THESIS

TREE-RINGS, HISTORIC DOCUMENTS, AND INTERPRETING PAST LANDUSE AND ENVIRONMENTS IN THE UPPER GREYBULL RIVER WATERSHED, NORTHWESTERN, WYOMING

Submitted by

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY MARCY REISER, ENTITLED: TREE-RINGS, HISTORIC DOCUMENTS, AND INTERPRETING PAST LANDUSE AND ENVIRONMENTS IN THE UPPER GREYBULL RIVER WATERSHED, NORTHWESTERN, WYOMING, BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS.

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ABSTRACT OF THESIS

TREE-RINGS, HISTORIC DOCUMENTS, AND INTERPRETING PAST LANDUSE AND ENVIRONMENTS IN THE UPPER GREYBULL RIVER WATERSHED, NORTHWESTERN, WYOMING

Set in a high montane Engelmann spruce parkland in the central Absaroka Mountains of northwestern Wyoming, this thesis combines dendrochronology, archaeology, and data from historic documents to explore past human activity and climate in the Upper Greybull River Watershed. Based on early Euro-American accounts of the region, and its rugged remoteness, this harsh environment might seem an unlikely place for past human groups to survive and thrive. However, research conducted in the area since 2002, as part of the Greybull River Sustainable Landscape Ecology (GRSLE) project, reveals a dynamic environment rich with both prehistory and history and one that illuminates the past but just as quickly obscure and erase it.

As a snapshot of ongoing research, this thesis presents tree-ring crossdating results for four historic cabins and associated structures collected prior to the Little Venus fire of 2006, including crossdates from a historic cabin that burned to the ground. Crossdating results are also presented for culturally modified trees in the area, including culturally peeled trees, and for a “ghost forest,” which may represent the remnants of an ancient forest that succumbed to fire in the late-1400s to mid-

1600s. Based on these crossdated samples, a preliminary standardized index of annual tree-ring growth, or master chronology, has been established which extends the tree-ring chronology back to 1260. This master chronology was then compared to historic documents from the region and accounts by early settlers of environmental conditions in the Upper Greybull River Watershed. This comparison has resulted in a more complex and nuanced understanding of past climate and human landuse, as well as highlighting stories about the past that only trees and historic accounts can tell.

This thesis is part of an ongoing and urgent effort to collect, preserve and crossdate tree-ring samples from this fire-prone region. Like much of the West, forests in this area have been devastated by a recent bark beetle epidemic, posing a significant threat to cultural resources, especially those made of wood.

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From the moment I set foot on campus to pursue a Master's degree, I knew I had made the right decision: trading in a well-paying office job for the chance to be outside and explore the past. I am never more certain of this than when in my study area. For making this possible and for supporting me in innumerable ways, I want to thank Dr. Larry Todd. His vision—not to mention his knowledge and commitment to archaeology—has inspired me greatly. Thanks to both Larry Todd and Becky Thomas for their hospitality and generosity throughout this research.

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Finally I want to thank both family and friends. It was while caring for my grandmother "Ginny" that I made the decision to go back to school. She gave me my first books on archaeology. Thanks to both mom and Sam for always supporting my endeavors and to my late father for sharing his love of history and the Rockies. Finally, I want to thank Nancy Wadsworth, who over the years has both challenged me and been an anchor. Thanks also to the fur balls: Jake, Ollie, Sprocket, and Jack for always greeting me at the door as though I could do no wrong. And, to Courtney Hurst, who tirelessly and with minimal crankiness read and edited and reread this thesis. On more than one occasion during this thesis process, she was forced to put her "size 9 ½'s down" to keep me on track. Her support and clever humor made all the difference.

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CHAPTER 1: INTRODUCTION AND OVERVIEW

The Landscape Setting: A High Montane Parkland and Ecotone

The edge between two ecosystems, or an *ecotone*, has long been considered an optimal location for organisms to reap the benefits of greater diversity available at an ecological intersection (Leopold 1946; Ries 2004). This convergence zone offers the inhabitants both landscape as well as environmental diversity, diachronic thermal and solar benefits, shelter, added resources, and predator/prey cover. Past human groups likely exploited the resources and ecological diversity found at forest edges, yet in rugged and remote montane regions such as the Absaroka Range in northwestern Wyoming where this study is located, the human signature upon the landscape can be both subtle and ephemeral. Furthermore, forest boundaries shift both gradually and abruptly over time as a result of such multi-scale ecosystem drivers such as climate, fire, species competition, pestilence, grazing, and human landuse.

In dryer climates, dead trees or remnant forests might lie on the ground for several thousand years (Nihjuis 2005), but at subalpine elevations in the temperate zone, the vestiges of trees are more likely to last only a few hundred years--unless preserved by glaciers or ice patches in which case they might last for millennia (Benedict et al. 2008). Past this point, surface preservation of forest vegetation at high elevation and any material remains related to human utilization of the forest declines sharply. Despite this, trees in subalpine environments can often live to be older than 500 years and thus reflect climate and environment at both annual and centennial scales (Peterson 2005), offering a high resolution glimpse at climate, the forest and associated human behavior during the recent past.

This project combines dendrochronology, archaeology, and data from historic documents to explore past human activity and climate at the upper reaches of a subalpine forest. At first glance and based on early Euro-American accounts of the region, this harsh environment might seem an unlikely place for past human groups. However, research conducted in the area since 2002, as part of the Greybull River Sustainable Landscape Ecology (GRSLE) project, reveals a high montane environment rich with prehistory and history; a temporal record dating back to the early stages of the Holocene (Todd 2005); and a dynamic landscape that elucidates the past but just as quickly obscures or erases it.

RESEARCH AND OBJECTIVES

GRSLE Research

The GRSLE project area is located in the Upper Greybull River Watershed along the eastern flank of the central Absaroka Range in northwestern Wyoming (Figure 1.1). Francs Peak, at 4009 meters, is the highest peak in the Absaroka Range (Knight 1994:154) and constitutes the southeastern extent of the watershed and its headwaters. Francs Peak is located less than five miles from the current study area. In 2002, when archaeological and ecological field investigation was first initiated in the Upper Greybull River and along its tributaries and major trails, a primary objective was to inventory archaeological sites in a “blank spot on the map." (Todd 2005), The GRSLE project area is part of the Shoshone National Forest and comprises one of the most remote portions of the Greater Yellowstone Ecosystem (GYE). Prior to 2002, no systematic archaeological survey had been conducted in the project area and only seven prehistoric sites had been previously recorded (Burnett 2005; Todd 2008). By the end of the 2009 field season, a total of 384 prehistoric and historic sites had been recorded as part of the GRSLE project, transforming a blank spot on the map into a model for how human groups have interacted with this high altitude environment over time.

