site, and concluding 5 meters south of Unit 4. The process of rehabilitation involved the excavator operator driving down the fireline (from north to south) and using the excavator bucket to pick up sections of the berm and place that soil back within the fireline. As dirt was dropped from the bucket it functioned to sift the dirt and artifacts within it. The entire berm was rehabilitated from the points I had selected to start and end at. As in Phase 1 during fireline construction, I observed the process of rehabilitation from east of the midline.

Beginning north of Unit 1, rehabilitation involved the excavator operator grabbing a section of the berm with the excavator bucket, then moving the arm over the fireline. They would move the arm across the width and length of the fireline as the bucket was being emptied to spread the soil evenly across the fireline. The excavator has a small blade, approximately 2 meters wide and 37 cm high, which was used to smooth out the surface of the midline as it was rehabilitated. When moving from the north of the site to the south, the blade was turned at an angle with the left edge forward to move the dirt from the lowered berm at the east across the fireline moving west. During rehabilitation, two experimental artifacts were seen falling from the excavator bucket, and were found within the fireline at Unit 1 after the operator had driven through it. The process of using the bucket followed by the blade was employed for the length of the site. One experimental artifact was seen just south of the datum on the east side of the midline during rehabilitation.

To complete the fireline rehabilitation, the excavator operator would lowered the blade and moved from the south to the north to again smooth out the soil that had been placed in the fireline. As I had observed some artifacts on the surface during the initial rehabilitation, I wanted to document their location prior to this final step. I walked from the south to the north of the midline, beginning south of Unit 4, and photographed each experimental artifact I encountered. A total of seven experimental artifacts were visible prior to the final step of rehabilitation.

At Unit 1, one artifact I had seen in the fireline was driven over during the return trip to the north. Figure 6.3 shows Unit 2 after rehabilitation. I conducted another survey of the experimental site to relocate the artifacts I had seen prior to the smoothing out of the fireline as well as look for any additional experimental artifacts. I located a total of 12 experimental artifacts, but could not relocate three of the artifacts I had seen prior to the fireline being smoothed out. Each artifact was flagged, as well as the locations of where an artifact had been seen previously but could not be relocated. I did the latter so that when I returned to recover the artifacts I would know where to dig and potentially screen.

Figure 6.3: Unit 2, looking north, after fireline rehabilitation

Recovery of Experimental Artifacts After Rehabilitation

The final recovery of experimental artifacts after fireline rehabilitation was postponed due to precipitation. Because I was using the total station to recover artifacts, I was not able to work in the rain. I expect that the rain would impact the locations of the artifacts I had flagged after the fireline was rehabilitated. It was also possible that the rain might have exposed additional artifacts I had not already flagged. On November 20, 2019, myself and a peer returned to the experimental site to recover the artifacts that had been exposed through rehabilitation of the fireline.

Prior to collecting the experimental artifacts, we conducted another survey of the entire site to attempt to locate additional artifacts. Four more artifacts were located. Beginning at the north end of the site at Unit 1 we recovered the experimental artifacts, recording their locations with the total station and placing them in unit bags with paper detailing their locations as described above. We moved south to S1 where there were both artifacts on the surface as well as two flags for where I had seen an artifact during the fireline rehabilitation but could not relocate. The soil where the artifacts were expected to be was scrapped and dug into using a shovel. One of these artifacts was recovered, the other artifact could not be relocated. Then we moved to Unit 2 where another flag had been placed where an artifact was expected to be. Here the artifact was relocated after digging into to soil once. No artifacts were found in Unit 3 but there were several south of that unit. At S3 we collected the artifacts that had been flagged. Here it was found that two artifacts that were flagged were actually two pieces of one experimental artifact. Unit 4 also did not have any experimental artifacts located within it, rather they were south of the unit. Similar to at S3, at S4 two flagged artifacts were actually two pieces of one artifact. Three more artifacts were recovered in S4 and, as we were preparing to wrap up, I spotted another that had been pressed down into the fireline. Walking back up the site we spotted another artifact south of Unit 2. In total, 15 individual artifacts were recovered after the fireline had been rehabilitated.

After the fireline was rehabilitated, all of the artifacts that were recovered were located within the fireline. The surface scatters were surveyed again however no additional artifacts were recovered from these locations. Refer to Table 6.1 above for the counts of artifacts recovered in each location after rehabilitation. Within the three locations I had flagged where I had seen an experimental artifact during the first stage of fireline rehabilitation but could not see it after the final pass during rehabilitation, two artifacts were recovered. Three experimental artifacts were recovered from within the boundaries of the experimental units, specifically Units 1 and 2. The remaining 12 experimental artifacts were recovered from the areas south of the experimental units. A total of three experimental artifacts recovered after the fireline had been rehabilitated were broken. Each of these artifacts had the broken pieces from them in close proximity. The impacts to these artifacts can be attributed to both fireline construction and rehabilitation, in some cases more specifically to rehabilitation.

Table 6.2 provides details on how and in what context experimental artifacts were recovered from. The counts and percentages in Table 6.2 are based on the locations from where artifacts were recovered as listed in Table 6.1 above. The percentage for the “surface” row considers artifacts that were visible and were known or thought to have been moved. The percentage represented in the “unmoved” row also represents artifacts that were visible on the surface, but were known to not have been moved during fireline construction and/or rehabilitation. The row “subsurface” refers to an artifact that was in the berm but was not recovered through screening before rehabilitation, and an artifact that was partially buried in the fireline after rehabilitation. “In berm” refers to artifacts recovered through the process of shoveling into the berm and screening those soils. Recall that no artifacts were recovered from within the screen, rather they were visible during shoveling.

Table 6.2: Counts (and percentages) of recovered experimental artifacts before and after fireline rehabilitation by context during recovery

Context	Before Rehabilitation	After Rehabilitation	Total
Surface	12 (33.5)	11 (73.4)	23 (45.1)
Subsurface	1 (2.7)	1 (6.6)	2 (3.9)
In Berm	5 (13.8)	2 (13.4)	7 (13.7)
Unmoved	18 (50)	1 (6.6)	19 (37.3)
Total	36 (70.6)	15 (29.4)	51 (100)

At the beginning of the CRWFM Project, a total of 154 experimental artifacts were placed within the simulated archaeological record. These artifacts were placed both on the surface and below the surface within four experimental units, as well as on the surface in three surface scatters. After a fireline was constructed through the experimental units, members of the fire crew walked through the surface scatters during fireline construction and prescribed burning, and the fireline was rehabilitated, a total of 50 individual experimental artifacts were recovered in Phase 3. This is 32.4% of the total number of experimental artifacts used and placed during Phase 1.

The above tables reflect that as operational effects of wildland fire management not exclusive to prescribed burning, mechanical fireline construction and rehabilitation remove surface and subsurface artifacts from their provenience. This affirms the hypothesis of the CRWFM Project. Most frequently, artifacts are found in locations in the direction of fireline construction, in the case of the CRWFM Project artifacts are found south of their original locations. These findings are not all that surprising, and they are in line with the findings of past studies and field reports. What is surprising are the results of data that inform how frequently artifacts are removed from their provenience, by what distance, to what degree fireline construction impacts subsurface artifacts, and the physical state of artifacts exposed to operational effects. These effects and others are addressed through analysis of data gathered throughout the CRWFM study in the following chapter.

CHAPTER 7: ANALYSIS

This chapter provides a detailed summary and analysis of the results of each phase of the CRWFM Project. Though conclusions from these findings will be drawn here, the implications of these will be addressed in Chapter 8. After discussing the numerous research questions of the CRWFM Project, the methodology of data analysis used to answer these questions is explained. The severity index used to describe impacts to cultural resources is defined. Following this are the results of Phases 1, 2, and 3. At the conclusion of each section of analysis of each experimental phase the reader will find a summary of the severity of the impacts unique to each phase. The most significant findings of the research for the experimental site as a whole are then summarized. Before moving on to the interpretation of these findings and the implications they have for archaeology and wildland fire management a discussion on the experiential aspect of experimental archaeology is provided.

Research Questions

The hypothesis of the CRWFM Project was that mechanical fireline construction will remove artifacts from their provenience. The experiments conducted as part of this research project, both mechanical fireline construction and rehabilitation, have affirmed this hypothesis. Several other research questions were included during the design and implementation of the study. Additionally, as the study was being conducted, and after data was gathered, more questions arose. These supplementary questions are of two types, those that inquire into the spatial disturbance of experimental artifacts, and those that inquire into the physical impacts to experimental artifacts.

To what degree are experimental artifacts spatially disturbed? Specifically, the horizontal and vertical displacement of artifacts is considered. If the experimental site is considered a three-dimensional space, horizontal displacement refers to movement in one of the four cardinal directions; vertical displacement refers to a change in elevation and more specifically a change in archaeological context. A follow up question is to determine whether the spatial disturbance of artifacts impacts the ability to interpret the archaeological record. The data that serves to answer these questions include the tools and methods used in fire management activities, and the terrain and soil type specific to the experimental units and the site as a whole. The measurements taken using the total station and recorded in hand drawn maps also contribute to answering these questions. Precipitation patterns and subsequent erosion are also considered. The likelihood of subsurface artifacts to be exposed as a result of operational effects is another question. Again, the tools and methods used in fire management are considered alongside terrain and soil type. I also sought to identify if there were specific areas within the experimental units or the site that were impacted more, or less, and what the factors behind this might be, as well as other patterns in spatial disturbance. An additional question that arose during the implementation of the study is where within the fireline berm would surface and subsurface artifacts from experimental units be found most frequently. As field data was being analyzed, questions arose regarding what type of site, precontact or historic, would be impacted more, and what type of artifact would most likely be lost.

A second set of research questions are those concerned with physical impacts to experimental artifacts. Using data related to fire management tools and methods used, fire behavior data, artifact context, and artifact material type, these questions can be answered. Specifically, the types of impacts to experimental artifacts overall and to each material type are considered, as well as the completeness of the artifacts and if this influences the ability to accurately identify and analyze the artifacts.

Methodology

The methodology for analysis can be separated into two parts related to the main groups of research questions, one part for the analysis of spatial disturbance to experimental artifacts, and one for analyzing physical impacts to artifacts. The analysis of this data is largely comparative of locations and conditions of experimental artifacts and the experimental site before and after conducting the mechanical construction and rehabilitation of the fireline for the prescribed burn. These actions most greatly impacted the experimental artifacts and simulated archaeological record. The indirect impacts and operational effects from the activities before, during, and after a prescribed burn have permanently affected experimental artifacts.

In the original design of the project, a total station was planned to be used to gather the location and context of experimental artifacts in both Phase 1 and Phase 3. A Nikon DTM 322 was used in both of these phases. Compounding effects of various factors, including frequent technical malfunctions of the device, as well as my own error in operating and lack of experience with the device, resulted in a large portion of the data gathered with the total station unable to be used. Specifically, the northing (N) and easting (E) coordinates from the total station were frequently off by several meters between the various days it was used. Considerable time and effort were spent trying to correct for the inaccurate measurements. This was met with limited success for all of the experimental artifacts. The exact degree of movement of 26 experimental artifacts used in the experimental units have been determined. Three of these artifacts, placed on the surface of Unit 1 in Phase 1, are known to have not moved during the study. The movement of the other 23 artifacts was calculated by comparing the distances of these artifacts to one of the three that had not moved as recorded with the total station in Phase 1 and Phase 3. The difference between the calculated distances for Phase 1 and Phase 3 was determined to be the distance that the artifact had moved. The spatial disturbances of surface scatter artifacts are estimated based off of their locations relative to the 26 artifacts from experimental units. It does appear that the elevation (Z) measurements that the total station took were minimally skewed, therefore these will still be used for all experimental artifacts recovered.

Physical impacts to experimental artifacts were analyzed through referencing the catalog descriptions and photographs created for each artifact prior to their placement in the simulated record during Phase 1. These catalog entries and photographs help to address changes to experimental artifacts that might inhibit their identification and interpretation. This includes breakage, disfiguration, staining or discoloration, and other surface features such as crazing and spalling.

To understand the degree to which the indirect impacts and operational effects inhibit the integrity of the experimental artifacts and interpretation of the simulated archaeological site, a severity index has been created. This index serves to help communicate the potential for damage to cultural resources, both sites and artifacts. This index will be used for both spatial disturbance and physical impacts to experimental artifacts as well as to the experimental site as a whole. The severity index provided here was constructed using the terms and definitions given by Gallagher (1978), with some adjustments that are specific to the CRWFM Project.

In his study on the impacts of the timber management practice of scarification, commonly used for regeneration of stands of Lodgepole pine, Gallagher found that this method would result in moderate to severe impacts to archaeological resources (1978). Scarification involves the use of a bulldozer with an oversized toothed blade to push dried timber slash into windrows that will be burned (Gallagher, 1978). While pushing slash into windrows the dozer blade simultaneously tills the soil, mixing loosened seeds into the soil (Gallagher, 1978). Gallagher established an experimental site of approximately 54 square feet with an average slope of 5-10% (1978, p. 292). Within his experimental site, a total of 99 post holes were created, each with three metal washers to represent artifacts within the post holes at depths of 6 inches, 3 inches and 1 inch; a fourth washer was placed on the surface of the post hole (Gallagher, 1978, p. 292). The process of scarification was then conducted through the experimental site and observations of changes to the ground surface and location of experimental washers were noted (Gallagher, 1978). Regarding the latter, Gallagher found that washers were displaced at greater distances horizontally than they were vertically, and that washers placed on the surface and at 3 inch depths were moved 20.5 inches and 34 inches, respectively (1978, p. 294). Additionally, it was found that 18% of the washers in the entire experimental site were lost, most frequently at the surface and 1 inch depth levels (Gallagher, 1978, p. 294). The findings of this study show that scarification can expose buried artifacts, disrupt the provenience of artifacts, and lead to the loss of known sites.

Though Gallagher's study is very useful, he does not consistently include measurements of displacement in his severity index. He defines heavy impacts in part as being found at a depth no greater than 1 foot (Gallagher, 1978, p. 297). The likelihood of heavy impacts occurring was dependent upon on factors of the presence of stumps, diameter of timber slash, and slope. Gallagher does not connect the horizontal and vertical displacement of washers to these factors in his 1978 report. Therefore, distances appropriate to the CRWFM study are based on the averages of the distances for the 23 experimental artifacts recovered in Phase 3 that were used in an experimental unit in Phase 1 and known to have moved.

The severity index, illustrated in Table 7.1 below, includes light, moderate, heavy, and severe impacts. Light impacts are those that involve some mixing of strata which potentially could disturb locations of archaeological resources. No or minimal physical damage occurs to artifacts. The ability to interpret these features is impaired. Moderate impacts mix strata as a result of horizontal and vertical displacement of soils. The depths are minimal however archaeological resources would sustain some physical damage, and interpretability of a resource or site would be questionable. Horizontal displacement of 1-4 meters is considered within the definition of moderate impacts. Heavy impacts mix strata as a result of horizontal and vertical soil displacement and involve depths no greater than 10 cm. Archaeological resources are physically damaged and/or removed from their provenience by greater than 4 but less than 7 meters. At the level of heavy impacts, interpretation of a resource or site is considerably reduced. Finally, at the severe impact level, strata are mixed horizontally and vertically and depths greater than 10 cm are involved. Artifacts are damaged severely enough to inhibit identification, and/or are removed from their provenience by greater than 7 meters; interpretation is nonviable. It should be noted that lack of physical damage and a light impact rating to a resource type does not necessarily coincide with light damage to a site. An artifact itself may be undamaged physically, but a dramatic change in its location can severely damage interpretation of the artifact as an object within a site. Therefore, the severity of spatial impacts and physical impacts are considered separately when discussing the data.

Table 7.1: Severity index for impacts to experimental artifacts

Impact	Soil Disturbance	Depth of Fireline	Horizontal Displacement	Physical Impact	Site Interpretability
Light	Minimal	N/A	< 1 meter	Rare	Impaired
Moderate	Strata mixed	< 5 cm	1-4 meters	Minimal	Questionable
Heavy	Strata mixed	< 10 cm	4-7 meters	Frequent	Reduced
Severe	Strata mixed	> 10 cm	> 7 meters	Frequent and detrimental	Nonviable

Phase 1

The most immediate impact of mechanical fireline construction to the CRWFM site was to artifact visibility. As mentioned in Chapter 4, I had located a total of 12 individual artifacts after the fireline had been constructed. This includes artifacts from experimental units and surface scatters. There was a total of 65 artifacts on the surface within the four experimental units that were visible prior to the fireline construction. The additional 34 experimental artifacts that were used in the three surface scatters accounts for a total of 99 visible artifacts across the experimental site prior to the fireline construction. The manual methods of fireline construction were likely to have impacted surface scatters S1 and W3. Crew members were seen walking where artifacts had been placed in these locations. I chose not to walk through these surface scatters to see how the crew of three had impacted them, as I was concerned that my walking through them could also result in impacts and skew my data. As I did not revisit the surface scatters after the fireline was constructed, the loss of artifact visibility for those locations cannot be measured accurately. The surface artifact visibility of experimental units can be discussed. For the experimental units, the construction of the fireline resulted in an 87.7% loss of surface artifact visibility.