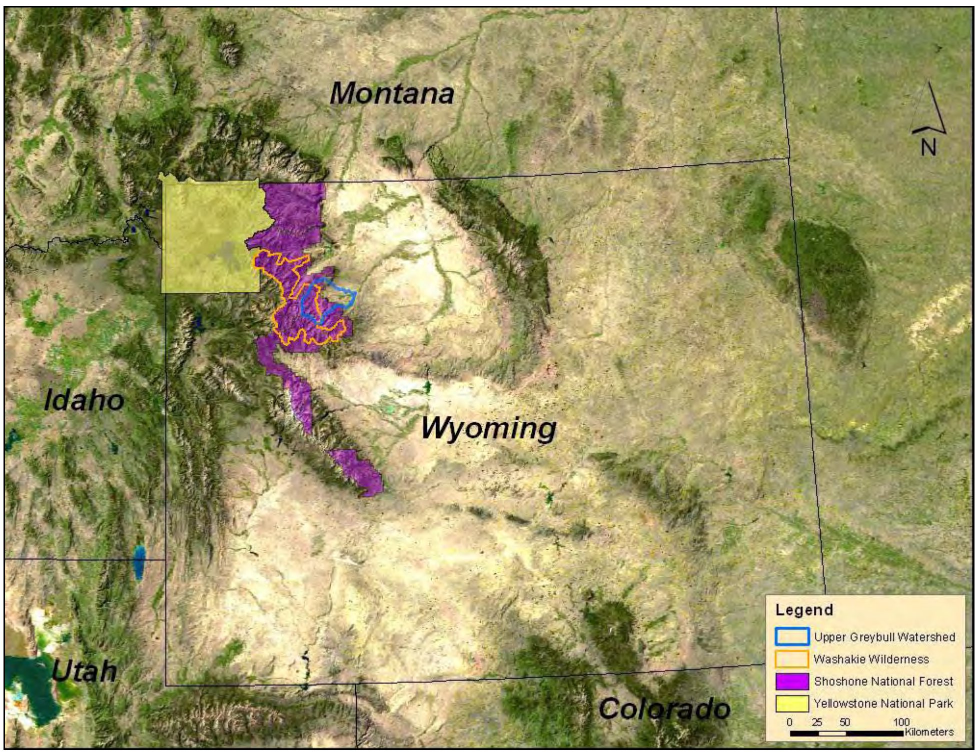


Figure 1.1. Map of the Upper Greybull Watershed, Yellowstone National Park, and forest and wilderness boundaries (ESRI 2006; WyGISC 2009).

The GRSLE project has produced multiple interdisciplinary studies that explore the relationship between culture and environment. These studies illuminate an active and dynamic landscape that not only influenced past human behavior but also affect the way in which the archaeological record is experienced today. For example, GRSLE research includes studies on the following: the influence of temperature, topology, and habitat structure on site location preference (Derr 2006); mass-wasting and landscape change as forces integral to archaeological context (Ollie 2008); the effect of biotic activity and geomorphic processes on site taphonomy (Bechberger 2010); and fire history and surface artifact composition as a reflection of dynamic, integrated, and evolving biotic and abiotic processes (Thompson 2008). Other studies include stone drivelines, walls and other features of stone and wood (Kinneer 2007); human behavioral response to landscape change and raw lithic procurement (Reitze 2004), obsidian sourcing and distribution patterns (Bohn 2007); the development of a chronology, based on stylistically distinctive lithic artifacts, establishing an occupation period spanning the Late Paleoindian to the Late Prehistoric (Burnett 2005) and examination of more recent landuse practices involving historic mining (Mueller 2007).

Recording the Remnants of a "Ghost Forest"

Ideas for this thesis began to take form in the summer of 2005. While conducting archaeological field research along Jack Creek, a major tributary of the Upper Greybull River, students from Colorado State University recorded the remnants of a "ghost" forest, or paleoforest, in an effort to reconstruct the boundaries of this ancient forest (Parks et al. 2005). The ghost trees consisted of downed and decaying snags and stumps, the remains of which were spread across an open alpine meadow, Figures 1.2a and b. Later, when comparing the spatial

Figure 1.2. Ghost trees: (a) overview of the “ghost” forest recorded in 2005; (b) a ghost tree where the middle section of the tree is more a shadow than wood

distribution of the ghost trees, the extant forest, and surface artifacts recorded from 2002 to 2005, the distinct boundaries between all three (Figure 1.3b) was provocative: little overlap existed between them.

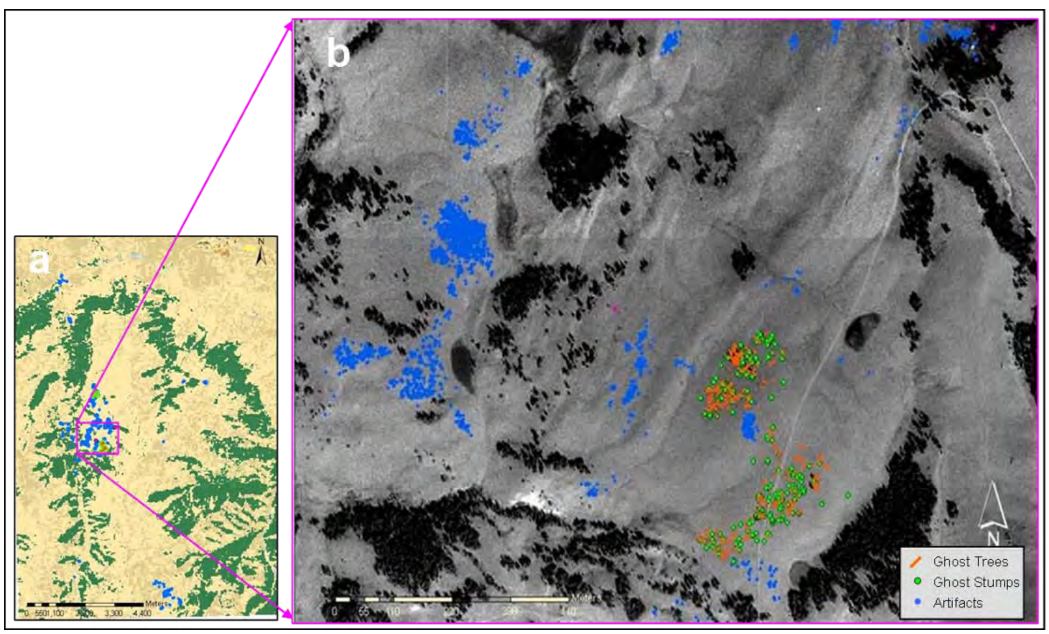


Figure 1.3. Spatial distribution of artifacts, ghost trees, and extant forest: (a) Landcover data showing the distribution of coniferous and mixed forest for the Phelps Mountain USGS quadrangle (USGS 2005); (b) Spatial distribution plotted on an orthographic image of the region (WyGISC 2005).

Not surprisingly, between 2002 and 2005, very few surface artifacts had been recorded in forested areas; a heavy layer of duff and significant numbers of snags, or downed trees, impeded visibility. The same could not be said, however, for the area encompassing the ghost trees. Located on a gentle sloping, open meadow where ground visibility seemed no different from surrounding areas, the lack of artifacts within the boundaries of the ghost forest was in stark contrast to the multitude of artifacts located at the margins of the remnant forest and beyond. Such discrete boundaries--between cultural remains and both extant forest and paleoforest—led me to three initial questions: “To what extent, if at all, was the forest in this subalpine environment used or occupied by past human groups,” and “If the forest was indeed inhabited or it’s resources exploited, was the human presence so ephemeral as to leave little trace, or could other factors such as environmental conditions or landscape taphonomy be a more plausible explanation for the paucity of artifacts?” An even more basic question followed: “What can trees, both living and dead, tell us about human behavior, landuse patterns, and the environment?”

In many ways, the experience of documenting the ghost forest and evaluating the spatial relationship between extant forest, paleoforest, and artifacts found in the open meadow reinforced the idea of another “blank spot on the map” to be explored –a theme that resonates throughout this study and the history of this region. In this instance, the “blank spot” refers to not only the lack of artifacts observed within past and present forested boundaries but also to the ephemeral nature of trees. The ghost trees, once an ancient forest “on the map,” are now a faint reminder of shifting forest edges and the dynamic interplay between climate, forest and grassland. While reflecting on the relationship between trees, open parkland and archaeology, questions for my thesis began to form. For example, assuming that the borderlands between forest and grassland attract both humans and mammals alike, “What evidence of past human activity still reside in the forest?” In other words, rather than a forest apparently devoid of archaeology, the question became “What story is missing that trees and the forested environment have to tell?” A second, but related question also surfaced: “Is it possible that even the ghost trees--those seemingly quiet vestiges of the past--obscure the archaeological record lying beneath them?” And from these, two additional questions emerged: “how might this archaeological cache be unlocked” and “do the ghost trees and the forest serve as markers on this landscape for underrepresented archaeological potential and, simultaneously, for an ephemeral and irreplaceable cultural and paleoenvironmental record that needs urgent attention?”

Research Context

With those initial questions in mind and a desire to explore this cultural void related to the forest, tree-ring samples for dendrochronological study were collected starting in 2006. In 2006, students from the GRSLE project assisted me in collecting more than 120 tree-ring samples from historic cabins, culturally modified trees, and both living and remnant trees in the area around Jack Creek. Just as we finished collecting these samples, another event was set in motion that would not only dramatically alter the landscape, but also provide new perspectives on both archaeology and the forest in this montane landscape and reorient my own research objectives.

The Little Venus Fire, ignited by lightning in June of 2006, burned nearly 14,000 ha (>34,000 acres) in the GRSLE study area, including much of the area where this current study is located. The fire, which burned at least three historic cabins and an unknown number of prehistoric wooden structures including several wickiups and a sheep trap, also had the effect of exposing unknown sites in previously inventoried areas and transforming the way we thought about other sites in the GRSLE project. In terms of this study, significant sites have now been documented well within the boundaries of the burned forest, adding a layer of cultural depth to this part of the ecosystem that might otherwise have remained undetected. Sites have also been recorded in patches of dead trees and at forest boundaries. These sites have revealed bison processing localities, hearths, trade beads, metal artifacts, ceramics, and many more artifacts which were rarely observed before the fire (Todd 2008). Some of these sites were known and considered relatively insignificant before the fire, but with increased surface and sub-surface visibility, our view of these sites has been completely transformed (Thompson 2008). In fact, a pre- and post-burn analysis of six previously recorded sites in the GRSLE study area by Burnett and Todd (2009) yielded astonishing results: post-fire site size increased by an average 652% and the number of artifacts increased by an average of 1592%. These statistics underscore how dramatically fire can change our perception of the archaeological record.

Like other multi-scale ecological processes and disturbance regimes common to the area, from mass-wasting events (Ollie 2008) to site biotic activity (Bechberger 2010), fire not only obliterates but also reveals, resorts, and renews. Figure 1.4 shows the oxidized soils and outline of a ghost tree post-fire. Prehistoric artifacts have been found in exposures like the one in the photograph, often with no indications of prehistoric occupation visible in the adjacent, intact grassland. The Little Venus Fire has served to erase the discrete boundaries between the forest and culture delineated in the 2005 ghost tree study and imbued a "blank spot" with unanticipated detail, yet, for me, the questions of how the forest has been accessed and used over time remains central.

Figure 1.4. The remains of a ghost tree after the Little Venus Fire.

Andrew Ellicott Douglass, who founded the discipline of dendrochronology, described tree-rings as "talkative" (1929). In my mind, even the shadow of a ghost tree, like the one pictured above, has a story to tell. Since the 2006 fire, additional tree-rings samples have been collected from historic cabins, living and remnant wood, and from ghost trees in order to address both the original questions from the ghost tree study, and others that have developed since.

Environment

The present-day landscape of the Upper Greybull Watershed and that of Jack Creek is typical of high altitude environments in much of Wyoming. Encompassing elevations ranging from approximately 2800 m to 3200 m the study area constitutes a subalpine ecosystem extending from just below treeline to the alpine and montane zones below. The area is characterized by open meadows, patches of conifers, ephemeral ponds, and hummocky spring sources. The area is dominated by Englemann spruce (*Picea engelmanni)* with alpine meadows comprised of mountain grasses and forbs and sagebrush (*Artemesia tridentada*). Small pockets of limber pine (*Pinus flexilis*) dot the landscape, but tend to be restricted to rocky outcrops and steeper terrain. Many game species take advantage of this ecosystem and its margins during the late spring and summer months but move from this subalpine environment into the foothills or below to survive the winter (Knight 1994:23). Others winter by hibernating or burrowing. Animal species that inhabit the study area include wapiti (*Cervus elaphus*), whitetail and mule deer *(Odocoileus hemionus and virgninianus*), pronghorn (*Antilocapra americana*), big horn sheep (*Ovis candensis*), gray wolf (*Canis lupus*), coyote (*Canis latrans*), wolverine (*Gulo gulo*), northern pocket gopher (*Thomomys* *talpoides*) and both the black bear (*Ursus americanus*) and the grizzly bear (*Ursus arctos horribilis*)

At this high altitude, the growing season is short; the result of a number of factors including topography and elevation, northern latitude, polar air masses, inner-continental location, and increased precipitation/decreased temperature at high elevation (Knight 1994:23). Topographical position and exposure are two of the strongest ecological drivers behind plant and animal distribution patterns: “In fact,” writes Knight, “high south-facing slopes that receive direct solar radiation throughout the year may be as dry as deserts at much lower elevations” (1994:24-25). In subalpine environments, the duration of snowpack appears to be a limiting factor for both seedlings and juveniles of woody trees (Graumlich 1994:175; Jackson 2005:1101; Peterson 2005). In addition, other studies have shown that summer temperatures can have an adverse effect on seedlings, perhaps due to their intolerance of extremes, while benefiting mature trees (Graumlich 1994:175; Jackson 2005).

The landscape of the study area reflects these ecological processes, with trees located along cooler north-facing slopes where snowpack lingers and available moisture is higher (Knight 1994), and along drainages where mesic conditions are minimized. Figures 1.5a and b show the distribution of the modern forest in the study area based on USGS land cover data (USGS 2005) and location of coniferous and mixed forest based on aspect. Using ESRI ArcGIS aspect calculator, a majority of the modern forest cover (88%) is located on northeast and northwest-facing slopes. Reflecting the dominant drivers described above, trees in the study area are limited mainly to north-facing slopes or areas with an available water source nearby, and the open meadows show little evidence of seedling establishment. As a final bit of context to this environmental overview of the study area, by 2005 virtually all the trees in this study had been devastated by a bark beetle outbreak. When the Little Venus Fire struck in 2006, most of these trees were already dead or dying. In an arid subalpine environment such as this, where increased solarization can have a profound effect on available moisture, regeneration after ecological disturbance can take hundreds of years (Knight 1994). In this respect, the tree-rings collected as part of this project provide not only an opportunity to chronologically situate sites and record human landuse, but also to capture and preserve part of an endangered record of subalpine ecological processes, including tree-line transgression and recession.