When I had located the 12 artifacts in Phase 1, I chose not to touch them as I did not want to influence their provenience and recovery planned for Phase 3 of the study. Only one of these artifacts could not be easily identified from referencing the pictures I took in the forest to those associated with the catalog. As such, all that can be said of this artifact was that it was located within the berm of the midline in S1 and was minimally visible. It is very likely that it was a white refined earthenware ceramic and was not part of S1 or any of the surface scatters. It is unknown if this experimental artifact was recovered in Phase 3. Concerning the other 11 artifacts seen after the fireline was constructed, information is available for their condition, where they were originally placed and where they were seen, and where they were recovered from. Table 7.2 provides this information for the 11 identifiable experimental artifacts located after fireline construction in Phase 1. Seven of the identifiable artifacts seen after the midline was constructed were part of the surface collection of an experimental unit and four were from surface scatters. Four of the artifacts from the units and two of the experimental artifacts used in the surface scatters were removed from their original location. Note that the distances provided below are approximations of exact measurements that are provided later in this chapter. In the second column, “WRE” stands for white refined earthenware ceramic type and “SW” stands for stoneware ceramic type.

Table 7.2: Spatial disturbance and physical impacts to experimental artifacts that were visible before and after fireline construction

Artifact Number	Artifact Material	Location Before	Location After	Distance of Disturbance	Condition	Recovered From
141	Lithic chert	Unit 1 surface	Unit 1 surface	-	Complete	Unit 1
34	Ceramic WRE	Unit 1 surface	Unit 1 surface	-	Complete	Unit 1
33	Ceramic WRE	Unit 1 surface	Unit 1 surface	-	Complete	Unit 1
113	Glass bottle	Unit 1 surface	Berm surface, S1	5 meters (south)	Complete	S1
179	Metal iron	Unit 1 surface	Base of berm edge of fireline, S1	4 meters (south)	Complete	S1
80	Glass bottle	Surface scatter S1	Middle of berm, Unit 1	3 and 6 meters (north)	Broken	Unit 1 and N1
49	Ceramic WRE	Unit 3 surface	Base of berm, edge of fireline, S3	6 meters (south)	Complete	S3
101	Glass bottle	Unit 3 surface	Fireline, center, S1	18 meters (north)	Complete	S1
71	Glass bottle	Surface scatter W3	Fireline, west edge, Unit 2	6 meters (north)	Complete	Unit 2
24	Ceramic SW	Surface scatter S1	S1	-	Complete	S1
66	Glass bottle	Surface scatter E3	E3	-	Complete	E3

In summary, artifacts on a flat surface would be moved south by a distance of 4-6 meters. Artifacts on a 5-10% slope were moved north by 6 and 18 meters. On one occasion an artifact originally placed at a 5-10% slope was moved south by 6 meters. Observing the construction of the fireline led me to expect that the majority of experimental artifacts would be moved south of their original locations. As noted in the table above, this was not always the case. The return trip of the bulldozer, to even the surface of the midline, had caused experimental artifacts to also be moved north of their original locations. Of the artifacts seen after the fireline was constructed, half of those that had been moved had been moved north of their original context. Only one experimental artifact, number 80 a glass jug base, was found to have been broken. This was one of the experimental artifacts that had been moved north as a result of the mechanical fireline construction. It is interesting that only one of the three glass artifacts that had been displaced during the fireline construction had been broken. No physical changes were observed on the ceramic and metal artifacts that had been displaced.

Another impact from the operational effect of fireline construction that I observed in Phase 1 was the removal of vegetation and fuels within the midline. In each of the three instances I observed this, experimental artifacts were also impacted. A rotted log located just outside of Unit 1 at the southeast corner was impacted by fireline construction. As the bulldozer moved dirt through Unit 1, this log split with one piece being reoriented perpendicular to the other piece. Experimental artifact number 80 was on the south side of this log. When the bulldozer made the return trip moving south to north to even out the surface of the fireline this artifact was moved north into Unit 1. This experimental artifact was the only one that was seen to be broken after the construction of the fireline. During Phase 3, five additional pieces of artifact number 80 were recovered north of Unit 1, about six meters north of where the artifact had been placed in Phase 1. The degree to which artifact number 80 was broken is discussed later in this chapter. Another instance of when removal of vegetation impacted an artifact was when a punky stump in the middle of the fireline was torn up during construction of midline. I had placed an experimental artifact on the south side of this stump as part of surface scatter S1, this artifact was recovered after the fireline was rehabilitated. Where the stump had been was a small hole and a scatter of rotted wood. In his study of impacts of scarification, Gallaher found that the uprooting of stumps resulted in large basin-shaped holes that could measure 18 inches in depth (1978, p. 293). These stumps had only been cut and left to dry for one year, which is possibly a factor in the impact Gallagher observed. The stump at my site had a larger diameter than those in Gallagher’s study however, possibly due to it being rotted, the hole created when it was torn up was only slightly wider in diameter than the stump had been. The depth of the stump cavity was approximately 30 cm (1 foot) deep. The third observation of fireline construction impacts to vegetation is discussed below under the section Phase 3.

Though the blade of the bulldozer used in this research is 2 meters 43.5 cm wide, the fireline was found to have a maximum width of 2.2 meters. This difference of over 41 cm can be attributed to the berm being constructed within part of the fireline. The average width of the fireline was between 1.9 and 2.1 meters, and the average depth was 24 to 30 cm. The majority of the area of Unit 1 was removed or buried in fireline construction. The total area of Units 2-4 was removed. The depth reflects that fireline construction would have exposed the buried artifacts. The most extreme widths of the fireline were observed at Units 1 and 2, and the most extreme depths were found at Units 3 and 4. These can be associated with the methods of fireline construction specific to these locations. Specifically, whether one or two passes were made through the units and where the blade was lowered to cut into the soil. In the video of the fireline construction an amber colored glass experimental artifact is seen in the center of the fireline approximately 3.5 meters south of Unit 4. One artifact matching what was seen in the video was placed in the northeast quadrant of Unit 4. This artifact, number 110, was not one of the 12 seen after the fireline was constructed. This artifact was later recovered 3 to 4 meters away.

The Munsell soil color for samples collected from Units 2-4 after the fireline was constructed differ from those collected prior to the fireline construction. The soil samples collected prior to the fireline being constructed were taken from the holes dug for a sample of subsurface experimental artifacts. Soil samples collected from the fireline after it was constructed were collected by scraping a trowel across the surface of the exposed soil. Table 7.3 below shows the Munsell colors of soils for Units 2-4 before and after (in *italics*) the fireline was constructed. There were slight variations in soil colors within the units prior to the fireline being constructed. Comparisons of the most common soil colors observed within the units are provided in the following table.

Table 7.3: Soil color comparisons for Units 2-4 before and after fireline construction

	Unit 2	Unit 3	Unit 4
Munsell Dry Before	7.5YR 5/2	7.5YR 5/2	7.5YR 5/2
Munsell Dry After	*10YR 5/2*	*7.5YR 5/2*	*10YR 6/4*
Munsell Wet Before	10YR 3/3	10YR 2/2	10YR 2/2
Munsell Wet After	*10YR 3/3*	*10YR 2/1*	*10YR 3/4*

In Unit 2 where the above soil sample was collected the depth of the fireline was 23 cm. Comparison of soil samples in the east of Unit 2 were also conducted. Prior to fireline construction the soil color in the east were Munsell dry 7.5YR 5/2 (brown) and wet 10YR 2/1 (black). In the east of Unit 2 the soil color after fireline construction was 10YR 6/4 (light yellowish brown) when dry and 10YR 3/4 (dark yellowish brown) when wet. Throughout

Unit 2 the depth of the fireline corresponds to the BA soil horizon of the Carrico and Carrico, dry soils and the A horizon of Kruse soil in the Cr4 complex (Appendix C). The soil color found in the east of Unit 2 was also found in the west of Unit 4. The depth of the fireline where the sample was collected in Unit 3 was 28 cm, which corresponds to the BA horizon for all soils in Cr4 complex (Appendix C). The soil collected from Unit 4 was a fine silt however, when wet its texture was somewhat like a clay. The fireline was the deepest here, and unlike the rest of the experimental site the exposed soil was light colored and dry after the fireline was constructed. The fireline depth at this location was 29 cm, which relates to the BA horizon for all soils in the Cr4 complex (Appendix C). Though there were no changes in soil colors before and after fireline construction in the Munsell wet soil colors for Unit 2 and Munsell dry colors for Unit 3, there was a greater difference in the Munsell soil colors in Unit 4. This may be attributed to the large amount of organic matter present on the surface of Unit 4 and the thick layer of duff in that location. The visible differences in soil colors between dry and wet sample can be attributed to different chemical processes of the soils. Distinguishing between soil colors when dry and wet helps to identify potential natural site formation processes that could impact interpretation.

The differences in Munsell colors for soil samples collected before and after the fireline construction reflect changes in strata. As stated above, the samples collected before the fireline was constructed were collected from holes dug for the placement of experimental artifacts. The change in strata reflected through the differing Munsell colors shows that the fireline was constructed to a greater depth than the experimental artifacts were placed in Units 2-4. This is confirmed by the measurements I took of the fireline depths. As the soil was removed by the bulldozer it would most frequently build up the height of the dozer blade then crumple down. In the first pass through a unit, such as at Units 2 and 4, a minimal amount of soil would be removed which would then form the base of the berm. The soil removed from a second pass, possibly being from a second stratigraphic layer, would be placed above this and form the top of the berm. The nature of the soil as it was moved by the dozer blade and construction of the berm show that significant mixing, or inversion, of strata will occur in mechanical fireline construction.

Overall, the severity of impacts incurred in Phase 1 range from moderate physical impacts to severe spatial impacts. The impacts to cultural resources regarding the spatial disturbance of artifacts are severe when considering mechanical fireline construction. The manual methods of fireline construction did not mix strata. Conversely, the artifacts in surface scatters S1 and W3 could have been minimally impacted by foot traffic. Therefore, this operational effect is a light impact to experimental artifacts. The significant reduction in visibility of artifacts as a result of mechanical fireline construction is considered a severe impact, as the inability to see a previously visible site minimizes the ability to interpret the site. Only one experimental artifact was broken in Phase 1. This artifact was later found to have been broken into six pieces, therefore the physical impacts of mechanical fireline construction to cultural resources can be considered moderate.

Phase 2

Data gathered during Phase 2 includes locating three other experimental artifacts within the fireline or on the fireline berm that had not been previously seen on the day that it was constructed. One of these artifacts was located on the west side of S1, and deemed to be part of the S1 surface scatter. The other two artifacts, an amber glass bottle base and a white refined earthenware hollowware rim, were located south of Unit 3. The glass artifact (number 109) was located on the west edge of the midline, and the ceramic artifact (number 35) was located on the surface of the berm. It is likely that these artifacts were exposed when the berm of the midline was cut into to create the second fireline around burn unit E. Both experimental artifact numbers 109 and 35 were placed on the surface in Unit 2 during Phase 1. Neither of these artifacts were relocated or recovered in Phase 3. Though the mechanical construction of a new fireline was brief and minimally impacted the CRWFM site, it is noteworthy that the consequences of this operational effect had the opposite result compared to that in Phase 1. Rather than reducing the visibility of experimental artifacts, the fireline construction in Phase 2 had exposed artifacts. Artifacts 109 and 35 were recovered after survey of the site in mid-April 2020. Artifact 109 was intact and on the west of the fireline, where it had been seen in Phase 2. This artifact had been moved approximately 12.5 meters south and 1.5 meters west of where is was placed in Phase 1. Artifact 35 was found broken into two pieces, 1.3 meters west of the midline in the berm of the new fireline that was constructed in Phase 2. This artifact was moved approximately 13 meters south and 2 meters east of where it had been placed in Phase 1.

Interestingly, during the prescribed burn I was not able to relocate all of the 12 experimental artifacts that I had seen on the surface of the berm immediately after the fireline construction. At the time, it was unclear what exactly had caused this, though a probable answer was discovered during recovery in Phase 3 and is discussed later in this chapter. One of the experimental artifacts I had seen in Phase 1, number 49 which had been placed on the surface in Unit 3, was located where the berm of the midline had been cut into to create the new fireline for burn unit E. After this new fireline was cut, artifact number 49 was not visible.

How the fire crew, and myself, moved across the experimental site during Phase 2 was very interesting to observe and experience. The midline functioned as a trail for use by the fire crew, myself, and even wildlife. During the prescribed burn it was very useful to walk within the fireline, especially for groups of people as it was 2 meters wide on average. It served as an easier route across the landscape than other areas and could be used as a short cut from one place to another. A large part of what I did during the prescribed burn was to walk within the firelines and light the fuels just outside of them. This activity could cause impacts such as breakage or reburial to artifacts located on or near the surface of a fireline. Since constructing a fireline changes what can be defined as the surface by exposing mineral soil, subsurface artifacts are more vulnerable to indirect impacts as a result of operational effects. It was realized in Phase 3 that an experimental artifact I had seen in the midline during Phase 1 but could not relocate in Phase 2 had been pushed down into the fireline, likely from being stepped on. Hoof prints of deer were also observed within the fireline after it had been constructed. This shows that wildlife was also using the midline as a trail, and their movement across the landscape could also pose the potential to break, move, or bury exposed artifacts.

On two occasions I observed some potential impacts to experimental artifacts from prescribed fire at Unit 1 and at surface scatter E3. There was very low fire behavior and patchy burning at Unit 1, where on the west side of the unit three experimental artifacts were located on the surface. One of these experimental artifacts was exposed to fire longer than another, and the third artifact was not exposed to fire at all. The experimental artifact that was exposed to fire the longest was number 33, a large sherd representing nearly 50% of a white refined earthenware ceramic plate. Impacts to this plate from fire are minimal; a grey to brown colored stain 6 cm long was present on the interior surface of the sherd. Some of this stain was easily removed with a cotton swab however, the staining remains in the cracks of the crazed glaze.

At surface scatter E3, 11 experimental artifacts were exposed to fire. Here, the fire behavior was slightly more intense than other places during the prescribe burn. After the newly constructed fireline had been blackened at the edge, a flank fire was made from the edge of the midline northeastwards though E3 and concluding at the datum. The fire spread steadily from the parallel lines of the flank fire with flame heights slightly greater than 12 inches at times. The dominant fuels here were green and dried grasses and dried pine needles. After the prescribe fire, only seven of the eleven (64%) experimental artifacts in E3 were recovered. This is likely due to the reduced surface visibility at E3; the heavy layer of fuels when burned had created a thick black blanket over the ground (see Figure 7.1). Another contributing factor to the inability to recover three experimental artifacts is the size of these artifacts. These artifacts were ceramic, obsidian, and glass of only 2, 2.5, and 6 cm in length respectively. The fourth unrecovered artifact was an 11 cm long corroded piece of iron wire. It was likely difficult to identify due to the buildup of soot on the rust. One iron artifact that was recovered from E3 had patches of black soot on the surface that masked the rust color and texture.

Figure 7.1: Decreased surface visibility after the prescribed burn

Of the seven artifacts recovered from E3, five had some degree of combustive residue (soot) on them. One of these artifacts was iron and another was a composite metal, glass, and synthetic light bulb base. These two artifacts had minimal soot staining on them which appeared in black patches. The other three artifacts with soot staining were all glass. The staining on these artifacts was more evenly spread across the surface of the experimental artifacts. The soot, which is a brownish caramel color, did temporarily change the appearance and color of these glass artifacts. Some of the soot was removed with washing the artifacts in water; using a dry cotton swab nearly removed all of the soot from two of the three glass artifacts. Before removing the soot, an olive-green glass artifact appeared slightly darker than it had been prior to being exposed to fire. Additionally, a manganese (light purple) colored glass artifact was initially recorded as appearing transparent (colorless) when recovered in Phase 3. Even after removing the soot it was difficult to see the manganese color of this artifact. The metal and composite artifacts used in E3 were cleaned with dry cotton swabs with minimal success. None of the ceramic artifacts recovered from E3 were impacted by the prescribed fire. A frequent observation while recovering the experimental artifacts in surface scatter E3 was that the fuels directly beneath an artifact were unburnt. Some fire crew members were seen walking through E3, but no major disturbances to locations of artifacts that were recovered were observed.