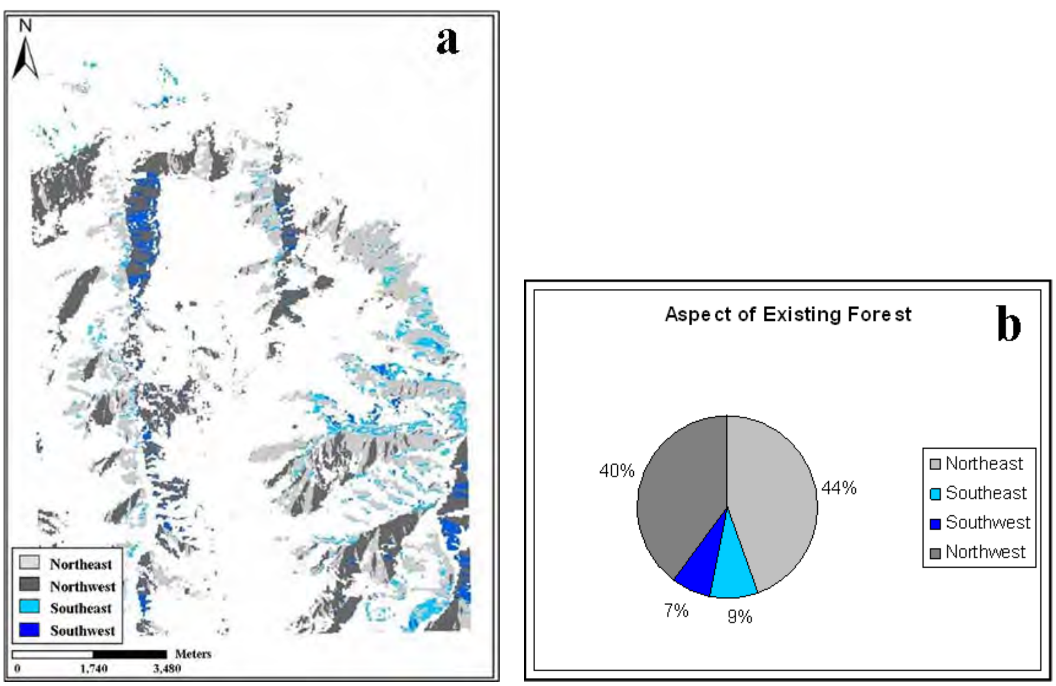


Figure 1.5. Distribution of forest by aspect: (a) distribution by aspect of coniferous and mixed forest for the Phelps Mountain quadrangle based on landcover data (USGS 2005); (b) the percentage of forest broken down by aspect for the Phelps Mountain quadrangle.

Study Area and Objectives

The majority of the tree-rings samples collected for this study come from cabins and trees located within the Jack Creek drainage. The study area is primarily located in the upper portion of Jack Creek, a major tributary of the Upper Greybull River, which runs north from its headwaters at Francs Peak, curving east as it drops into the Bighorn Basin. Two additional drainages of the Upper Greybull River form a smaller portion of the study area. Tree-ring samples have been collected from a cabin along Piney Creek (a major tributary that feeds into the Greybull from the north) and from two cabins east of Jack Creek, which are located on tributaries that drain into the Greybull from Francs Fork, another major tributary of the Greybull. At the confluence of Jack Creek and the Greybull River, near the modern-day Jack Creek campground, are the trailheads for several historic trails, including the Jack Creek Trail from which four of the seven historic cabins in this study can be accessed. Further up the Greybull River are additional historic trails that link the various tributaries and drainages of the watershed. Of the 30 historic cabins that have been documented as part of the GRSLE project, most are situated along these interconnected historic trails. This network of cabins and trails are indicative of the kind of historic activities that took place in this remote region during the last 150 years. The GRSLE project area, like much of the Shoshone National Forest, has been used historically as summer range for cattle and sheep, big game hunting, recreation, mining, and oil and gas exploration (Edgar and Turnell 1978; Pickett 1913; Franc Von Lichtenstein 1886-1903; Anderson 1933; Woods 1997; Mueller 2006).

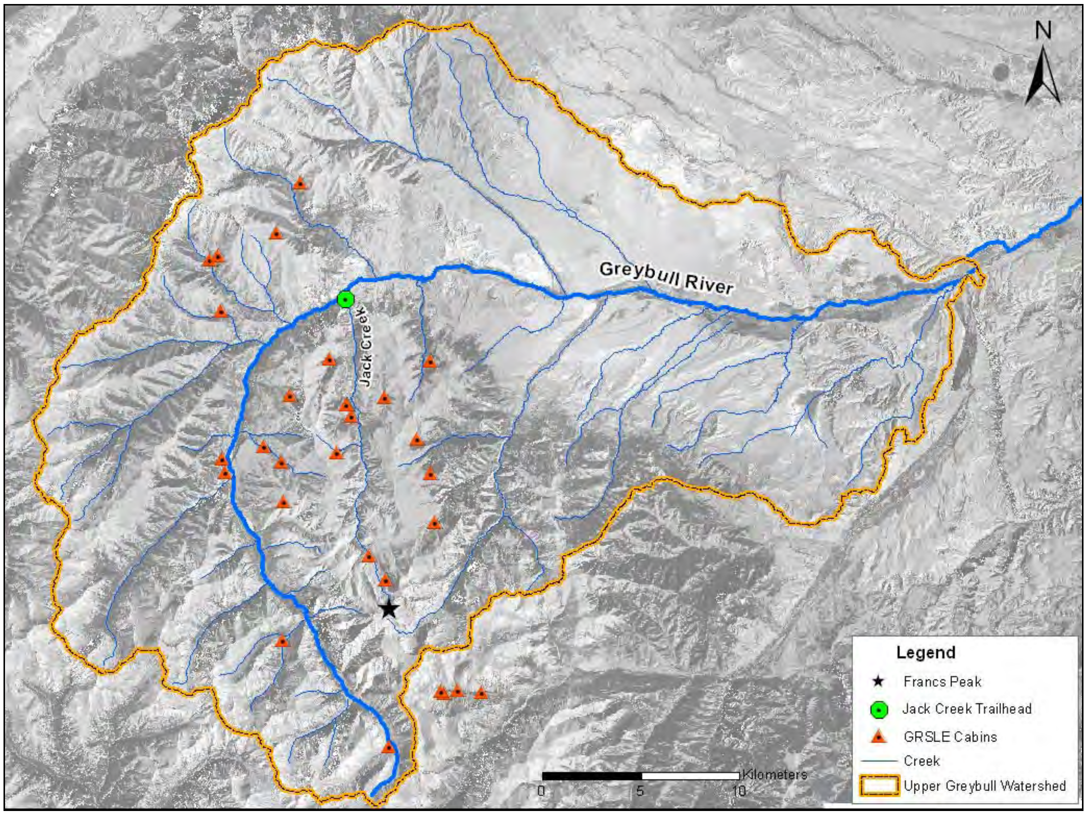


Figure 1.6. Map of the study area including watershed, Francs Peak, GRSLE cabins and Jack Creek trailhead

This project attempts to integrate the views of this landscape as archaeologically and culturally marginal with increasing evidence of a long used and active landscape that is both culturally rich and "talkative." At the heart of this study are those initial questions posed above, which focus on three central considerations related to trees, the adjacent grassland, and archaeology: 1) Rather than a perception of trees as silent ecological sentries, "what might trees and the forest tell us about past human behavior, landuse, and environment"; 2) "How does the forested environment and landscape taphonomy erase, obscure, and reveal the archaeological record"; and 3) "How do other proxies such as historic documents compare to the stories these trees have to tell?" The following outlines the four main objectives of this study that grew out of these preliminary questions and describes the thesis organization:

Objective 1

To explore the notion of "emptiness" in regard to historic conceptualizations of the wilderness as devoid of a human presence, as well as impressions of the forest, as largely "empty" until fire revealed un-discovered archaeological material. Chapter 2 summarizes the historical context and attempts to answer the question of "Who was present on this landscape and when."

Objective 2

To collect, preserve and cross-date archaeological-related tree-ring samples from this fragile and threatened environment. This ongoing and pressing objective is part of a much larger, long-term effort to collect and preserve endangered and rapidly disappearing archaeological-related wood; this thesis provides only a snapshot of this objective. Chapter 3 describes the science and theory behind dendrochronology and outlines methods used in sample collection, preparation, and crossdating. Chapter 4 presents the results of the crossdating analysis.

Objective 3

To illuminate the cultural practices that involves wood or the forested environment in the study area. Chapter 4 discusses land use activities and the tree-ring crossdating results. Culturally peeled trees are discussed in Chapter 5 as a possible adaptive strategy in times of environmental stress and as a future research direction.