At surface scatter W3, nine ceramic artifacts were exposed to prescribed fire. Only two of these experimental artifacts were not recovered. This can be attributed in part to their small size, as they were 3 cm and 4.7 cm in length. One of the original ten experimental artifacts used in W3 was seen in the fireline in Phase 1 and was therefore not exposed to fire. Of the six experimental artifacts that were recovered in W3 during Phase 3, only one was noticeably and significantly impacted by the fire. This artifact is a ceramic sherd of a white refined earthenware holloware handle, split down the length of the handle so that the paste is exposed on the interior surface. Paste refers to the unglazed portion of a ceramic vessel, and is useful in the identification of ceramic type and can be used in methods of dating artifacts. When this artifact (number 38) was placed in W3 it was placed with the paste facing upwards. The edge of artifact number 38 on the glazed exterior surface was minimally burnt and stained. The interior surface of exposed paste was stained a grey color nearly across the entire surface. Neither the staining on the glazed surface nor that on the paste could be removed through dry or wet cleaning methods. No cleaning solutions were used to attempt to clean artifact number 38 further. As noted above, during Phase 1 when the midline was being constructed, one individual was seen walking through W3. It is likely that they disturbed the locations of some of the experimental artifacts in this surface scatter. It was not observed if W3 had been impacted by the movements of the fire crew during Phase 2.

Survey of the site in the spring resulted in recovering an artifact that had been placed on the surface of Unit 2. This artifact, a sherd of a white refined earthenware hollowware rim, was found to have been heavily burned. It is likely that it had been displaced to one side of the midline and into fuels that were burned. Cleaning this artifact was partially successful. I used a cotton swab to remove the soot, yet much staining remains on the paste and in the crazed glaze on both surfaces. A transfer print on the interior surface of the sherd is discolored and difficult to identify relative to how it appeared in Phase 1.

As discussed in Chapter 5, stump burnout is a consequence of fire that poses a threat to both the integrity and physical condition of cultural resources. As part of the burn prescription to reduce understory fuels, stumps were targeted when they were not located at the base of living trees. One stump, located south of the experimental site, was lit during the prescribed burn. Approximately five hours after fuel from a drip torch was doused over the stump, it resembled a crater with flames continuing to burn from the walls and from an opening at the base. Measurements of the stump were not taken prior to it being ignited, though it can be reasonably assumed to have been approximately 50 cm to no more than 70 cm in diameter. This stump continued to smolder for six days. The next time the stump was revisited was 22 days after the prescribed burn, within this time the stump had completely burned out. The stump cavity measured approximately 40 cm in depth and 140 cm in diameter. Figure 7.2 shows the burned-out stump cavity containing both ash and charcoal, evidence of both flaming and smoldering combustion. How far the root system had been burned was not easily visible.

Figure 7.2: Burned-out stump cavity

In summary, the addition of a dozerline and the movement of the fire crew were indirect impacts to experimental artifacts that took place during Phase 2 of the study. If fire, in the context of prescribed burning as a method of wildland fire management, can be considered an operational effect, it too had impacts to experimental artifacts. Spatial disturbances to experimental artifacts were minimally observed in Phase 2. The exposure of two experimental artifacts that had been buried in the berm is considered a heavy impact; due to being exposed they were vulnerable to other unknown impacts that resulted in the inability to recover them in Phase 3. In the spring, only after some erosion had occurred, were these artifacts recovered. Movement within the fireline had a light impact regarding the location of experimental artifacts, but could pose the potential to cause more moderate impacts. Physical impacts to experimental artifacts in Phase 2 resulted from exposure to fire in the form of discoloration. As this impact was largely temporary or did not significantly decrease the ability to identify the artifacts this was a light impact. However, the fire had reduced surface visibility, potentially inhibiting the location of 10 experimental artifacts, which can be understood as a moderate impact.

Phase 3

A total of 35 individual experimental artifacts were recovered during the first recovery, prior to rehabilitation of the fireline, in Phase 3. It was during this step in the research that one artifact (number 80) that had been broken was found in two significantly different locations. Of the 35 artifacts, 30 were recovered from the surface of the site or were visible on or in the berm of the midline. The other five were recovered from within the berm of the fireline. Each of these five artifacts had been part of an experimental unit rather than a surface scatter. It should be noted that the three surface scatters were also recovered prior to rehabilitation. Considering only the experimental artifacts that had been placed within experimental units, a total of nine were visible. Of the 35 recovered experimental artifacts, 60% were from the surface scatters and 40% were from experimental units. Prior to the fireline being rehabilitated, the majority of artifacts recovered from the midline were located in Unit 1. The next most frequent location of recovery in the midline was S4. Table 7.4 illustrates from where experimental artifacts were recovered in Phase 3 before the fireline was rehabilitated. Note that the artifact listed for location N1 is the artifact that was broken and located in two places, in N1 and Unit 1. This artifact is therefore counted once in the table as part of N1.

Table 7.4: Total counts of recovered experimental artifacts by location prior to the fireline being rehabilitated

Location	Artifact Count	Total % of Recovered Artifacts
N1	1	2.8
Unit 1	4	11.4
S1	9	25.7
Unit 2	1	2.9
S2	1	2.9
Unit 3	2	5.7
E3	7	20
W3	6	17.1
S3	1	2.9
Unit 4	-	-
S4	3	8.6
Total	35	100

The above table shows that the majority of artifacts recovered were located outside of the boundaries of experimental units. Not considering the surface scatter artifacts that were not impacted, 10 artifacts were recovered from north or south of an experimental unit, compared to only seven recovered from within a unit. All but one of these 10 artifacts had been recovered south of an experimental unit, or in the area between two units. As Unit 4 is located south of Units 1-3 it is surprising to have not recovered any artifacts from within its boundaries. Given the above data, one would think that there would be potential for some artifacts from the northern portions of the site to have been moved into Unit 4. In total, 22.7% of the entire experimental site was recovered prior to the fireline being rehabilitated.

It was during the first recovery of experimental artifacts in Phase 3 that I saw the contemporary plastic bottle cap that has been previously discussed. This bottle cap was located on the surface of the berm, in S1. In Figure 7.3, one can see that the cap was located just south of a rotted stump. This is the stump discussed above that had been ripped out during the construction of the midline. There are two plausible scenarios for how the bottle cap became part of my site. One possibility is that the bottle cap had been deposited prior to my time in the area on the UIEF and was exposed through fireline construction. It could have been located near the stump and was exposed when it was uprooted. Vegetation or the bottle cap being below the surface could have prevented me from seeing it in Phase 1 when I had placed an experimental artifact against the stump. The faded color and wear marks on the cap might support this first possibility. As the bottle cap was not seen after the fireline had been constructed, it is also possible that it was deposited more recently. It is known that members of the fire crew were walking in the area both inside and outside of the fireline. A second piece of evidence to support the latter is that the cap smelled like drip torch fuel. As the cap was recovered from the top of berm, one would not expect drip torch fuel in an area where combustible fuels had been removed. Perhaps the cap had fallen out of the pack or pocket of one of the fire crew members. This cap can be evidence of use of the fireline as a trail to facilitate movement, and highlights the contributions of the present to the archaeological record.

Figure 7.3: Contemporary plastic bottle cap and uprooted stump on fireline berm

The stump in the above picture is the stump noted in the Phase 1 section above that had an experimental artifact placed next to it on the south side. This artifact, number 64, was recovered after the fireline was rehabilitated, approximately 8 meters south and 2 meters east of where it had been placed in Phase 1. Review of video of the rehabilitation shows that where number 64 had been recovered from was just south of an area where a large amount of rotted wood, likely part of the stump, had been located in the berm. Number 64 was not visible prior to rehabilitation as it had been buried in the berm.

Screening sections of the berm provided insight into impacts of fireline construction on vegetation. At the beginning of the study, a small bush was located near the center of Unit 1. This bush was completely removed during the fireline construction. Experimental artifact number 179 was located on the north side of this bush in Phase 1. After the fireline had been constructed, this artifact was located in S1, approximately 4 meters south and over 2 meters east of where it had originated. Interestingly, the bush was found in the berm of the midline at the southeast corner of Unit 1, while screening sections of the berm to relocate artifacts. The bush was located approximately 2.5 meters south and 2 meters east of where it had been previously. Review of video footage of the construction of the midline shows that the tread of the bulldozer had picked up this bush after it had been uprooted and moved it to the southeast of Unit 1 in the berm. The bush was likely buried in the berm as a result of the return trip of the bulldozer. Two additional experimental artifacts had been placed near this bush in Phase 1, one on the surface and one 10 cm below the surface. The artifact that had been placed on the surface, number 11, was recovered in the midline during survey of the site in the spring. This artifact was intact, and it was determined to have moved approximately 12 meters south and a minimum of 3.5 meters west of where it had been placed in Phase 1. The subsurface artifact was not recovered.

The process of screening sections of the berm to recover experimental artifacts also provided answers to a question that arose during the study. Immediately after the midline had been constructed, 12 experimental artifacts were visible, however, two days later during the prescribed burn only eight of these were visible. During the prescribed burn three other artifacts were located, making a total of 11 visible experimental artifacts. Five days after the prescribed burn there were even fewer artifacts visible on the surface of the midline berm. Some of the artifacts that had disappeared were recovered from within the berm in Phase 3. During the period between the prescribed burn and Phase 3 it had snowed on the UIEF. This episode of precipitation had been significant enough to cause the experimental artifacts to sink into the berm where they were no longer visible. Three artifacts that were seen but had vanished in the time that recovery in Phase 3 began were not recovered.

The rehabilitation of the midline was an operational effect that impacted several artifacts in numerous ways. As discussed in the previous chapter, 15 artifacts previously unseen were exposed during the rehabilitation of the fireline. These artifacts were not only visible from where I stood, but the operator of the excavator who was conducting the rehabilitation could also see artifacts as they were exposed. This is unlike the construction of the fireline, during which the visibility of artifacts was rapidly reduced to anyone at the site. The fireline rehabilitation process also obscured a total of three artifacts, one of which was ultimately not recovered in Phase 3. After rehabilitation, the majority of recovered artifacts were located in S4, followed by S1 and S3. Only 3 were recovered from within the boundaries of an experimental unit. Table 7.5 details the locations of where experimental artifacts were recovered from after rehabilitation of the fireline. A total of 15 individual experimental artifacts were recovered after the fireline had been rehabilitated. All but three of these were placed within experimental units in Phase 1.

Table 7.5: Total counts of experimental artifacts recovered after fireline rehabilitation by location of recovery

Location	Artifact Count	Total % of Recovered Artifacts
Unit 1	2	13.4
S1	3	20
Unit 2	1	6.6
S2	1	6.6
Unit 3	-	-
S3	3	20
Unit 4	-	-
S4	5	33.4
Total	15	100

Similar to the results of recovery prior to rehabilitation, the majority of artifacts were recovered outside of the boundaries of experimental units. It is noteworthy that in both recovery processes, no artifacts were recovered from within Unit 4. The fact that artifacts were largely recovered south of experimental units shows that the degree to which fireline construction and rehabilitation would displace artifacts was significant. Rehabilitation of the fireline resulted in a recovery of 9.7% of the entire experimental site.

After the fireline had been rehabilitated five experimental artifacts, 33.3% of those recovered after rehabilitation, were found to have been broken. All but one of these artifacts were bottle glass, the other being a ceramic sherd of a white refined earthenware bowl. Survey in the spring resulted in recovering another ceramic artifact that had been broken. As a whole, eight experimental artifacts that were recovered had been broken as a result of fireline construction, rehabilitation, or most often a combination of the two operational effects. This is

25% of the total recovered experimental artifacts. Table 7.6 provides information regarding the severity of breakage to all of the broken experimental artifacts in the CRWFM study. Only three experimental artifacts that were broken remained complete regarding their state in Phase 1. The majority of the artifacts that were broken, and for which not every piece was recovered, represent less than 30% of the artifact as documented in Phase 1.

Table 7.6: Analysis of physical damage to experimental artifacts as a result of mechanical fireline construction and rehabilitation. Those recovered before rehabilitation, or where rehabilitation was not conducted, are in **bold**.

Artifact	Material	Percentage Recovered	Number of Pieces Recovered	Source of Impact
80	**Glass**	**45**	**6**	**Construction**
71	**Glass**	**25**	**1**	**Construction and Burn**
35	**Ceramic**	**100**	**2**	**Construction**
82	Glass	100	2	Rehab
106	Glass	28.75	3	Construction and Rehab
49	Ceramic	10	1	Construction
69	Glass	20	1	Construction and Rehab
110	Glass	100	2	Construction and Rehab

For three of the experimental artifacts that were broken, the source of this impact can be definitively linked to the construction of the fireline. Two of these artifacts, numbers 80 and 71, had been used in two of the three surface scatters. Number 71, though impacted by the fireline construction, was not seen to have been broken at the time. Number 71 was located within the fireline, and when recovered at the beginning of Phase 3 was found to be broken. It is very likely that the source of breaking for number 71 was combination of the fireline construction bringing it into the fireline where it was then stepped on during Phase 2. It was determined that number 35 was broken when the new fireline around burn unit E was constructed in Phase 2. As for the remaining five experimental artifacts, rehabilitation of the fireline is found to be a main source of their breaking. Three artifacts were likely broken as a combination of the fireline being constructed and rehabilitated. Two of these artifacts, numbers 106 and 69, were placed below the surface in Phase 1. Therefore, due to the fact that they were recovered it is known that they were impacted by fireline construction, it is simply unclear if they were also broken in the process, as they were not visible prior to rehabilitation.

Artifact number 49 was also likely broken as a result of both fireline construction and rehabilitation. This artifact had been seen in Phase 1 however, after the new fireline was cut in Phase 2, splitting the midline berm, number 49 was no longer visible. As about 90% of this artifact was not recovered in Phase 3, it can be said that the construction of the second fireline had caused it to break. During survey of the site in the spring, a second piece of number 49 was recovered 12 meters east of the midline, from the center of the new fireline around burn unit E. This second sherd was located approximately 6 meters south and 13.5 meters east of where artifact number 49 was placed in Phase 1. This second sherd represents approximately 15% of the original artifact, meaning 75% of the original artifact remains unrecovered. The sherd of number 49 recovered in Phase 3 does not mend with the sherd recovered in the spring. Therefore, a minimum of two additional sherds of this artifact remain at the experimental site.

The 35 individual experimental artifacts recovered prior to the rehabilitation of the fireline varied in the degree to which they were spatially disturbed. A total of 16 of these were from the three surface scatters and were not found in the fireline, berm, or definitively removed from their context. Of the 35 experimental artifacts, 10 were from experimental units and had moved horizontally by an average of over 7 meters. Therefore, heavy to severe impacts to spatial disturbance were most common and can be attributed to fireline construction. After the fireline was rehabilitated, spatial disturbance was most frequently a severe impact. Physical impacts to artifacts prior to rehabilitation were minimal though, due to broken artifacts being recovered in multiple pieces, this impact is considered moderate. The rehabilitation of the fireline caused more instances of physical damage to experimental artifacts that resulted in more damage to the completeness of an artifact. However, this impact can still be considered moderate as of complete artifacts was not possible.

Experimental Site Impacts

A total of 50 individual experimental artifacts were recovered after the two methods of recovery in Phase 3. This is 32.5% of the total number of experimental artifacts used in the CRWFM study. Of the experimental artifacts used in experimental units, 21.7% of the total were recovered. A total of 70.6% of the artifacts used in surface scatters were recovered. This does not include the four additional individual artifacts recovered during survey of the site in April 2020. I consider those separately, as I am primarily concerned with the success of site recovery shortly after fire management operations. Notably, prior to the survey in the spring, 100% of the surface artifacts used in Unit 2 were unrecovered. Total site recovery was 54 artifacts, 35% of the site, of which 25% of artifact used in experimental units were recovered. Recovering four individual artifacts in the spring shows there is some potential for erosion to expose artifacts at a site where a fireline has been rehabilitated. Table 7.7 below indicates the success of recovery of experimental artifacts for each location and context in percentages of the original count of artifacts.

Table 7.7: Percentages of original experimental location and context counts that were recovered and unrecovered

Location and Context	Phase 1 Count	% Recovered	% Unrecovered
Unit 1 Surface	20	50	50
Unit 1 Subsurface	20	-	100
S1	13	69.2	30.8
Unit 2 Surface	15	20	80
Unit 2 Subsurface	13	38.5	61.5
Unit 3 Surface	15	26.7	73.4
Unit 3 Subsurface	12	-	100
E3	11	63.6	36.4
W3	10	80	20
Unit 4 Surface	15	26.7	73.4
Unit 4 Subsurface	10	40	60
Site Surface Total	99	26.2	73.8
Site Subsurface Total	65	16.4	83.6
Site Total	154	32.5	67.5

A total of 28 (56%) of the experimental artifacts recovered were removed from their original location and/or context. Including the artifacts recovered in the spring, the percentage of displaced recovered artifacts is 59.3%. Table 7.8 details where each of these artifacts were placed in Phase 1 and from where they were recovered. In the context column for Phase 3, “berm” refers to the berm of the fireline at the experimental site. This includes artifacts visible on the surface of the berm or sticking out from it, and “buried” refers to those that were buried within the berm. In the table “rehab” refers to experimental artifacts recovered within the rehabilitated fireline. These were all visible on the surface. It is important to note that prior to the fireline being rehabilitated, these artifacts were not visible, therefore their context during the study changed more than once. The term “fireline” refers to artifacts found on the surface of the fireline. “Erosion” is used for artifacts recovered in mid-April, 2020.

Table 7.8: Experimental artifacts that were spatially disturbed with their original locations and context and those from which they were recovered from

Artifact	Location Phase 1	Context Phase 1	Location Phase 3	Context Phase 3
179	Unit 1	Surface	S1	Berm
119	Unit 1	Surface	Unit 1	Buried
113	Unit 1	Surface	S1	Buried
153	Unit 1	Surface	S1	Rehab
92	Unit 1	Surface	Unit 1	Rehab
82	Unit 1	Surface	Unit 1	Rehab
11	Unit 1	Surface	S1	Erosion
64	S1	Surface	S1	Rehab
80	S1	Surface	Unit 1, and N1	Berm
178	S1	Surface	S1	Berm
51	Unit 2	10cmbs	S2	Buried
103	Unit 2	10cmbs	Unit 3	Buried
84	Unit 2	10cmbs	S3	Rehab
106	Unit 2	10cmbs	S3	Rehab
44	Unit 2	10cmbs	S2	Rehab
46	Unit 2	Surface	S3	Erosion
109	Unit 2	Surface	S3	Erosion
35	Unit 2	Surface	Phase 2 fireline	Erosion
71	W3	Surface	Unit 2	Fireline
54	W3	Surface	Unit 2	Rehab
101	Unit 3	Surface	S1	Fireline
6	Unit 3	Surface	S3	Surface
42	Unit 3	Surface	Unit 3	Buried
49	Unit 3	Surface	S3, Phase 2 fireline	Rehab, Erosion
137	Unit 4	Surface	S4	Berm
110	Unit 4	Surface	S4	Rehab
70	Unit 4	Surface	S4	Rehab
12	Unit 4	Surface	S4	Rehab
52	Unit 4	10cmbs	S4	Rehab
97	Unit 4	10cmbs	S4	Rehab
69	Unit 4	10cmbs	S4	Rehab
174	Unit 4	10cmbs	S4	Rehab

Experimental artifacts placed on the surface, in a unit or in a surface scatter, were more frequently recovered than those that were placed 10 cm below the surface in experimental units. Artifacts placed on the surface of the experimental site accounts for 71.8% of the experimental artifacts that were recovered and had been removed from their location or context. Three of these were reburied in the process of fireline construction. Artifacts placed subsurface account for 28.2% of the experimental artifacts that had been removed from their context and were recovered. As a total of 65% of the entire experimental assemblage was not recovered after Phase 3 and survey in the spring. It can be considered that the majority of these 100 artifacts were removed from their location and/or context. In total, between 79% and 85.7% of the experimental assemblage had been horizontally or vertically displaced.

The recovered experimental artifacts that were used in experimental units in Phase 1 provide insight into horizontal and vertical displacement as a consequence of mechanical fireline construction and rehabilitation. Due to the inaccuracy of total station measurements, the artifacts used in the surface scatters cannot be confidently analyzed in this way. Though, it should be noted that four experimental artifacts, used in surface scatters S1 and W3, that were recovered are known to have been at least horizontally displaced. It should be noted that only 25% of the experimental artifacts used in the experimental units were recovered. Though this is quite a low percentage, the analysis of this data has been informative. As stated previously, not recovering all of the experimental artifacts can be attributed to either horizontal or vertical displacement or a combination of the two.

Half of the recovered artifacts used in experimental units were displaced south and east of their original locations. Considering the methodology of fireline construction, this is not surprising. A total of 28% of the recovered artifacts used in experimental units were displaced south and west. The following averages only consider the artifacts recovered in Phase 3, as the measurements for the displacement of the artifacts recovered in the spring were approximations not based on total station measurements. The average horizontal displacement of artifacts used in experimental units was 7.26 meters. Specifically, artifacts were displaced 4 meters 89 cm south and 5 meters 74 cm east on average. The most extreme movement of an artifact south was 10 meters 71 cm. A notable occurrence of an artifact being moved northward by 18 meters 93 cm was also observed. Comparison of the averages of displacement for experimental artifacts used in Unit 1 to those in Units 2-4 show that averages south and east are greater for the units with some degree of slope. Similar to the site as a whole, movement east was greater than movement south for the experimental artifacts located on a slope. Specific displacement measurements, calculated from the total station measurements, for all of the artifacts recovered in Phase 3 are provided in the table in Appendix A.

The vertical displacement of experimental artifacts used in experimental units are described by archaeological context (surface or subsurface) in the Table 7.8. Considering elevation changes as well, the average vertical disturbance was an increase of 13 cm or a decrease of 65 cm. Experimental artifacts were most frequently moved down slope from where they had originated. At Unit 1, the average increase and decrease in elevation were very close, being 34 cm and 32 cm respectively. As there was minimal slope change at Unit 1 and S1 where these artifacts were recovered from this is not surprising. The average increase in elevation for artifacts used in Units 2-4 was 95 cm when including the extreme of a 1 meter 95 cm increase. The average decrease was 74 cm for artifacts used in Units 2-4.

Though the exact horizontal displacement of experimental artifacts used in surface scatters cannot be determined, the vertical displacement is known. Of the 34 experimental artifacts used in the three surface scatters, 24 were recovered. Of these 24, 20 are known to have not been horizontally displaced. The average vertical displacement of the 20 experimental artifacts is a decrease of 2 cm. This minimal decrease in elevation may be due to the fire crew walking through the surface scatters and displacing artifacts, or to an error in the function of the total station. The four experimental artifacts known to have been horizontally displaced are numbers 80, 71, 178 and 54. Both numbers 80 and 71 were broken. Number 80 was recovered from two different locations, and displaced horizontally by approximately 3 and 6 meters. For the locations from which number 80 was recovered from, the average was an increase in elevation of 32 cm. Again, number 80 was used in S1 and recovered in Unit 1 and N1 where there is no slope. Numbers 71 and 54 were displaced horizontally by a minimum of 6 meters, with their average vertical displacement being a decrease of 26 cm. Both of these artifacts were located north of their Phase 1 provenience however, they were located in the fireline which was at a depth less than their original context. The displacement of number 178 cannot be approximated. Not only does mechanical fireline construction and rehabilitation displace artifacts in the path of the fireline, these operational effects can also displace artifacts in close proximity. The area of potential impact for these operational effects will need to be greater than the width of the fireline.

In the previous section I described where experimental artifacts were recovered from on the CRWFM site before and after the fireline was rehabilitated. Table 7.9 below considers where experimental artifacts were recovered from in Phase 3 both before and after the fireline was rehabilitated. Included in this table are the total percentages of frequency of recovery location. Again, included in this count is the two locations of experimental artifact number 80. This artifact is counted once in the table under the location N1.

Table 7.9: Counts of experimental artifacts recovered by location on the experimental site including frequency of recovery location

Location	Artifact Count Recovered Before Rehabilitation	Artifact Count Recovered After Rehabilitation	Total %
N1	1	-	2
Unit 1	4	2	12
S1	9	3	24
Unit 2	1	1	4
S2	1	1	4
Unit 3	2	-	4
E3	7	-	14
W3	6	-	12
S3	1	3	8
Unit 4	-	-	-
S4	3	5	16
Total	35	15	100

The highest frequencies of experimental artifacts were recovered from surface scatter S1 and the location named S4, south of Unit 4. This may be in part due to a higher number of artifacts located where they would be likely to be displaced into S1, namely the 40 total artifacts in Unit 1 and the additional 13 artifacts in S1. Additionally, as fireline construction most frequently moved artifacts to the south, it would be expected for any number of the artifacts located north of and within Unit 4 to potentially be displaced to S4. Considering then the next highest frequencies, it is found that surface scatters E3 and W3 and Unit 1 have fairly high counts of artifacts recovered from them. It is not surprising to see high counts recovered in the surface scatters, as these were minimally impacted by the mechanical fireline construction. Again, not all experimental artifacts were recovered from these locations, which can be attributed to decreased surface visibility after the prescribed fire and small artifact size. Comparing the frequency of experimental artifacts recovered from Unit 1 to other experimental units, the higher frequency may be attributed in part to Unit 1 being twice the size of the other three units. The lack of slope at Unit 1 may also be a contributing factor. Referring back to Table 7.7 above, Unit 4 had the highest frequency of recovery, at 66.7%. All of the Unit 4 artifacts recovered were recovered from S4.

Analysis of where the recovered experimental units were placed in Phase 1 can inform what areas of the units were most frequently impacted by mechanical fireline construction and rehabilitation. This information is provided in Table 7.10. Note that because this is based off of the artifacts that were recovered in Phase 3, not all unit contexts are listed. Here the abbreviations for cardinal directions refer to quadrants of the experimental units if one were to divide the units into four sections.

Table 7.10: Counts of spatially disturbed artifacts by experimental unit quadrants based on total count of recovered experimental artifacts

Unit	Unit NW	Unit SW	Unit SE	Unit NE	Total
Unit 1 Surface	3	2	2	2	9
Unit 2 Subsurface	-	2	1	2	5
Unit 3 Surface	2	-	1	1	4
Unit 4 Surface	1	1	1	1	4
Unit 4 Subsurface	-	-	1	3	4
Total	6	5	6	9	26

Experimental artifacts placed on the eastern side of units were most frequently impacted. The difference in artifact counts in each unit on the west and east sides is not a factor influencing this. However, one influence might be that Unit 1 was 12 square meters larger than the other three units, and the western edge of this unit was not impacted by fireline construction or rehabilitation. Considering then only the three 2x2 meter units, the eastern side of experimental units were still impacted more than the western sides. Though there were occasionally considerable depths in the western halves of units, the greater impact to the east can be attributed to the construction of the fireline berm on the east side of the midline.

An unexpected yet significant pattern arose during the CRWFM Project. This pattern became apparent in Phase 3, and even more so during analysis. Certain material types of experimental artifacts were more frequently recovered than others used in the study. Table 7.11 provides the percent frequencies of recovered experimental artifacts separated by artifact type for those recovered in Phase 3. The frequencies for recovered artifacts by the number of that artifact type used in the study, and the frequencies for the total number of artifacts used in the entire study are provided. For example, 20 ceramic artifacts were recovered, this is 40% of the total number of ceramic artifacts used in the study, and 13% of the total artifacts of all types used in the study.

Table 7.11: Percent frequency of recovered experimental artifacts by material type

Artifact Type (n recovered)	% Frequency of Recovery by Type	% Frequency of Recovery by Site
Ceramic (20)	40	13
Glass (19)	41.3	12.3
Metal (6)	20.7	4
Synthetic (3)	37.5	2
Lithic (2)	9.5	1.3

Though more experimental artifacts of ceramic or glass were used in the study, less than 50% of these material types were ultimately recovered. In addition to there being more artifacts of these material types used in the study to potentially have been located, characteristic properties of these materials can be attributed to their greater recovery. Ceramics and glass are more visible even when obscured by dirt or vegetation due to their color and ability to reflect light. Additionally, the shape of the artifacts of these materials contribute in part to their greater visibility. Many of these artifacts were circular or cylindrical, which contribute to their visibility as they do not lie completely flat on a surface. In contrast, the majority of the metal artifacts used were iron. These were corroded and often in more “natural” looking shapes. Rust can appear orange or brown, and iron nails might resemble sticks. Though fewer synthetic materials were used in the study than lithics, it is interesting that more were recovered. This may in part be due to two of these synthetic artifacts being located in surface scatters outside of where the fireline was constructed. Though lithic materials, particularly obsidian, are reflective, by their nature of being stone they can blend into the landscape more easily. The artifacts recovered in the spring include three individual ceramic artifacts and a second sherd of a broken ceramic artifact recovered in Phase 3, and one glass artifact. Though I frequently saw local quartz at the site during this survey, much to my surprise no lithic artifacts were recovered.

The smaller size of some of the metal and the lithic artifacts might also have been a contributing factor to their lower recovery. However, some large metal artifacts were not recovered, including the majority of a shoe for a draft horse measuring 18 cm long and 15 cm wide. A 23 cm long flat file was also not recovered. Large ceramic artifacts not recovered include a 17 cm long base of a stoneware jug, and a nearly 13 cm long body sherd of a white refined earthenware pitcher. In summary, the inability to recover artifacts may in part be due to their material type and size. However, this is largely due to the inability to locate them on the surface even after the fireline was rehabilitated.

The horizontal and vertical displacement of artifacts across the experimental site were dissimilar in their severities. Horizontal displacement is a heavy impact for the site as a whole, though nearer to severe for artifacts used in an area of 5-10% slope. The vertical displacement can be considered light when related to increases in elevation. When decreases in elevation are considered however, the severity is heavy. For both increases and decreases in elevation, the severity is heavy for artifacts located on a slope of 5-10%. For the whole site physical impacts can be said to be moderate. However, this is based on only 14% of the recovered artifacts; if more artifacts were recovered this impact might be more severe. Additionally, this is conditional on the interpretability of broken artifacts. Each of the artifacts that were broken had some type of distinguishing feature that was retained. In other situations, an artifact might not have these features to begin with, or the part of the artifact with such features might be broken and lost.

Experimental and Experiential Archaeology

From an academic view point, the experiences of the researcher have little added value to the data gathered in experimental archaeology (Outram, 2008). Experiential aspects might only be seen as valuable for their ability to ease public engagement and education, “but that potentially positive by-product should not be allowed to create confusion over experimental aims” (Outram, 2008, p. 4). I have found that reflecting on my role and experiences in the process of this study to be quite useful to the purpose of the research. Rather than creating confusion over the purpose of this study, reflection on my feelings of frustration and discouragement has proved to be valuable information as it adds to the understanding of the impacts of the operational effects of wildland fire management on the archaeological record.

Earlier in this chapter I presented the finding that after the fireline was constructed only 12.3% of the entire assemblage of experimental artifacts used in the experimental units were visible. As part of data collection in Phase 1 I took measurements of the width and depth of the fireline as it transected each experimental unit. Taking measurements of the firelines entailed me being within each experimental unit, close to the ground, while I measured and mapped the fireline. In this process I also took pictures of each unit. I walked along the length of the midline to access each of the units. This entire process took approximately three hours.

If any other experimental artifacts had been visible at that time, especially within the experimental units, I would have seen them. Additionally, after the fireline was rehabilitated, I spent one hour surveying the site to locate artifacts. Though the berm was rehabilitated for greater than the length of the experimental site, the area was no longer than approximately 260 feet. An hour is a considerable amount of time to survey such a small area. I spent that time paying close attention to the soils in the rehabilitated fireline, walking the length of the site both north and south multiple times. The inability to recover more artifacts was shocking, as I had placed these artifacts in the simulated archaeological record myself. I had photographed, mapped, and measured with the total station the location of each experimental artifact. This was done after spending several hours cataloging, marking with India ink, photographing, and sorting into experimental units and contexts each individual artifact. Non-experimental sites will be extremely difficult to recover after being impacted by operational effects. Even for known sites, the time and resources needed to recover them might not be economical.

In addition to the amount of time preparing the experimental artifacts, several hours were spent simulating the archaeological record. Myself and two peers conducted this over a four day period. In total it took 31.5 hours of labor to establish the experimental units, dig holes for subsurface artifacts, record artifact locations, and photograph and map the experimental units. In contrast, the construction of the fireline was done by four individuals, one operating the bulldozer and the other three clearing fuels west of the midline. The total amount of labor spent on constructing the fireline, both mechanically and manually, was 24 minutes. Therefore, for every minute spent destroying the simulated record, 1 hour and 20 minutes were spent in creating it. The rapid 87.7% loss of visibility of artifacts from fireline construction was a surprise, and only recovering 22.7% of the entire site prior to rehabilitating the fireline was discouraging. Even after the fireline has been rehabilitated, 67.5% of the experimental assemblage remains lost. It will be highly unlikely to recover low-density sites after they are impacted by mechanical fireline construction and rehabilitation. Intensive survey prior to prescribed burning or wildland fire might be necessary to prevent the total loss of low-density sites. Additionally, the less time between when a cultural resource is impacted and is documented or recovered the better the chances are for retaining information necessary to site interpretation.

I hope that my experiences can prepare others for the shock of the loss of a site that has been impacted by operational effects. These experiences can inform cultural resource specialists of the added amount of resources and time needed if recovery of a known site is a management objective. As the impact to cultural resources from mechanical fireline construction occurs rapidly, it is highly important to be prepared to respond quickly to resource needs. Knowing this, training for cultural resource specialists and wildland fire managers should promote problem solving skills and encourage less reliance on boiler-plate resolutions.