Objective 4

To compare two very different proxies, “talkative” tree-rings and historic documents, in order to reconstruct past climate and better understand the ways in which the climate may have influenced past human behavior. Chapter 5 summarizes the four objectives listed above and discusses results. Chapter 5 outlines the development of a standardized master chronology for the study area, which can be used to reconstruct climate and forest dynamics. This chronology is then compared to historic accounts from the area that chronicle temperature and climate events. Chapter 5 closes with a discussion of future research--including further analysis of tree-rings to more completely reconstruct past climate and environment and advocates for immediate and directed attention towards the preservation of this fragile record of past human activity before it is irretrievably lost.

CHAPTER 2: HISTORICAL FOUNDATIONS

> "Yes! This stupendous display of nature's handiwork will be to me 'a joy forever.' It lingers in my memory like the faintly defined outlines of a dream. I can scarcely realize that in the unbroken solitude of this majestic range of rocks, away from civilization and almost inaccessible to human approach, the Almighty has placed so many of the most wonderful and magnificent objects of His creation, and that I am to be one of the few first to bring them to the notice of the world."
>
> --Nathaniel Pitt Langford (1905:97), *the Discovery of Yellowstone Park 1870*.

Archaeologists have long debated the extent to which montane environments adjacent to the North America Great Plains were visited and inhabited by humans. Some archaeologists have argued, for example, that during Paleoindian times, or the early Holocene post-glacial period, high mountain peaks acted as a thoroughfare by providing relatively unencumbered "travel routes" above glacial expanses (Nabakov and Loendorf 2004:18). Alternatively, George C. Frison has proposed a foothill-mountain Paleoindian adaptation in which cultural groups responded to different economic resources and devised subsistence strategies that optimally exploited the available resources (Frison and Walker 2007). The Medicine Lodge Creek (MLC) site, located at an ecotone between the interior Big Horn Basin and the Big Horn Mountains and excavated by Frison starting in the 1960s, exemplifies this foothill-mountain Paleoindian tradition. The MLC site provides evidence for an entirely different set of procurement strategies from that of Plains groups. The foothill-mountain adaptation included a high reliance on small to medium sized-mammals and birds and plant food, and required a different set of monitoring procedures related to seasonality and the short duration of plant food resources like berry patches, limber pine seed production, roots, and tubers (Frison and Walker 2007). Others have presented a “mountain refugia” scenario in which, especially during periods of severe drought on the Plains, prehistoric peoples followed game into higher elevations and found safe haven in moist and cool mountain retreats (Benedict 1978, 1992, 1999; Benedict and Olson 1978; Meltzer 1999; Nabakov and Loendorf 2004:18). Writing about land use in the southwest, Daniel Amick (1996) has proposed yet another scenario, a “conveyance zone,” where Plains groups traveled annual, season-based circuits that moved from the Plains to the foothills/mountains and then back to potential interaction zones on the Plains for gathering and trade. While none of these scenarios is necessarily contradictory, they do reflect the growing body of literature that examines land use in western montane environments and the interactions between native groups who have been traditionally thought of as distinct--the Plains, Foothills (Plateau), and Mountain groups. Bender and Wright (1988) have argued, in fact, that where mountains form an integral part of the landscape in North America, “archaeologists have demonstrated that reconstruction of regional prehistory cannot be successfully achieved without considering the processes by which local populations adapted to mountainous ecosystems.” Despite this insistence on integrating and understanding montane adaptations, archaeologists, according to Bender and Wright, have been slow to embrace the Rocky Mountains as more than a marginal environment in relation to human existence. “Much of this oversight,” they write, “probably derives from our own culturally embedded notions of mountains as inaccessible and marginal (Bender and Wright 1988:619).

It was within this context that in 2002, Dr. Lawrence C. Todd from Colorado State University launched the Greybull River Sustainable Landscape Ecology (GRSLE) project, an archaeological field school conducted in the central Absaroka Range of Northwestern Wyoming. This portion of the Shoshone National Forest, which includes the Washakie Wilderness, constitutes some of the most remote and "pristine" areas of the Greater Yellowstone Ecosystem (Figure 1.1). Few places could better typify Bender and Wright's notions of mountains as "inaccessible and marginal." As mentioned previously, prior to 2002 no systematic archaeological investigations had ever been conducted the GRSLE study area further illustrating the point of an overlooked environment.

After eight field seasons of the GRSLE project, the notion that this montane environment could be characterized as inaccessible, marginal or bereft of a long temporal human presence is contradicted by the archaeological evidence: over 73,200 chipped stone artifacts have been recorded and 384 prehistoric and historic sites have been identified. Of the 797 projectile points recorded, 219 are typologically distinct enough to assert the presence of humans on the landscape dating back to the onset of the Holocene and spanning the temporal designations: Paleoindian: 17; Early Archaic: 21; Middle Archaic: 33; Late Archaic: 193; Late Prehistoric: 252; and others that have been identified more generally as unknown Archaic or not prehistoric (Todd, personal communication 2009). Such findings are, quite obviously, at odds with notions of an untouched, unaltered and temporally-static mountain environment.

Historical Context: Who was Present and When?

Answering the question, however, of *who* was present on the landscape and *when* is hardly a simple task. The Big Horn Basin was one of the last areas in the West to be explored and settled by early Euro-Americans (Larson 1965; Woods 1997). Thus, first-hand historical accounts for this region, especially of the Absaroka Mountains, are sparse. Additionally, the study area was originally part of the Yellowstone Park Forest Reservation, the first forest reserve in the Rocky Mountains. Set aside by President Harrison in 1891 as part of the Forest Reserve Act, the act authorized the withdrawal of land from the public domain in order to provide a buffer for what would later become Yellowstone National Park. Thus, public perceptions of the area as pristine, rugged, and a natural oasis empty of inhabitants were formed early on. Finally, the tendency to view montane environments as inaccessible and marginal in terms of past human adaptations have biased ethnographic and archaeological accounts of the region, especially those conducted (or, rather, not conducted) in the early twentieth century. This chapter explores how Euro-American conceptions of the Yellowstone region as vacant and newly "discovered" has served to continually reinforce culturally-ladened notions of both "The Frontier" and of "The Wilderness." Such perceptions not only influence modern day interpretations of montane environments and past human adaptations, they also influence how historians and archaeologists investigate the question of who occupied this landscape both historically and prehistorically. The story, or stories, of who inhabited this land and when is inextricably tied to the story of European exploration and the "discovery" of America.

Early Accounts: Trappers and Explorers near "Yellow Stone"

Early territorial maps of present-day Wyoming are most notable for a lack of topographic detail in the northwestern corner of the region in comparison to other portions of Wyoming and the Frontier in general (Figure 2.1a and b). The Yellowstone area is surrounded on all sides by formidable mountains--the Absaroka,

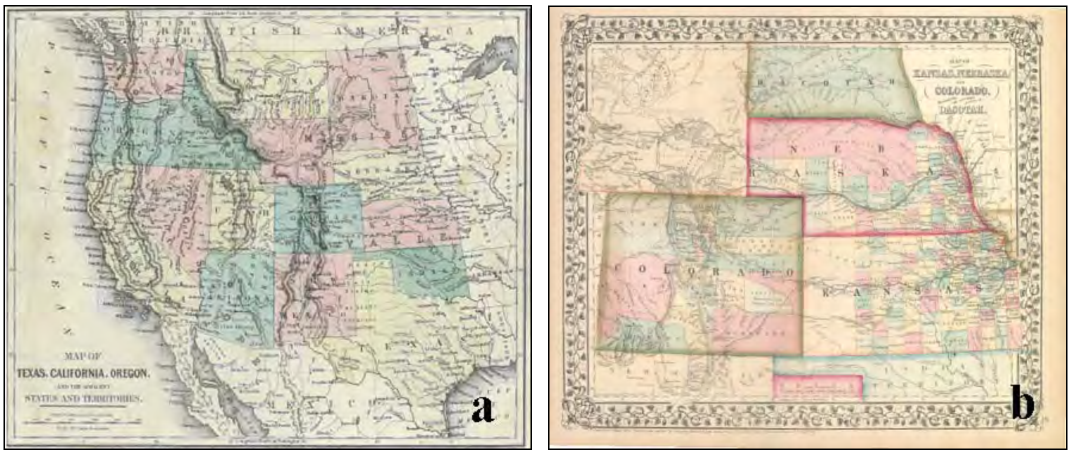


Figure 2.1. Historic maps of the West: (a) "Map of Texas, California, Oregon and Mountain and the Adjacent States and Territories," the Absarokas are not depicted (personal collection, unknown 1867); (b) 1867 "Map of Kansas, Nebraska and Colorado, Showing also the Southern portion of Dacotah" with the mountains of northwestern Wyoming only vaguely represented (personal collection, map by S. Augustus Mitchell, Jr.)