The experimental site sustained significant damage from mechanical fireline construction and rehabilitation. The spatial and physical impacts were greater as results of fireline construction and rehabilitation compared to the prescribed burn. Over half of the recovered artifacts were spatially displaced, and the majority of the experimental site remains unrecovered. The goal of the following chapter is to provide specific implications of the data presented above. Recommendations for archaeologists and wildland fire managers and suggestions for future research are also given.

CHAPTER 8: CONCLUSION

When considering wildland fire as harmful to cultural resources, the first hazard that comes to the minds of many is the fire itself. In sharing the topic of my thesis research with others, I was frequently met with confused looks when I said I was not researching the impacts of fire. Even after explaining my research and associated goals I would still be asked questions about the effects of fire to cultural resources. Fire is certainly an important force that deserves consideration when discussing the management of cultural resources. Indeed, I ultimately could not avoid including the effects of fire to cultural resources in the research presented here; yet my primary interest was on the spatial and physical impacts resulting from mechanical fireline construction and rehabilitation, which had much greater impacts to the simulated site. While an observer of some aspects of wildland fire management, and a participant in others, this study has provided me with the opportunity to merge the fields of archaeology and wildland fire management. This affords an understanding of the ways in which the latter can impact the material evidence of human history. The purpose of this study was to identify and measure how the indirect impacts and operational effects of wildland fire management will affect archaeological sites. This information could then be shared with cultural resource specialists and wildland fire managers and fire personnel so that their work will be appropriate and effective in protecting and managing cultural resources. The research presented here can be used in training to prepare cultural resource specialists and wildland fire managers for what to expect as a result of operational effects.

Operational effects are the consequences of fire management activities, and can include the use of fire suppressants, clearing land to create helipads and safety areas, and manual and mechanical fireline construction and rehabilitation. The occurrence of operational effects is dependent on the occurrence of fire. Though only one facet of operational effects, mechanical fireline construction and rehabilitation provide a starting point for exploring changes in management practices that can benefit the management of cultural resources. Erosion and vandalism are two types of indirect impacts to cultural resources. As of mid-April 2020, impacts of erosion at the experimental site are negligible. No instances of vandalism were observed or suspected in this study. The chances for erosion and vandalism to occur increases after cultural resources, such as artifacts, are impacted by operational effects. Each of the other potential sources of indirect impact deserve future dedicated research to contribute a holistic understanding of the ways in which they can affect cultural resources.

In writing this chapter I realize that I've unintentionally refrained from using the term "indirect impact" throughout the majority of the previous chapters. This is likely because what I have learned through this research is that operational effects are in fact a very direct source of impact to cultural resources. The use of the term indirect is beneficial for understanding differences in fire effects and non-fire effects, and that erosion and vandalism often result as a consequence of other impacts. However, when considering human management of fire, mechanical fireline construction and rehabilitation are not any less directly threatening to cultural resources than fire is. Therefore, the reader should keep in mind that indirect does not mean such impacts are subordinate to or any less severe than those sustained by fire. Indeed, the findings of this study show that mechanical fireline construction and rehabilitation have more severe impacts than fire.

Summary of Findings

As an application of experimental archaeology, this study began with the hypothesis that mechanical fireline construction will remove artifacts from their provenience. The data gathered in this study extend beyond affirming the hypothesis, providing insight into other questions of spatial disturbance and physical impacts to artifacts. Although physical impacts to artifacts were infrequent, the spatial disturbance of artifacts and the inability to recover the majority of those used in the study indicates the severity of mechanical fireline construction and rehabilitation. These operational effects are necessarily driven by human choice and action, regardless of whether they result from a human or naturally ignited fire. The fact that methods of fire management in the U.S. have varied historically as a result of expanded knowledge and advances in numerous scientific disciplines speaks to the potential for advances in archaeological knowledge to also shift the methods used in future fire prevention and suppression.

Field experiments began with the simulation of an archaeological site using both replica precontact artifacts and authentic historic materials. The simulated site consisted of four experimental units located across an area with a 0-10% elevation gradient. This area followed the path of a prearranged fireline for a prescribed burn on the Flat Creek Unit of the UIEF. The fireline was constructed using a Type 4 bulldozer prior to the prescribed burn.

Artifacts were consistently spatially displaced. Of the 54 recovered artifacts, 59.3% were spatially displaced. As a total of 100 artifacts, 65% of the experimental site, have yet to be recovered, it can be assumed that between 79.2% and 85.7% of the total site was spatially displaced. Though horizontal displacement was most frequently between 4 and 7 meters, this impact involved substantial mixing of strata and depths greater than 10 cm, making it a severe impact overall. Vertical displacement was a heavy impact. On average, artifacts were displaced horizontally by 7.26 meters and vertically by a decrease of 65 cm. Such great spatial displacements will mean that artifacts are removed from rooms or features, or even an entire site. The bulldozer used in this study is the smallest dozer currently approved for use in wildland fire management. If displacement over 7 meters is the consequence of using machinery with a blade 2.43 meters wide, dramatic increases in displacement should be expected when Type 1 dozers with blades measuring 3.91 meters wide are used.

The most immediate impact of mechanical fireline construction was a rapid 87.7% reduction in artifact visibility. The potential for known sites to become obscured is great. The inability to see something like a feature or an artifact severely reduces if not outright prevents the ability to interpret and protect it. Furthermore, this can hinder the assessment of spatial and physical impacts to resources within a site. Visibility of cultural resources may fluctuate through the duration of wildland fire management activities. This fluctuation may be attributed to natural site formation processes, but most frequently it will occur during modification to, or the rehabilitation of, a fireline. The operational effect of fireline rehabilitation may increase the visibility of artifacts. Still, the provenience of these artifacts will have been severely disturbed, ultimately inhibiting the interpretation potential of a site.

The provenience of artifacts is disturbed initially by mechanical construction of a fireline. This operational effect will mix strata, often inverting the strata of a site. Rehabilitation adds to the process of mixing of strata. Mechanical fireline construction will displace artifacts in the forward direction of the bulldozer when the blade is in use. As a consequence of the berm being constructed on the east of the fireline, artifacts in the east half of experimental units were more frequently impacted by the operational effects. With an average fireline depth of 26 cm, materials on or near the surface are at greatest risk of spatial displacement as a consequence of operational effects. Artifacts or resources at depths greater than 30 cm might be spared. This is dependent upon the depth of mineral soil, which dictates the depth of fireline construction. The context in which an artifact is found after exposure to operational effects is far from the original provenience. Certainly, buried artifacts can be brought to the surface and surface artifacts can be buried. Recovery of artifacts that were on the surface will be easier than recovery of subsurface artifacts. Sites with high densities of artifacts may have a better chance of recovery, or the ability to identify unknown sites. The recovery of a known site, even one with a fairly high density, is extremely difficult. The larger the area a site spans the lower the percentage of the site impacted by fireline construction will be. Therefore, historic sites such as middens may likely suffer fewer impacts than a precontact site such as an area where stone tools were manufactured.

When rehabilitation of a fireline occurs, the potential for an artifact to be displaced by several meters will increase. Further separating an artifact from its provenience and associated materials inhibits the ability to interpret a site, as the strata is mixed and datable information within it is lost. Two stages of recovery of experimental artifacts were conducted, one before and one after fireline rehabilitation. Before the fireline was rehabilitated, the average horizontal displacement of artifacts was found to be 8.7 meters. The average horizontal displacement of artifacts after fireline rehabilitation was 7.53 meters. Decreases in elevation prior to the fireline being rehabilitated were 31 cm on average; the average decreases after rehabilitation were 87 cm. These averages reflect that fireline construction and rehabilitation impact sites differently regarding the direction of artifact displacement. In particular, the spatial displacement of artifacts to the east after rehabilitation was less than that after fireline construction. This is due to the location of the fireline berm and that soil being moved west during rehabilitation. Though artifacts buried in the berm could have been moved closer to their original provenience during rehabilitation, they were already severely displaced.

Measurements of spatial displacement also differs across slopes. Horizontal spatial displacements of artifacts were found to be greater by 3.6 meters for artifacts located on slopes of 5-10% compared to those located where there was no slope. Artifacts on a slope of 5-10% experienced a decrease of 42 cm greater than artifacts located where there was no slope. Therefore, cultural resources located on slopes are more vulnerable to not only erosion but also greater spatial displacement.

Exposure and damage are major physical impacts to cultural resources. Breaking and staining from combustive residue were two types of damage observed in the CRWFM study.

Both of the physical impacts to experimental artifacts can be considered light to moderate impacts and can inhibit the ability to interpret an archaeological site. Appendix D provides before and after photographs and descriptions of experimental artifacts that were stained and broken in this study. Only 14.8% of the recovered experimental artifacts were found to have been broken by the mechanical construction and/or rehabilitation of the midline. The majority of these artifacts were glass, and two were ceramic. All of the broken artifacts were hollow or cylindrical in shape. The most frequent occurrences of broken artifacts were documented after the fireline was rehabilitated. The severity of breakage varied for each artifact. Still, the artifacts did not lose distinguishable features that could be used to identify and date them. Many of the artifacts I used were fairly large, so when they were broken, they were still easily recoverable. Depending on the site formation processes, individual artifact size at a non-experimental site might be much smaller. Historic artifacts may be more vulnerable to breaking, yet they can be more easily identified in the field which can lead to a higher recovery of historic sites. Too few lithic artifacts were recovered to speak confidently on the potential for artifacts breaking at precontact sites.

The prescribed burn only temporarily impacted experimental artifacts physically, and no significant spatial displacement of these artifacts was observed. Staining from combustive residue (soot) was an impact to 12.9% of the recovered artifacts. In this study it was determined that soot could be easily removed from glass artifacts with minimal effort and resources, though it permanently impacted ceramic and metal artifacts. Staining was largely not a factor that could inhibit the interpretation of artifacts. However, on one occasion it posed the potential to do so. In the previous chapter I discuss how after being exposed to smoke and stained by soot, an olive-green colored glass artifact was thought to be a darker shade of green and a manganese glass sherd appeared transparent. Though the difference between olive green and dark olive green is negligible in the identification and interpretation of a historic glass artifact, the difference between transparent and manganese could pose an issue. Manganese colored glass was used most commonly from 1875-1920 (Lockhart, 2006). The most common type of transparent glass recovered from later 19th century and 20th century historic sites has been used since at least 1864 (Miller, Samford, Shlasko, & Madsen, 2000). These dates are used by historical archaeologists to calculate the duration and time for which a site was used or occupied. Though many historic sites have an abundance of dateable artifacts, misidentification and incorrect dating of one artifact type can impact the entire calculation. A greater number of correct dates is valuable in calculating period of use or occupancy. Misidentification of manganese glass could impact the dating of a site, especially when the only diagnostic feature of a glass artifact is the color.

In summary, it can be said that with increasing exposure to operational effects the severity of impacts to cultural resources will also increase. This relationship is heightened for increases of slope on which artifacts are located. Artifact material type and context can also play into this relationship, as brittle artifact types such as glass are more likely to break, and surface or near surface artifacts will be most easily moved. Compounding spatial and physical impacts result in the inability to recover and interpret a site.

Recommendations

With the knowledge of how mechanical fireline construction and rehabilitation destroys archaeological sites, ways in which to alter management methods in the fields of both archaeology and wildland fire can be considered. These alterations may be used to prevent or mitigate impacts to cultural resources. The recommendations given here should be considered contributions, rather than replacements, to those already offered and implemented by professionals and researchers (see Traylor et al., 1990; Winthrop, 2004; Sturdevant, 2009; Ryan et al., 2012a; and Gerow, 2013). Prior to conducting this research, it was already decidedly inadvisable to construct a fireline through an archaeological site. Beyond the obvious, I hope to provide here potential resolutions to instances when a bulldozer cuts through a site. A brief guide for cultural resource specialists and land managers that summarizes the findings of this study and recommendations outlined below is included as Appendix B of this document.

Similar to the effects of fire to cultural resources, impacts from operational effects are context dependent. As stated above, factors such as terrain, site type, and cultural resource types are related to the severity of impacts from mechanical fireline construction and rehabilitation. Though I present them in broad terms, the reader should bear in mind that the implications outlined above are based on the phenomena observed in the CRWFM experimental site context. The recommendations are therefore inherently inappropriate for some environmental, archaeological, and fire settings. Resource specialists and land managers should determine what is appropriate for the regions they work in and the cultural and natural resources specific to each locale.

Though it will certainly be challenging, protection of the materials in the archaeological record can be conducted in tandem with management of wildland fire. With climate driven changes in wildland fire frequency, size, and intensity, management actions will likely need to accommodate to an increasing demand to prevent and suppress such fires. Prescribed fire might be employed more frequently to prevent wildfire incidents, and suppression tactics on wildfire incidents may become more aggressive. The cooperation of both archaeologists and wildland fire managers is necessary to the success of both.

Once a fireline has been constructed through a site, the proveniences of artifacts are lost and cannot be replaced. To limit the continued displacement of artifacts as a consequence of operational effects, some measurements can be taken. The first action to be taken is to survey the path of a fireline before it is constructed. This is already in practice in federal wildland fire management, as it is an important step in preventing unnecessary impacts to sites. Survey does not guarantee that a site will not be bulldozed, therefore mitigation methods are needed. It is recommended that if during the mechanical construction of a fireline artifacts or other cultural resources are encountered, and the fireline depth has not yet reached mineral soil, that manual methods be employed to finish fireline construction. It is recommended that this be done within an area with a radius of at least 4 meters from where resources are encountered. I realize that this may be impossible during wildfire incidents. Though costly in time and labor it could still be employed during prescribed burning. Use of hand tools to finish the construction of a fireline will provide greater opportunity to avoid cultural resources and prevent further damage to those that have been exposed. Additionally, the location of the fireline should be adjusted when possible if cultural resources are encountered. The exposed resources should still be protected from fire impacts by manually clearing fuels around them or by employing wet lining.

It will be extremely difficult to avoid breaking artifacts during mechanical fireline construction, particularly for subsurface resources. The best option is to avoid cultural resources and sites, but when this cannot be avoided it is best to diligently survey an area and monitor operational effects. During the fireline construction at my site I stood to the east, this being the side of the fireline where the berm was constructed. I would recommend monitoring construction opposite to the side that the berm is constructed on. This would allow one to observe as artifacts are displaced into the berm. Should damage to a resource be observed, the best, and possibly only, option is to document this impact and respond accordingly to the resource needs. In the CRWFM study, pieces of broken artifacts were found over 2 and 3 meters from the pieces they could mend with. A minimum of a 4 meter radius would be an appropriate area to survey for broken pieces of a single artifact. If there is time to do so, surface materials should be assessed including photographed and their locations recorded. As collection of materials is less common in current cultural resource management, recording resources in this way can aid in determining significance of a site and in future survey. From the data in this study it is difficult to speak on how to mitigate breakage of artifacts at an unknown site.

Steps can be taken to decrease further spatial displacement of artifacts when a fireline is rehabilitated, though the benefits for doing so are limited and dependent upon cultural resource management objectives. When rehabilitating a fireline, it is recommended that an effort be made to replace sediments moving opposite to the direction of the fireline construction. For example, at the CRWFM site, the fireline was constructed primarily moving north to south. If rehabilitation was conducted moving south to north, the soils in the fireline berm, and any artifacts within them, would have had greater potential to be deposited closer to their point of origin. The benefit of this would be to aid in interpretation of associations between the displaced artifacts and resources not impacted, such as those still buried or found outside of the fireline.

Cultural resource specialists and fire managers need to weigh the benefits and costs to certain rehabilitation methods. If a fireline is rehabilitated mechanically, the machine should be situated within the fireline, and remain within the boundaries of it as best as possible. When heavy equipment is operating outside of a fireline the tread can displace soils which will impact surface and near surface artifacts. Though machinery can crush artifacts within the fireline, damage to these already displaced resources might be preferred over damage to artifacts that have otherwise not been impacted. Machinery with a bucket has a lower potential to further displace and break artifacts compared to a blade. Manual rehabilitation could be the best option where cultural resources are present. If the cultural resource management objective is to protect resources from erosion and vandalism, leaving a fireline berm unrehabilitated might serve as a protective measure. However, rehabilitation could protect subsurface artifacts from the same impacts, as their being closer to the surface through the creation of a fireline increases their vulnerability. Other than the settling of soils in the midline, no signs of erosion were observed during survey of the experimental site in mid-April 2020. Interestingly, sections of the fireline south of the site, where slope is 15-20% and the berm was not rehabilitated, have begun to erode. Here, erosion was most apparent on the east of the fireline close to the berm. To limit water erosion of rehabilitated firelines, furrows are often cut into the fireline or straw wattles are placed. Cutting furrows can harm near surface resources, therefore use of straw wattles would be preferred where resources are encountered. The spring survey of the site revealed that the potential to recover additional artifacts after rehabilitation is low, but not impossible. Therefore, survey of a site following snowmelt is advised to determine vulnerability of artifacts to vandalism and erosion.

The artifacts in the surface scatters were exposed to fire and foot traffic. Though the severity of these impacts were low, they are still undesirable. In a sense, the berm of the fireline had insulated artifacts within and beneath it from the impacts of fire and foot traffic. Unfortunately, this protection will last only as long as the fire operations, as firelines are most often rehabilitated. Resource specialists and managers should consider what is appropriate for their specific management goals in decisions for fireline rehabilitation and construction. The short duration and low intensity of the prescribed fire in this study sustained less drastic impacts to the simulated site than the fireline construction and rehabilitation did. Containment methods such as wet lining and burnout might be preferred alternatives over the irreversible loss of a site through fireline construction.

Vegetation within firelines are additional factors in the spatial impacts of both surface and subsurface resources. Stumps in particular can expose subsurface resources and disrupt the stratigraphy of those not brought to the surface. When possible, firelines should be constructed in areas with close to zero green or partially rotted stumps. Treatments of stumps prior to fireline construction might also be necessary. Survey of an area should be done as soon as possible after fireline construction and rehabilitation, and after an incident. This is particularly important when precipitation is forecasted, as exposed artifacts could be left vulnerable to erosion as well as reburial.

This study has demonstrated that resources can be impacted multiple times and to differing severities during wildland fire management actions, therefore it is recommended that resource specialists document at which stages of wildland fire management a resource is impacted. Records should continue to be maintained where firelines have been constructed and where resources are found to have been impacted by them. This would ensure that future managers and researchers are aware of impacts to site formation processes as firelines may not be readily identifiable in the archaeological context after an extended period of time.

When working in an area where cultural resources are known or expected to be, having greater means to respond will be beneficial. Most of all, having more trained eyes to monitor the fire management operations is recommended. This does not necessarily mean more archaeologists; it would be extremely valuable to have fire personnel familiar with cultural resources they might encounter so that they can assist in mitigation. This should include both hand crews and dozer operators. I include the latter because in the CRWFM Project it was found that artifacts were visible to the individual operating the excavator during rehabilitation. Though much of the attention of the fire crew was focused on the prescribed burn, I would not exclude the potential for fire personnel to have time during a prescribed fire to take GPS coordinates of a cultural resource to report to a cultural resource specialist. When possible, training in identifying cultural resources should include visits to sites, as artifacts appear much different halfway buried in the ground or obscured by fuels than they do on a table. Training could be implemented as a seminar for dozer bosses and operators and line crews. For cultural resources less easily identifiable to non-specialists, such as hearths and building foundations, a pocket guide might be useful in addition to a seminar. In my experience, fire personnel are eager to share their experiences with cultural resources. This eagerness can be an open door to education on the proper treatment of cultural resources and can facilitate collaboration on mitigating indirect impacts.

Future Directions

As suggested at the outset of this chapter, the topic of impacts incurred on cultural resources resulting from wildland fire management deserves much greater attention. Future directions in research should inquire into different operational effects and methodologies, as well as into specific cultural resource types. Such research could involve testing the recommendations that I have made here. For example, imagine a scenario in which artifacts are encountered during mechanical fireline construction and mineral soil has not yet been reached. In order to construct an effective fireline, additional soil will need to be removed. This could displace or damage the exposed artifacts. It would be useful to determine if the production rate for manually completing such a fireline could be efficient enough to do so. Granted the area cleared by a dozer is much larger than a handline, therefore hand crews would be working in a wider area. Perhaps an area of 4 meters on either side of an artifact, as I have suggested might be appropriate, would be small enough to manually complete fireline construction efficiently while also preventing further damage to an artifact or cultural resource from mechanical operational effects. Research should include comparisons of handline production rates in areas where fuels have and have not been cleared by a dozer. Such research should also consider the minimum number of crew members needed to conduct this work efficiently while minimizing time and labor costs.

I had wanted to compare the impacts of manual fireline construction to those of mechanical fireline construction. Consequentially, it proved to be impractical at the CRWFM experimental site. Due to the limited slope, the area where the midline was constructed is not an area where a handline would be constructed. I was also concerned with how to simulate an archaeological record with artifact material types highly prone to fracture in a way that would be safe to individuals hacking away at it with Pulaskis. In my own experience excavating with a mattock on a 30% slope, glass artifacts and rock would often fracture and could be thrown towards myself. From this experience, I suspect that construction of handlines would have similar spatial displacement and physical impacts on artifacts. Still, I believe it would be highly valuable to conduct specific research to compare the severity of impacts incurred through both manual and mechanical fireline construction.

In addition to the difference in handline and dozerline impacts, other operational effects such as the use of fire suppressants ought to be studied in depth. As there are various types of chemical based fire suppressants it is important to understand how each can impact cultural resources differently. The major impacts from suppressants include staining and corrosion of certain materials. Some suppressant types might have temporary impacts, while others are more permanent. Research into methods for removing suppressants from cultural resources and preservation of those resources is something I will be involved in shortly.

Exploring treatment options for stumps that are located in the path of a fireline would also be valuable. In this study a rotted stump was uprooted during the construction of the fireline. Though the cavity was not much larger than the stump had been, an experimental artifact placed near it had been displaced. It would be interesting to determine if rotted stumps have less severe impacts to resources near them than green stumps, specifically if the depth and size of the cavities of these stump types can be calculated and predicted. If one stump type is more detrimental, perhaps scoring it down to mineral soil and removing it by hand would be a method for preventing it to be uprooted by mechanical fireline construction.

It would also be beneficial to explore different firing techniques and their relation to fire impacts to surface cultural resources. As the amount of soot buildup is dependent upon the proximity of an artifact to the origin of a fire, intentionally lighting near surface artifacts might be recommended. Though it seems counter-intuitive to light where artifacts are, combustive residue build up is lower closer to the origin of a fire (Haecker, 2012). This would of course be dependent upon the material type of the resource, as different materials have different melting points. Fuel type and density will also contribute to soot buildup. For example, grass fires burn quickly, decreasing the amount of time smoke will be present near an artifact (Sturdevant, 2009; Haecker, 2012). A combination of fuels treatment and change in firing technique could be a way around soot-stained cultural resources. Employing wet lining, using water to create a barrier to the spread of fire, might also be used alongside or preferred over different firing techniques.

I regret not including more lithic materials in this study, as the majority of the information I gained was that these materials were easily lost. Rather than situating the lithic experimental artifacts as stand-alone objects, I should have simulated debitage scatters. Having several flakes located in close proximity to one another would likely have supplied different information regarding the impacts of mechanical fireline construction. Greater depths at which artifacts are placed and placing artifacts closer together stratigraphically would contribute additional understandings of how they are impacted. Different percentages of slopes should also be considered. Of course, replication of this study in areas with different vegetation and soil compositions will be extremely useful to determine the applicability of the results and recommendations. Finally, ethnographic and sociological studies of the fire management culture would be useful for addressing shared stewardship needs and preventing vandalism.

Returning to Cultural Resource Values

For those interested in the stories and experiences of past peoples, the archaeological record provides a way through which the present can interact with the past. Truly, in doing so the past in turn interacts with us, shaping our understandings of who we are, and who we will become. Though various forces contribute to its final state, the archaeological record is created by people, who knowingly or not, left materials behind to be interpreted, used, and assigned value. Though the archaeological site in the CRWFM Project was simulated, real archaeological sites have been razed by the mechanical construction of firelines. What becomes of the stories of those who contributed to the creation of these sites? The implications of the findings I have presented here are hard to ignore. If the fireline had instead been constructed through a real and unknown archaeological site, rather than a simulated one, it is very likely that the stories of those who contributed to its creation would be lost and remain untold. How will the loss of these connections to the past impact us?

Though this is only one study, it provides a starting point by illustrating and quantifying the ways in which mechanical fireline construction is consistently detrimental to the archaeological record and artifacts within it. The knowledge gained through this research can be extended to other tangible and intangible cultural resources, as well as wildland fire settings beyond prescribed fire. An inherit value of archaeology is its ability to bring people together. The management recommendations and opportunities for future research I have provided here are reflective of the great potential to foster the relationship between managers of wildland fire and cultural resources. With their combined effort, a connection to the past can be carried on long into the future.

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APPENDIX A: MEASUREMENTS OF SPATIAL DISTURBANCE OF RECOVERED EXPERIMENTAL ARTIFACTS

The unit of measurement in the below table is metric. Letters following the Northing and Easting change measurements denote the cardinal direction in which an artifact was displaced. A plus sign with Elevation change measurements denotes an increase in elevation and a minus sign denotes a decrease. The first three artifacts in the table were unmoved during the study. Tick marks for the surface scatter artifacts represent the inability to calculate measurements of spatial disturbance.

Location and Context	Artifact Number	Northing Change	Easting Change	Elevation Change
Unit 1 Surface	141	-	-	-
	34	-	-	-
	33	-	-	-
	179	4.314 S	6.362 E	0.534-
	119	-	-	0.054+
	113	5.252 S	6.091 E	0.012-
	82	0.557 N	0.439 E	0.017-
	92	1.144 N	0.782 E	0.143+
	153	5.48 S	1.989 E	0.707-
S1 Surface	80	-	-	0.156, .252, .539+
	24	-	-	0.0-
	73	-	-	0.07-
	178	-	-	0.28-
	87	-	-	0.01+
	117	-	-	0.01-
	152	-	-	0.03-
	32	-	-	0.02-
	64	-	-	0.81-
Unit 2 10cmbs	51	2.445 S	3.324 W	0.354-
	103	4.724 S	1.528 W	0.527-
	84	7.719 S	0.473 E	0.946-
	106	10.716 S	2.642 W	1.346-
	44	2.498 S	1.434 W	0.279+
Unit 3 Surface	101	18.926 N	4.056 W	1.948+
	6	6.302 S	4.497 W	1.097-
	42	0.246 N	1.438 W	0.064+
	49	6.507 S	0.346 E	0.989-
E3 Surface	115	-	-	0.03-
	173	-	-	0.02-
	98	-	-	0.03-
	90	-	-	0.04-
	66	-	-	0.03-
	10	-	-	0.03-
	2	-	-	0.02-
W3 Surface	71	-	-	0.31-

	38	-	-	0.03-
	8	-	-	0.02-
	30	-	-	0.05-
	13	-	-	0.05-
	29	-	-	0.02-
	17	-	-	0.03-
	54	-	-	0.13-
Unit 4 Surface	137	1.923 S	9.469 E	0.209-
	110	6.52, 6.493 S	7.357, 7.597 E	1.154, 0.992-
	70	7.544 S	9.096 E	1.095-
	12	5.205 S	8.465 E	0.741-
Unit 4 10cmbs	52	1.516 S	9.449 E	0.009-
	97	1.356 S	8.553 E	0.067-
	69	3.16 S	8.348 E	0.458-
	174	7.656 S	6.904 E	1.128-

Note: Artifact number 80 was recovered in three distinct locations, therefore three elevations are listed. Additionally, artifact number 110 was recovered from two distinct locations, the second measurement for each change correspond with the second location

APPENDIX B: A WILDLAND FIRE GUIDE TO UNDERSTANDING IMPACTS OF OPERATIONAL EFFECTS TO CULTURAL RESOURCES

Introduction

This document briefly summarizes technical information regarding the impacts of operational effects to cultural resources incurred during methods of wildland fire management. This guide will aid cultural resource specialists and fire personnel in their collaboration in compliant fire management planning, prescribed burning, and may even be extended to their response to wildfire incidents. Outlined below are best practices in mitigating impacts to cultural resources that result from fire management methods.

The majority of the information presented here is the result of formative research regarding the impacts of operational effects of wildland fire management to cultural resources. Specifically, operational effects before, during, and after a prescribed burn were studied. The research study was conducted in a ponderosa pine and Douglas fir forest in northern Idaho, at an elevation of 3,100 feet. Four experimental units were created; one 4x4 meters in size, and three 2x2 meters in size. The 4x4 meter unit was established in an area of no slope, and the three 2x2 meter units were located on a slope of 5-10%. Each unit contained experimental artifacts of replica precontact and authentic historic materials placed at the sediment surface and 10 cm below the surface. A total of 154 experimental artifacts were used.

Operational effects have the most consistently detrimental impacts to cultural resources in a variety of environmental and fire settings. The impacts of operational effects are no less severe than those sustained by fire. The findings of this study reflect that mechanical fireline construction and rehabilitation have more severe impacts than prescribed fire.

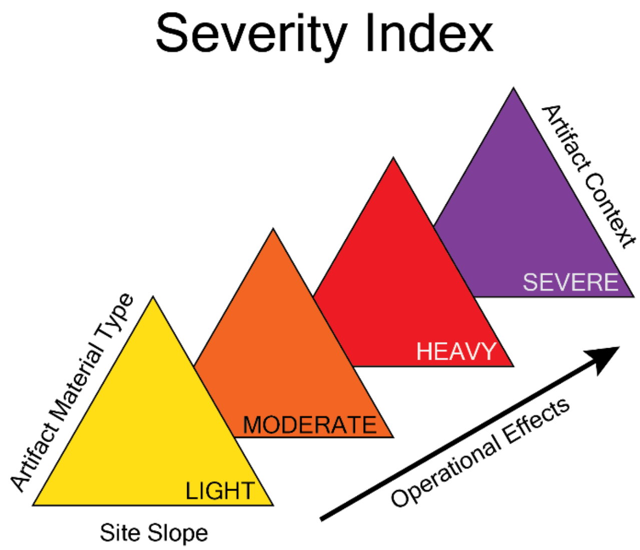
Key Terms

- <u>Cultural resources:</u> Any material/nonmaterial, tangible/intangible element of the environment that has cultural value to a group of people. Some examples include precontact or historic structures or features such as building foundations or hearths; artifacts of lithic, ceramic, glass, metal, or synthetic materials; and landscapes or features on a landscape, such as a cave or trail, that are integral to the practices or beliefs of a culture

- Artifact: Any material object used or manufactured by a human in the past. Examples include stone tools, ceramic dishes, and iron cans
- Provenience: Location of an artifact when found. Specifically, horizontal and vertical locations within stratigraphic layers
- Operational effects: Fire management actions dependent upon the occurrence of fire and are associated with suppression, rehabilitation and mitigation. Some examples include mechanical fireline construction through use of a bulldozer, and application of fire suppressants
- Fireline: An area where fuels have been removed to create a barrier that prevents the spread of fire. Specifically, the area is dug to mineral soil and should be 1.5 times as wide as the surrounding fuels are tall.
- Rehabilitation: Returning a fireline to close to its physical state prior to construction. This can involve replacing soils and vegetation, and cutting furrows to minimize erosion. In this study, rehabilitation involved returning displaced soils back into a fireline.

Operational Effects

Operational effects such as mechanical fireline construction and rehabilitation can impact cultural resources, specifically artifacts, in a variety of ways. At an archaeological site, slope artifact context, and artifact material type are variables that can influence the degree to which operational effects impact cultural resources. As exposure to operational effects increases, the severity of the impact increases.



Removal of artifacts and other cultural resources from their provenience through operational effects is irreversible. The displacements observed in this study reflect that cultural resources will consistently be removed from site features or rooms, and potentially even entire site boundaries. For the following information, a Type 4 bulldozer was used in mechanical fireline construction, and a CAT 305.5 E2 CR excavator was used in mechanical fireline rehabilitation. Of key interest are site destruction and change in artifact provenience resulting from horizontal and vertical spatial displacement, as well as breakage or other characteristic changes to artifacts.

<u>Site Impacts</u>

A total of 50 artifacts, 32.5% of the entire simulated site, were recovered after mechanical fireline construction and rehabilitation. Of the recovered artifacts, 56% were spatially displaced. The average horizontal displacement of artifacts for the site was 7.26 meters. A decrease of 0.65 meters was the average vertical displacement. As not all of the artifacts were recovered, 79.2-85.7% of the entire site can be assumed to have been spatially displaced.

<u>Sites by Slope</u>

Impacts of mechanical fireline construction and rehabilitation vary by slope. For slopes greater than 30% firelines are constructed manually. At an area of 0% slope, average horizontal displacement was 5.92 meters, and vertical displacement was a decrease of 0.28 meters on average. Artifacts in an area of 5-10% slope were horizontally displaced by 9.48 meters on average, and were vertically displaced by a decrease of 0.84 meters.

Site Type

Artifact density varies by site, with typically much higher densities found on historic sites than on precontact sites. Mechanical fireline construction will not only displace artifacts, but also obscure many artifacts to the point of reburial. Fireline construction resulted in obscuring 87.7% of the artifacts visible at the beginning of the study. Historic materials such as ceramic and glass are more easily recoverable than ferrous metal artifacts. Though local quartz was seen at the site, chert and obsidian lithic materials were infrequently recovered.