Teton, Gallatin, Beartooth and Snowy ranges--and would have been difficult to traverse by early explorers. Lending credence to a perception of this area as inaccessible and uninhabited, the region is considered to be one of the last areas explored by Europeans, precisely because of the difficulty in navigating the terrain and, later, on account of "Indian hostilities." In 1804-06, for example, while exploring the newly acquired Louisiana Territory, Lewis and Clark chose a route to the Pacific Coast north of present-day Wyoming, avoiding the daunting canyons of the Big Horn Basin that made river travel through the area difficult (Woods

1997:27-28). After breaking with the expedition, two former Corps of Discovery members, George Drouillard and John Colter, headed into the Bighorn Basin in 1807-08 as trappers and have been credited with the first documented exploration of the Yellowstone basin (Beal: 1949:35-40). Their routes and observations are incorporated into Clark's map of 1814 (Figure 2.2a and b).

Figure 2.2. Maps of the Lewis and Clark expedition: (a) the Lewis and Clark map of 1814 (US Geological Society 2010); (b) Colter's route superimposed on the Lewis and Clark map of 1814 (Lewis and Clark, Fort Mandan Foundation 2010).

A dotted line marks "Colter's Route in 1807," which places Colter close to present-day Yellowstone National Park (YNP). The blue circle approximates the location of the GRSLE research area (this portion of the map, which probably relied upon second-hand accounts and inference, is not to scale).

Colter is often credited with the being the first white man to enter the park, returning with descriptions of the natural wonders and bubbling, hot waters of the basin, but it remains unclear whether he actually saw these phenomena first hand. For one thing, the western loop of his route, east of the Absarokas is geologically inaccurate on the 1814 map (Beal 1949:42). This raises an interesting point: early diary accounts kept by European explorers are teeming with descriptions of contact with both Indians and old trappers who shared their knowledge of the landscape and often directed these explorers or accompanied them on their routes. Yet, it is the explorers who are credited with discovery, and the experiences and expertise of both Indians and old trappers are only tangentially acknowledged or chronicled.

One of the richest accounts of this early period and of interactions between fur trappers and Indians comes from the diary of Osborne Russell, a trapper who wrote of experiences between the Rocky Mountains and the mouth of the Columbia as a member of the Wyeth Expedition beginning in 1834 (Haines 1955). In his diary he describes both daily experiences and the interaction between Indians and other fur traders while traveling through the interior of the West. In 1834, for example, he writes of attending one of the most famous fur trading gatherings, the "Rendezvous," in the region--a meeting of whites and Indians that occurred annually on a small western branch of the Green River at "Ham's Fork" from 1824-1840. He describes the gathering as composed of "600 men, including men engaged in service, white, half breed, and Indian fur trappers" (Haines 1955:3). In 1836, after leaving this annual Rendezvous near Fort Hall, Russell's party headed up the Snake River with the objective of reaching the "Yellow Stone." Figure 2.3 depicts the route the party took to the Yellow Stone from the 1836 Rendezvous at the confluence of Horse Creek and the Green River as well as their return route the following year through the Big Horn Basin. Note the cartographic void (circled in blue), or empty space, where the central Absaroka Range is located.

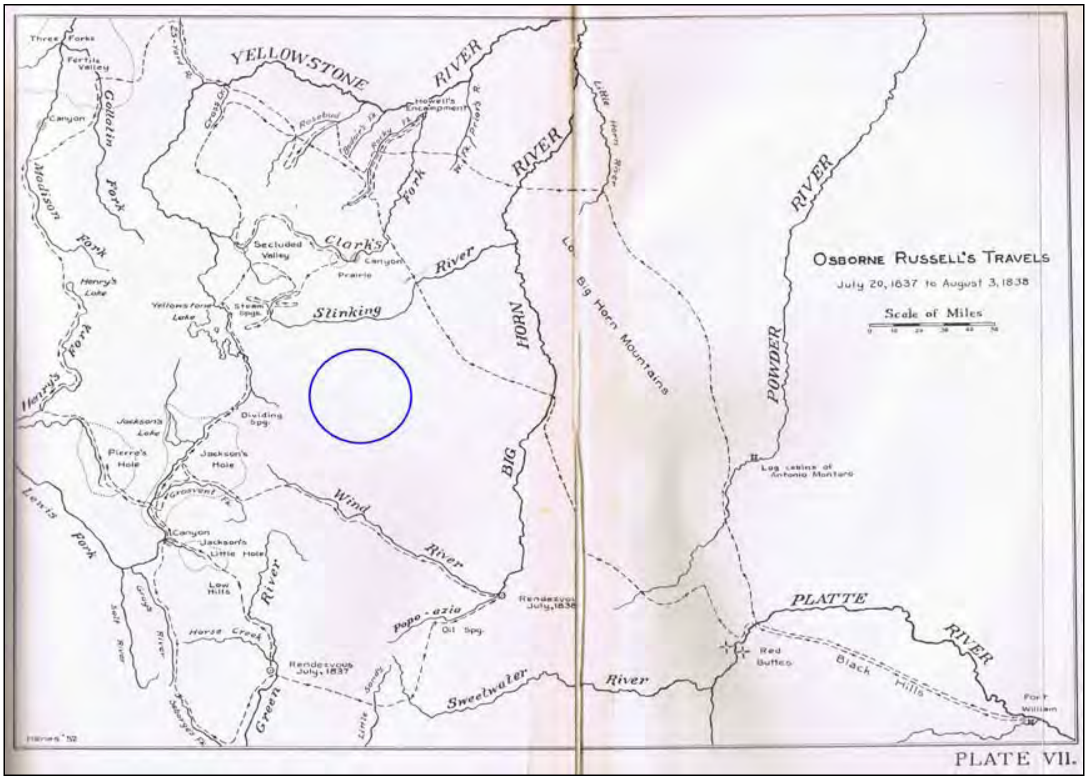


Figure 2.3. Map of "Osborne Russell's Travels, July 20, 1837 to August 3, 1838" (Haines 1955). The study area is circled in blue and the route depicted with a dotted line on the map.

Along the way, Russell chronicled numerous encounters or near-encounters with Indians as the party circumvented the Yellowstone region. For example, when the party is most likely in the Wind River Basin,[1] the party meets up with two young Indian men hunting mountain sheep who identify themselves as "Shoshonies."[2] The Shoshoni talk of their family to the north of the Wind River Basin and to the southeast of Yellowstone Lake and provide directions on how to get to the Yellowstone area along the streams of the south fork of the Shoshoni River. They further state that to the north of the stream is where the buffalo and

[1] Russell describes his location: "On the West and North of us [was] one vast pile of huge mountains crowned with snow." According to notes by Haines (1955:22), Russell and his party were looking at the Absaroka Range and in notes from the 1965 revised edition, Haines identifies the location as the Wind River Basin.