Artifact Type

Artifacts analyzed in this research include obsidian and chert lithic flakes, and 20th century glass, ceramics, ferrous metal, and synthetics. Of the recovered artifacts, 7 were physically damaged as a result of fireline construction and rehabilitation. A total of 6 glass artifacts were broken; 1 ceramic artifact was broken. On only two occasions was the entire broken artifact recovered. Most frequently the amount of a broken artifact that was recovered was less than 30% of the original complete artifact.

In summary, nearly 70% of an archaeological site will be lost in mechanical fireline construction and rehabilitation. The majority of a site will be spatially disturbed by 7 meters or more. This severely inhibits the ability to recover a site and make accurate interpretations. Artifacts from sites located on slopes will suffer greater displacement. Low density sites will also be more severely impacted. Historic materials may suffer greater physical damage, yet these are easier to identify and recover than are lithic materials.

Additional Indirect Impacts

The following examples highlight other operational effects and consequences of these effects that can also impact cultural resources. Included are observations from this study and others.

Erosion:

- Wind and water driven erosion can further impact cultural resources by damaging the resources or further displacing exposed materials from their provenience
- The impacts of erosion can be greater when a fireline is not rehabilitated, particularly when furrows are not cut or straw wattles are not used

Increased Human Presence:

- The greater presence of humans at a site poses greater potential for exposed artifacts to be broken or removed from their provenience
- Use of firelines as a trail, even after rehabilitation, poses greater potential for artifacts to be stepped on and broken

Fire Suppressants:

- Staining of cultural resources is of great concern where fire suppressants are used, corrosion is also a potential impact
- Use of water can physically damage surface materials that have been heated by fire

Mitigation Protocols

The following are recommendations for the mitigation of adverse impacts to cultural resources that are likely to result from operational effects. The reader should determine what is appropriate for the environmental and cultural contexts in which they work.

Both cultural resource specialists and fire managers can play a role in protecting cultural resources from the impacts of operational effects. The following are actions that both parties can take to help reach this goal, categorized by estimates of cost and labor efforts.

Low cost/Low labor:

- Minimal scraping and tool scarring during mop-up activities
- In mechanical rehabilitation, rehabilitation should be conducted in the opposite direction of construction; alternatively, sediments should be pushed in from the sides of a fireline when no surface resources are threatened
- Alternative mechanized equipment; rubber tires rather than tracked skidders, use of buckets over the use of blades in fireline rehabilitation

Low cost/Medium labor:

- Immediately document with photographs and GPS coordinates when and where a cultural resource is encountered

- During non-incident activities, when resources are encountered, manually complete the construction of firelines that have not reached mineral soil with one pass of a bulldozer within a 4 meter radius of the exposed resource
- Manually rehabilitate firelines where resources are encountered
- Backfill stump cavities to prevent collapse of sediments around exposed features
- Avoid constructing fireline where there is an abundance of green or partially rotted stumps
- Work with prescribed fire project planners to accommodate cultural resource concerns into the burn prescriptions

Medium cost/Medium labor:

- Survey areas prior to fireline construction; prepare alternative routes should cultural resources be encountered, ensuring that firelines will remain effective (mc/ml)
- Identify and define high value resources and develop plans for protecting them prior to a fire incident; ensure that fire managers know about and have access to these plans
- Have cultural resource specialists brief suppression crews and other fire personnel on identification of cultural resource types specific to an area, and how to conduct themselves appropriately when encountering such resources
- Cold trail and wet line versus mechanical and manual fireline construction

Conclusion

Like the effects of fire to cultural resources, impacts from operational effects are context dependent. Factors such as terrain, site type, and cultural resource types are related to the severity of impacts from mechanical fireline construction and rehabilitation. Additionally, equipment type used in management activities will influence the severity of impacts. The results of this study are reflective of the impacts resulting from the use of a Type 4 dozer. The severity of spatial and physical impacts should be expected to increase in magnitude with equipment of Types 1-3.

This brief summary of information identifying and describing the impacts of operational effects to cultural resources can equip both cultural resource specialists and fire personnel with the knowledge necessary to make effective and holistic management decisions during both prescribed burning and wildland fire incidents.

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APPENDIX C: CUSTOM SOIL RESOURCE REPORT- CRWFM 2019

United States Department of Agriculture

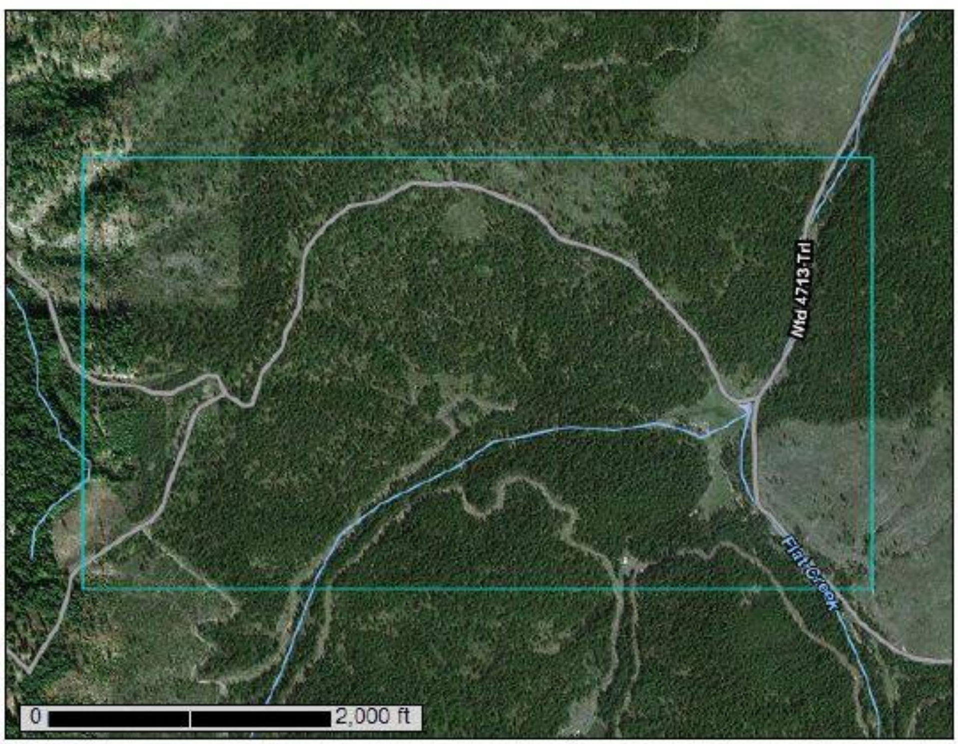
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Latah County, Idaho

CRWFM 2019



February 2, 2020

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

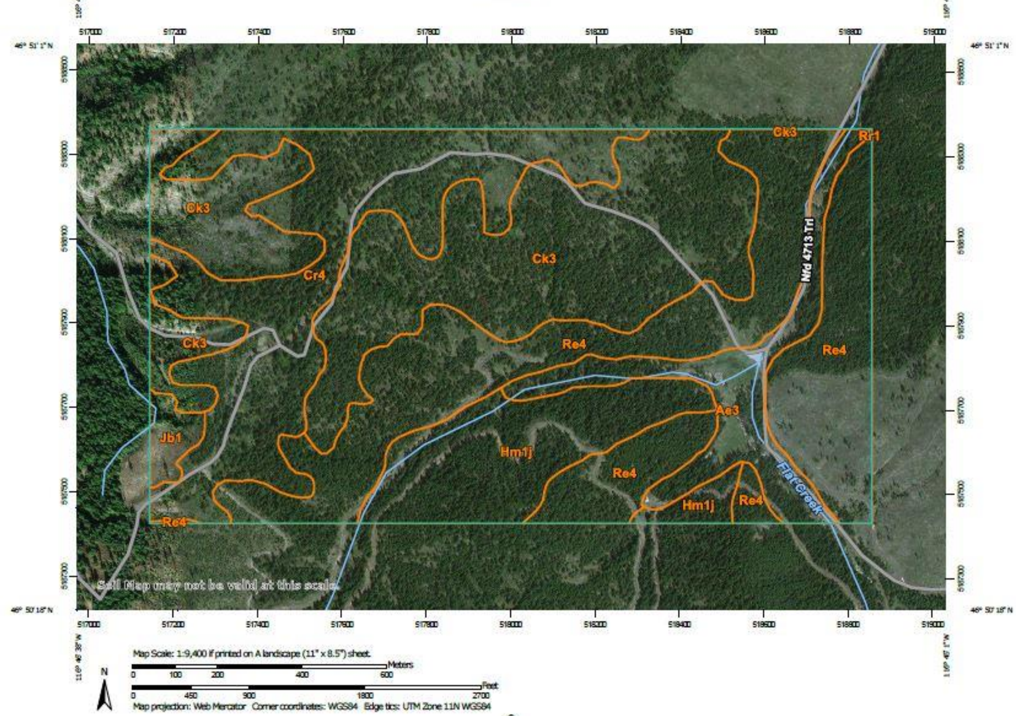
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Custom Soil Resource Report

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Latah County, Idaho
Survey Area Data: Version 9, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 24, 2014—Sep 8, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ae3	Aquandic Endoaquepts-Mannering-Spacecreek complex, 0 to 12 percent slopes	30.6	7.7%
Ck3	Carlinton-Carrico-Kruse complex, 8 to 35 percent slopes	119.0	30.1%
Cr4	Carrico-Carrico, dry-Kruse complex, 5 to 35 percent slopes	82.2	20.8%
Hm1j	Norwidge-Threebear complex, 5 to 30 percent slopes	42.8	10.8%
Jb1	Jacot-Lado-Vassar complex, 10 to 30 percent slopes	4.9	1.2%
Re4	Reggear ashy silt loam, 5 to 25 percent slopes	116.2	29.4%
Rr1	Reggear-Reggear, moist complex, 10 to 35 percent slopes	0.1	0.0%
Totals for Area of Interest		**395.8**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Latah County, Idaho

Ae3—Aquandic Endoaquepts-Mannering-Spacecreek complex, 0 to 12 percent slopes

Map Unit Setting

National map unit symbol: pmsn
Elevation: 2,500 to 3,000 feet
Mean annual precipitation: 25 to 47 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 85 to 120 days
Farmland classification: Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Aquandic endoaquepts and similar soils: 55 percent
Mannering and similar soils: 30 percent
Spacecreek and similar soils: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Aquandic Endoaquepts

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

A - 0 to 10 inches: ashy silt loam
Bg - 10 to 52 inches: loam
C - 52 to 60 inches: sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 2 to 8 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: High (about 9.4 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C/D
Ecological site: MEADOW (R009XY018ID)
Hydric soil rating: Yes

Description of Mannering

Setting

Landform: Flood-plain steps

Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Volcanic ash and mixed alluvium

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 7 inches: ashy silt loam
Bw1 - 7 to 27 inches: ashy loam
Bw2 - 27 to 46 inches: gravelly silt loam
BC - 46 to 55 inches: very fine sandy loam
C - 55 to 63 inches: loam

Properties and qualities

Slope: 2 to 12 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 1 to 27 inches
Frequency of flooding: Very rare
Frequency of ponding: Frequent
Available water storage in profile: Moderate (about 7.9 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B/D
Other vegetative classification: western redcedar/queencup beadlily (CN530)
Hydric soil rating: No

Description of Spacecreek

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Volcanic ash over mixed alluvium

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
Oe - 1 to 2 inches: moderately decomposed plant material
A - 2 to 5 inches: medial silt loam
Bw - 5 to 20 inches: medial silt loam
2Bt - 20 to 37 inches: loam
2BC - 37 to 53 inches: sandy loam
2C - 53 to 60 inches: sandy loam

Properties and qualities

Slope: 2 to 12 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None

Frequency of ponding: None
Available water storage in profile: High (about 10.8 inches)

Interpretive groups
Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B/D
Other vegetative classification: western redcedar/wild ginger (CN545)
Hydric soil rating: No

Ck3—Carlinton-Carrico-Kruse complex, 8 to 35 percent slopes

Map Unit Setting
National map unit symbol: pmz2
Elevation: 2,800 to 3,400 feet
Mean annual precipitation: 30 to 41 inches
Mean annual air temperature: 43 to 46 degrees F
Frost-free period: 95 to 130 days
Farmland classification: Not prime farmland

Map Unit Composition
Carlinton and similar soils: 45 percent
Carrico and similar soils: 20 percent
Kruse and similar soils: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carlinton

Setting
Landform: Hillslopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Volcanic ash over loess

Typical profile
Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 8 inches: ashy silt loam
Bw - 8 to 19 inches: silt loam
B/E - 19 to 31 inches: silt loam
E/B - 31 to 39 inches: silt loam
Btxb - 39 to 60 inches: silty clay loam

Properties and qualities
Slope: 8 to 35 percent
Depth to restrictive feature: 31 to 46 inches to fragipan
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)

Depth to water table: About 8 to 26 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Other vegetative classification: grand fir/ninebark (CN506)
Hydric soil rating: No

Description of Carrico

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess and volcanic ash over residuum weathered from granite

Typical profile

Oi - 0 to 0 inches: slightly decomposed plant material
A - 0 to 6 inches: ashy silt loam
AB - 6 to 8 inches: ashy silt loam
BA - 8 to 13 inches: silt loam
Bt - 13 to 20 inches: gravelly loam
BC - 20 to 24 inches: very gravelly loam
Cr - 24 to 60 inches: bedrock

Properties and qualities

Slope: 15 to 35 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Other vegetative classification: grand fir/ninebark (CN506)
Hydric soil rating: No

Description of Kruse

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex

Parent material: Loess and volcanic ash over colluvium derived from granite and/or gneiss and/or schist

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 10 inches: ashy silt loam
BA - 10 to 14 inches: silt loam
Bt1 - 14 to 26 inches: silt loam
2Bt2 - 26 to 43 inches: loam
2BCt - 43 to 51 inches: loam
2C - 51 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 15 to 40 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 11.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Other vegetative classification: grand fir/ninebark (CN506)
Hydric soil rating: No

Cr4—Carrico-Carrico, dry-Kruse complex, 5 to 35 percent slopes

Map Unit Setting

National map unit symbol: pmz4
Elevation: 2,970 to 4,650 feet
Mean annual precipitation: 31 to 39 inches
Mean annual air temperature: 43 to 46 degrees F
Frost-free period: 95 to 130 days
Farmland classification: Not prime farmland

Map Unit Composition

Carrico and similar soils: 40 percent
Carrico, dry, and similar soils: 25 percent
Kruse and similar soils: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carrico

Setting

Landform: Hillslopes

Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and volcanic ash over residuum weathered from granite

Typical profile

Oi - 0 to 0 inches: slightly decomposed plant material
A - 0 to 6 inches: ashy silt loam
AB - 6 to 8 inches: ashy silt loam
BA - 8 to 13 inches: silt loam
Bt - 13 to 20 inches: gravelly loam
BC - 20 to 24 inches: very gravelly loam
Cr - 24 to 60 inches: bedrock

Properties and qualities

Slope: 5 to 35 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Other vegetative classification: grand fir/ninebark (CN506)
Hydric soil rating: No

Description of Carrico, Dry

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and volcanic ash over residuum weathered from granite

Typical profile

Oi - 0 to 0 inches: slightly decomposed plant material
A - 0 to 6 inches: ashy silt loam
AB - 6 to 8 inches: ashy silt loam
BA - 8 to 13 inches: silt loam
Bt - 13 to 20 inches: gravelly loam
BC - 20 to 24 inches: very gravelly loam
Cr - 24 to 60 inches: bedrock

Properties and qualities

Slope: 5 to 35 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Other vegetative classification: Douglas-fir/ninebark (CN260)
Hydric soil rating: No

Description of Kruse

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and volcanic ash over colluvium derived from granite and/or gneiss and/or schist

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 10 inches: ashy silt loam
BA - 10 to 14 inches: silt loam
Bt1 - 14 to 26 inches: silt loam
2Bt2 - 26 to 43 inches: loam
2BCt - 43 to 51 inches: loam
2C - 51 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 5 to 35 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 11.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Other vegetative classification: grand fir/ninebark (CN506)
Hydric soil rating: No

Hm1j—Norwidge-Threebear complex, 5 to 30 percent slopes

Map Unit Setting

National map unit symbol: v263
Elevation: 2,800 to 3,400 feet
Mean annual precipitation: 35 to 40 inches
Mean annual air temperature: 38 to 44 degrees F
Frost-free period: 50 to 110 days
Farmland classification: Farmland of statewide importance, if drained

Map Unit Composition

Threebear and similar soils: 45 percent
Norwidge and similar soils: 45 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Threebear

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Volcanic ash over loess

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 3 inches: medial silt loam
Bw - 3 to 18 inches: medial silt loam
2E/B - 18 to 26 inches: silt loam
2B/E - 26 to 40 inches: silt loam
2Btxb - 40 to 69 inches: silty clay loam

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: 20 to 40 inches to fragipan
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 4 to 28 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B/D
Other vegetative classification: western redcedar/queencup beadlily (CN530)

Hydric soil rating: No

Description of Norwidge

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Volcanic ash over loess

Typical profile

Oi - 0 to 3 inches: slightly decomposed plant material
A - 3 to 6 inches: medial silt loam
Bw - 6 to 17 inches: medial silt loam
2E - 17 to 26 inches: silt loam
2Bt/E - 26 to 42 inches: silty clay loam
2Btxb - 42 to 81 inches: silty clay loam

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very high (about 15.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Other vegetative classification: western redcedar/queencup beadlily (CN530)
Hydric soil rating: No

Jb1—Jacot-Lado-Vassar complex, 10 to 30 percent slopes

Map Unit Setting

National map unit symbol: 1tpt3
Elevation: 2,960 to 4,660 feet
Mean annual precipitation: 33 to 43 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 85 to 120 days
Farmland classification: Not prime farmland

Map Unit Composition

Jacot, warm, and similar soils: 50 percent
Lado, dry, and similar soils: 25 percent

Vassar and similar soils: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Jacot, Warm

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Upper third of mountainflank, mountaintop
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Volcanic ash over colluvium derived from granite and/or gneiss

Typical profile

Oi - 0 to 0 inches: moderately decomposed plant material
A - 0 to 3 inches: ashy silt loam
Bw - 3 to 17 inches: ashy silt loam
2Bt - 17 to 34 inches: sandy loam
2BC - 34 to 48 inches: gravelly coarse sandy loam
2C - 48 to 61 inches: very gravelly loamy coarse sand

Properties and qualities

Slope: 10 to 30 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Other vegetative classification: western redcedar/queencup beadlily (CN530)
Hydric soil rating: No

Description of Lado, Dry

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Upper third of mountainflank, mountaintop
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Volcanic ash over loess over colluvium derived from granite and/or gneiss

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 3 inches: medial silt loam
Bw - 3 to 16 inches: medial silt loam
2Bt - 16 to 24 inches: silt loam
2B/E - 24 to 31 inches: silt loam
3Bt - 31 to 47 inches: loam
3C - 47 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 10 to 30 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very high (about 13.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Other vegetative classification: western redcedar/queencup beadlily (CN530)
Hydric soil rating: No

Description of Vassar

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Upper third of mountainflank, mountaintop
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Volcanic ash over colluvium over residuum weathered from granite and/or gneiss

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 4 inches: ashy silt loam
Bw1 - 4 to 22 inches: ashy silt loam
2Bw2 - 22 to 33 inches: coarse sandy loam
2C - 33 to 51 inches: gravelly loamy coarse sand
2Cr - 51 to 60 inches: bedrock

Properties and qualities

Slope: 10 to 30 percent
Depth to restrictive feature: 40 to 60 inches to paralithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Other vegetative classification: western redcedar/queencup beadlily (CN530)
Hydric soil rating: No

Re4—Reggear ashy silt loam, 5 to 25 percent slopes

Map Unit Setting

National map unit symbol: 1hktn
Elevation: 2,700 to 3,100 feet
Mean annual precipitation: 26 to 28 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 85 to 120 days
Farmland classification: Not prime farmland

Map Unit Composition

Reggear and similar soils: 75 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Reggear

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope, toeslope, backslope
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Volcanic ash over loess

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 4 inches: ashy silt loam
Bw - 4 to 8 inches: ashy silt loam
EB - 8 to 18 inches: silt loam
Bt/E - 18 to 31 inches: silt loam
Btxb - 31 to 60 inches: silty clay loam

Properties and qualities

Slope: 5 to 25 percent
Depth to restrictive feature: 24 to 39 inches to fragipan
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C/D
Other vegetative classification: grand fir/queencup beadlily (CN520)
Hydric soil rating: No

Rr1—Reggear-Reggear, moist complex, 10 to 35 percent slopes

Map Unit Setting

National map unit symbol: rn9t
Elevation: 2,600 to 3,400 feet
Mean annual precipitation: 26 to 28 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 85 to 120 days
Farmland classification: Not prime farmland

Map Unit Composition

Reggear and similar soils: 50 percent
Reggear, moist, and similar soils: 35 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Reggear

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Linear, convex
Parent material: Volcanic ash over loess

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 4 inches: ashy silt loam
Bw - 4 to 8 inches: ashy silt loam
EB - 8 to 18 inches: silt loam
Bt/E - 18 to 31 inches: silt loam
Btxb - 31 to 60 inches: silty clay loam

Properties and qualities

Slope: 10 to 35 percent
Depth to restrictive feature: 24 to 39 inches to fragipan
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C/D
Other vegetative classification: grand fir/queencup beadlily (CN520)
Hydric soil rating: No

Description of Reggear, Moist

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, convex
Parent material: Volcanic ash over loess

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 4 inches: ashy silt loam
Bw - 4 to 8 inches: ashy silt loam
EB - 8 to 18 inches: silt loam
Bt/E - 18 to 31 inches: silt loam
Btxb - 31 to 60 inches: silty clay loam

Properties and qualities

Slope: 10 to 35 percent
Depth to restrictive feature: 24 to 39 inches to fragipan
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C/D
Other vegetative classification: western redcedar/queencup beadlily (CN530)
Hydric soil rating: No

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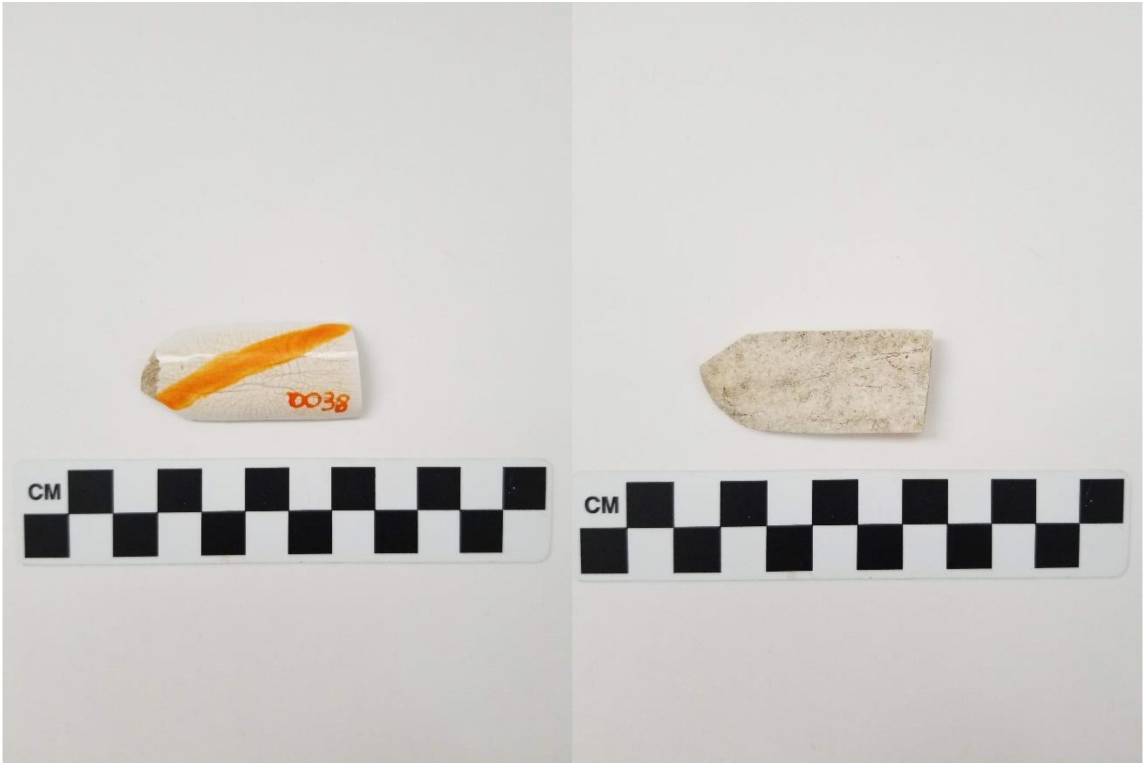
APPENDIX D: PHYSICALLY IMPACTED EXPERIMENTAL ARTIFACTS

Stained Artifacts

Artifact #33 Before- White refined earthenware ceramic plate

Artifact #33 After- Note new staining in center and increased staining in crazed glaze of rim on right



Artifact #38 Before- White refined earthenware ceramic, partial hollowware handle. Left is exterior surface; right is interior surface (paste)

Artifact #38 After- Heavy staining on top edge of sherd exterior and heavy patchy staining on paste on interior

Artifact #46 Before- White refined earthenware, hollowware rim, decorated with green and purple floral transfer print

Artifact #46 After- Heavy staining in crazed glaze, transfer print discolored and pattern difficult to discern

Artifact #66 Before- Transparent bottle glass finish; after-artifact had been cleaned twice

Artifact # 90 Before- Manganese bottle glass base

After- artifact cleaned twice, note less residue on right

Artifact #98 Before- Olive green bottle glass base; after- staining remains on India Ink

Artifact #173 Before- Iron bracket with iron nut; after- note heavier staining on nut on left

Broken Artifacts

Artifact #35 Before- White refined earthenware ceramic sherd, hollowware rim and body

Artifact #35 After- 100% of original artifact, 2 sherds mend

Artifact #49 Before- White refined earthenware ceramic sherd, hollowware (bowl) rim and body

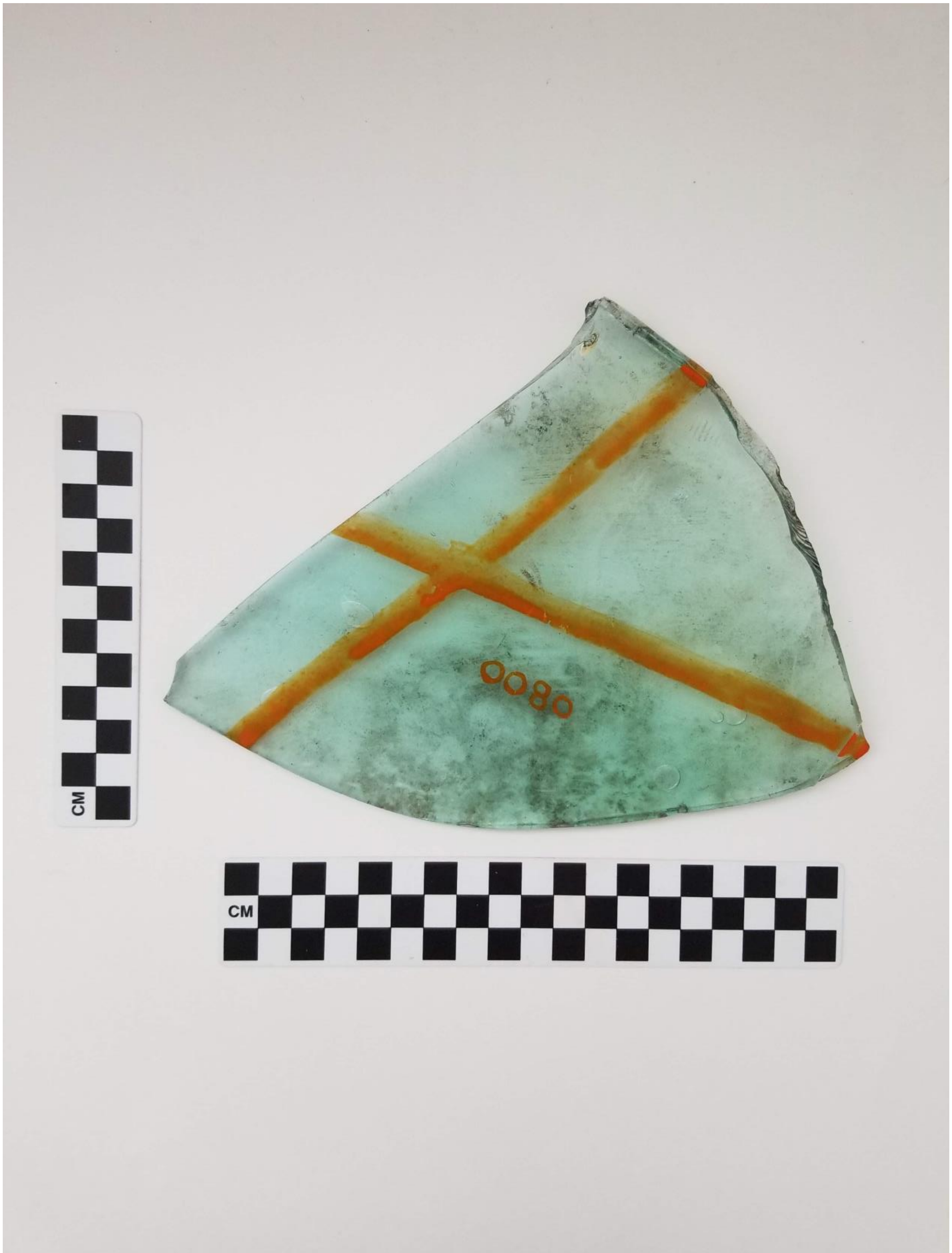
Artifact #49 After- Approximately 25% of original artifact

Artifact #69 Before- Transparent glass flask finish and body

After- Sherd of flask shoulder, approximately 20% of original artifact

Artifact #71 Before- Transparent bottle glass shoulder with mold seam

After- Mold seam present, approximately 25% of original artifact



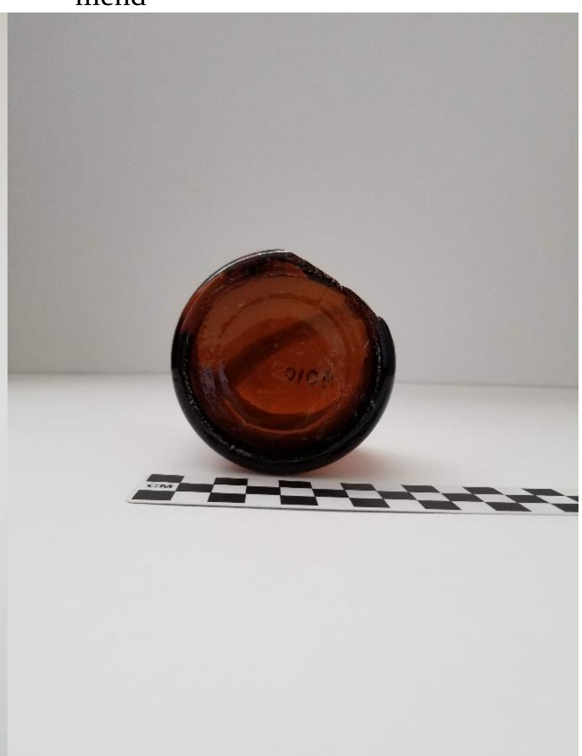
Artifact #80 Before- Natural blue green glass jug base

Artifact #80 After- 45% of original artifact, 6 total sherds mend

Artifact #80 After- 5 sherds on left found in N1, 1 sherd on right found in Unit 1

Artifact #82 Before- Natural blue green glass bottle base

After- 100% of original artifact, 2 sherds mend



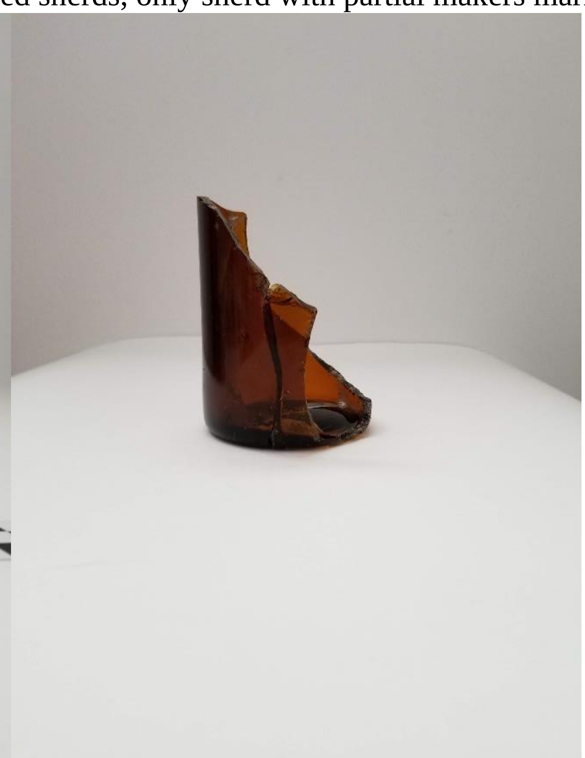
Artifact #106 Before- Brown glass bottle base and body

Artifact #106 Before- A B Co makers marks and post mold seam

Artifact #106 After- Bottle base only, approximately 28.75% of original artifact

Artifact #106 After- One of 3 recovered sherds, only sherd with partial makers mark

Artifact #110 Before- Brown glass bottle base and body



After- 100% of original, 2 sherds mend