[2] These Indians were probably members of the Chief Washakie's Shoshoni (Haines 1955:23)

Crow reside (Haines 1955:23). The territory they describe, along with its inhabitants, more than likely encompass the GRSLE study area.

Other depictions in the diary of encounters with Indians offer insight into Indian culture as witnessed by early Euro-Americans. Near a branch of the Yellow Stone, writes Russell, the party comes across what was probably a band of Shoshoni:

> "Here we found a few Snake Indians comprising 6 men 7 women and 8 or 10 children who were the only Inhabitants of this lonely secluded spot. They were neatly clothed in dressed deer and Sheep skins of the best quality and seemed to be perfectly contented and happy. They were rather surprised at our approach and retreated to the heights where they might have a view of us without apprehending any danger, but having persuaded them of our pacific intentions we then succeeded in getting them to encamp with us. Their personal property consisted of one old butcher Knife nearly worn to the back two old shattered fusees which had long since become useless for want of ammunition a Small Stone pot and about 30 dogs on which they carried skins, clothing, provisions etc on their hunting excursions. They were well armed with bows and arrows pointed with obsidian The bows were beautifully wrought from Sheep, Buffaloe and Elk horns secured with Deer and Elk sinews and ornamented with porcupine quills and generally about 3 feet long " (Haines 1955:26-27).

The party proceeded to trade with the Snakes and later one of the Snakes "drew a map of the country on white Elk Skin with a piece of Charcoal after which he explained the direction of the different passes, streams etc From them we discovered that it was about one days travel in a SW direction to the outlet or northern extremity of the Yellow Stone Lake" (Haines 1955:27). These two encounters demonstrate the depth of knowledge these Indians had of the area and landscape as well as the location of other Indian groups and available resources.

Accounts like the ones provided by Osborne Russell and other fur traders during the same era—accounts of the Rendezvous, the skirmishes, the friendly encounters with Indians, intermarriage and everything in between--make it abundantly clear that depictions of the Yellowstone region as uninhabited and inaccessible are patently incorrect. As the next section will explore, notions of the Frontier as yet undiscovered and empty of humans was not only wrapped up in European conceptions of civilization and colonial claims to territory, but also imbued the discipline of anthropology with a set of preconceived assumptions that limited early investigations of the region.

Colonialism and Settlement of the Bighorn Basin

During early exploration of the New World, competition between European countries for title, based on claims to original discovery, were shored up by either discounting native claims to land or rendering indigenous territory empty or forsaken.[3] This myth of the Frontier as deserted or alternatively, as uncivilized and newly "discovered," persisted over the next three centuries despite shifting territorial claims to land and demarcations, and it continued to be a prominent theme in historic documents throughout the nineteenth century. In 1842, as one example, Captain John C. Fremont entered Wyoming, discovering the highest peak in the land and naming it Fremont Peak. He writes of the occasion: "We had

[3] In the Introduction to the Eighteenth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian 1896-'97, *Indian Land Cessions in the United States*, for example, Cyrus Thomas wrote of the colonial laws, "In all these claims and contests between the civilized nations of Europe, the Indian title to the soil is nowhere allowed to intervene, it being conceded that the nation making the discovery had the sole right of acquiring the soil from the natives and of establishing settlements on it (Powell 528). Thomas further observes that as early as 1529, Spanish law discounted native claims to land, "no claim by the natives to unoccupied and or uninhabited territory appears to have been recognized. Such territory was designated as 'waste lands,' and formed part of the royal domain" (Powell 1899: 539)

climbed the loftiest peak of the Rocky Mountains, and looked down upon the snow a thousand feet below, and, standing where no human foot had stood before, felt the exultation of first explorers" (Ticknor and Fields 1856:88). Such myths served to not only justify conquest and territorial sovereignty, but by the 19th century, reaffirmed the sacredness of a national enterprise. In this context, with no perceived claim to the land or to its discovery, Native Americans were seen as mere interlopers or as nothing more than extensions of a wilderness that was in the process of being tamed.

After the Treaty of Guadalupe-Hidalgo in 1848, when all of present Wyoming came under the control of the United States, rapid changes in the region ensued. The U.S. government purchased Fort Laramie in 1849 and by the 1860s, a military presence existed in the Big Horn Basin (Woods 1991). The transcontinental telegraph was completed in 1861. The Bozeman Trail was established in 1863, and in 1866, Nelson Story drove the first cattle herd through Wyoming. In 1867, Fort D.A. Russell and Camp Carlin were established, Cheyenne was founded, and the Union Pacific Railroad reached Wyoming.

Fur trappers and prospectors were some of the earliest Euro-Americans to enter the Upper Greybull River Watershed area. In the fall and winter of 1869-1870, against objections of officials in Washington and the Indian treaties of 1868, members of the Big Horn Expedition crossed into Indian grounds and camped near the Greybull. The Big Horn Expedition comprised primarily of prospectors and citizens. These "Big Horners" conducted some of the first prospecting parties into the area surrounding the Greybull, and by 1873 gold prospectors were active in the

Absaroka Mountains (Edgar and Turnell 1978; Woods 1997:62). Despite the Indian treaties of 1868, gold discoveries in the Yellowstone basin and the efforts to build railroads placed increasing pressure on Native Americans to cede their land. In 1877, the Mountain Crows sold the Greybull River portion of their country; although, they continued to use the land for subsistence hunting for a number of the following years (Edgar and Turnell 1978).

Both Count Otto Von Lichtenstein, better known as Otto Franc, and Colonel William D. Pickett, led some of the first hunting parties into the Big Horn Basin and the Greybull River area. Professional buffalo hunters were soon to follow. Otto Franc likely hunted the Greybull area in the fall of 1877, building a cabin along the Greybull River the following year (Edgar and Turnell 1978). Col. Pickett hunted in the mountains near the Greybull, starting in 1879 (Pickett 1913). That same year, Otto Franc brought cattle into the Greybull and established the first ranch, the Pitchfork. Col. Pickett describes the "Grey Bull River country" in 1881 as "wholly free from the contaminating influences of the white man" (Pickett 1913: 207), but in a few short years the Greybull River valley would be completely transformed. First-hand accounts of the early 1880s describe this area as centered around hunting, trapping, and increasingly, cattle herding. In the early 1880s, game was still abundant in the region drawing many professional hunters (Edgar and Turnell 1978). The Shoshoni and Crows continued to hunt the land annually or seasonally, often camping near trading posts--trading and gathering supplies--or "calling on"[4]

[4] The notion of "calling on" someone is a phrase often used in early accounts of the West. It was common courtesy for visitors passing through an area to visit or at least acknowledge their presence in an area. What is also clear from these accounts is that there was a tremendous amount of exchange and interaction in the area between Native Americans, trappers, travelers, settlers and hunters.

early settlers and outfitted camps (Franc Von Litchenstein 1886-1903; Pickett 1913; Arland 1872-1889). However, by 1885, bison had been all but extinguished from this area, and the wave of Euro-American expansion was inescapable. In 1886, Colonel A.A. Anderson, traveled to the area and staked claim to a 160-acrea homestead, which became the Palette Ranch, along the Upper Greybull in a valley near Piney Creek (Figure 4.1). In his autobiography, published in 1933, Anderson laments the transformation of this region:

> "Beginning with deforestation, the wholesale slaughter of the buffalo and other game, wasteful methods of farming, the squandering of water-power sources and of wealth in mineral oil, the history of the country under white occupation has been the heedless waste and destruction of our natural resources." (1933:89-91).

By the turn of the century, Anderson became one of the primary advocates for the establishment of the Yellowstone Forest Reserve to conserve and protect the natural environment including wild game, water, and the forest. On July 1, 1902, Anderson became the first superintendent of the Yellowstone Forest Reserve, appointed by President Theodore Roosevelt.

The Making of Yellowstone and the Unmaking of the Indian

Merrill D. Beal, one of the first historians of Yellowstone National Park, described northwestern Wyoming in the 1860s and 1870s as tumultuous and particularly agonizing for Indians:

> "It was a time when racial antagonisms and cultural conflicts swept every tribe into the whirlpool. Each in turn wrecked itself against the might of federal power. Finally, a crimson trail was stretched toward Yellowstone when Nez Perce Joseph chose to make it a part of his escape route. The Park area and its environs was by way of becoming the Indians' last refuge. Therefore, the destiny of

> Yellowstone itself was contingent upon Solution of the Indian problem" (1949:147-48).

As the 1860s came to a close, the fate of the native inhabitants of the interior West was assured. In the same year that Wyoming became a territory (1868), Chief Washakie signed a treaty at Fort Bridger, agreeing to relocate his Eastern band of the Shoshoni, along with their neighbors, the Bannock, to the Wind River Reservation. The Cheyenne and Arapaho relinquished claim to Wyoming land and moved to the Dakotas (Hunt 1941), and the Mountain Crow signed a treaty that established the Crow reservation in Montana (Woods 1997:69).

It was in this atmosphere that the Folsom-Cook party made the first recognized Euro-American visit to Yellowstone in 1869. This was followed by the Washburn-Langford-Doane Expedition in 1870 (Beal 1949; Langford 1905). Nathaniel Pitt Langford, diarist of the Washburn Expedition, describes their first encounter with Indians: "To-day we saw our first Indians as we descended into the valley of the Yellowstone. They came down from the east side of the valley, over the foot hills, to the edge of the plateau overlooking the bottom lands of the river, and there conspicuously displayed themselves for a time to engage our attention" (Langford 1923:67). Upon the return of the Washburn Expedition, Langford traveled to the east and regaled the public with stories of the natural wonders to be found in Yellowstone. Congress quickly moved to set aside 3,448 square miles of Yellowstone country, establishing America's first National Park on March 1, 1872. Langford became the first Superintendent (Langford 1923; Beal 1949; Nabakov and Loendorf 2004).

Nabakov and Loendorf describe the agenda of the United States government after the creation of Yellowstone National Park:

> "federal policy in general sought to abrogate American Indian interests in the greater Yellowstone region (as elsewhere in the west) . . . as far as any traditional hunting, foraging, trading, raiding, or other cultural activities were concerned, by the early 1880s Indians were effectively banned from entry into Yellowstone National Park" (2004:28).

In 1878, Philetus Norris, second superintendent of the park, launched a campaign to alter public opinion regarding the Indians and the park, ostensibly provoked by Bannock horse-stealing raids on tourists and laborers and subsequent negative publicity. In 1880, Superintendent Norris visited all of the Indian reservations in the Rocky Mountains, securing pledges from these tribes to cease entry into the park. "These agreements," writes Beal,

> "were widely advertised, and in order to further neutralize any fear of Indian trouble a policy of minimizing past incidents was evolved. The recent invasions were represented as unprecedented, actually anomalous. Indians had never lived in Yellowstone, were infrequent visitors because they were afraid of thermal activity!" (1949:91)

Contradicting these assertions, Norris, himself, had, at least on one occasion, encountered a permanent camp: "In trailing a wounded bighorn I descended a rocky dangerous pathway. In rapt astonishment I found I had thus unbidden entered an ancient but recently deserted, secluded, unknown haunt of the Sheepeater aborigines of the Park" (Beal 1949:85). Norris dismissed these fleeting encounters with Indians and the evidence of their presence in the area (Beal 1949). In his 1881 report on Yellowstone, he writes:

> "The only real occupants of the Park were a pigmy tribe of three or four hundred timid and harmless Sheepeater Indians . . . Whether these people are the remnant of some former race, as the legendary

> wild men of the mountains, or are descendants of refugees from the neighboring Bannock and Shoshone Indians, is not known, although their own traditions and the similarity of their languages and signals indicate a common origin, or at least, occasional intermingling. These Sheepeaters were very poor, nearly destitute of horses and firearms . . . Other traces of this tribe are found in the rude, decaying, and often extensive pole or brush fences for drive-ways of the deer, bison, and other animals . . ." (Hughes 2000:63-65; Beal 1949:85-86)

In addition to Federal and park efforts to restrict Native Americans to reservations and showcase the park as an unadulterated "Wonderland," the persistence of Euro-American conceptions of the wilderness as untrammeled and newly-discovered space further reinforced the image of Yellowstone National Park as "a geologic paradise, a pristine botanical garden, and an Elysium for wild game," devoid of an historic Native presence (Beal 1949:7). In sum, by the turn of the century, portrayals of Indians in regard to the greater Yellowstone area depicted them as superstitiously shunning the fiery, bubbling landscape or, alternatively, as diminutive, harmless, and anachronistic relics of the past. Thus, not only were Indians physically removed from Yellowstone, and for that matter, most of Wyoming; with time they came to occupy only a mythological presence in Yellowstone.

Who were the "Sheepeaters": Anthropology or Mythology

> "What happened to the timid Tukuarikas? They simply vanished from the scene as the white men invaded their refuge. They left without contest for ownership or treaty of cession. That is the way most Americans would have had all Indian tribes behave!
>
> ---Merrill D. Beal, 1947

> "These are a shy, secret, solitary race who keep in the most retired parts of the mountains, lurking like gnomes in caverns and clefts of the rocks, and subsisting in a great measure on the roots of the earth."
>
> ---Washington Irving, 1910 (Hughes 2000:15)

Ethnographic literature and historical documents are also quite consistent in portraying the Sheep Eaters--a tribe of "simple but well fed and good humored Savages" (Haines 1955:38)—as the only true inhabitants of Yellowstone. Beal (1949:67) writes,

> "Tukuarikas or Sheepeater Indians—'Tuku' means mountain sheep and arka, 'eat.' They did not possess ponies or firearms. They wore furs and skins and lived among the rocks in the Gardner River canyon in Yellowstone and in the Salmon River Mountains of central Idaho. There were some two hundred Indians in the Yellowstone tribe. Their main support was from game and fish. These Indians did not possess any distinctive culture of their own, but, hermit- like, they seemed concerned only to carry on by themselves until further notice."

The Sheep Eaters are described repeatedly as lacking horses, small in stature, bereft of culture, isolated and dwelling in caves or hidden in mountain crags. Susan S. Hughes (2000:9) argues that these mythical Sheep Eaters may be more a Euro-American construction than representative of a real tribe of Indians. She contends that images applied to these mountain dwellers replicated old stereotypes of savage, Indian, and Digger. The derogatory term "Digger" was originally used to characterize native California and Nevada hunting and gathering Shoshoneans and then applied to residents of the park (Nabokov and Loendorf 2004:29). The appellation of "Digger" came to be synonymous with all Shoshone who did not have horses or who did not practice bison hunting--whether they resided in the deserts or in the mountains (Hughes 2000:15). Eventually, "Digger" was used to describe the desert Shoshoni while the mountain Shoshoni inherited the equally weighted and derogatory appellation of "Sheepeater" (Hughes 2000:18).

The Sheep Eater designation was also not limited to the Shoshoni. Both the Henderson Expedition of 1866 and the Folsom-Cook party refer to Bannock-speaking "Sheepeaters" (Hughes 2000:19). Nabokov and Loendorf (2004:43) mention a Crow informant who, looking down upon a flat area along the Stinking River (the Shoshone River), pointed to a place where "the Sheep Eaters used to camp," referring to a branch of the Crow known as Those Who Eat Bighorn Sheep (*lisaxpuatduushe*). Thus, in addition to depicting a particular band of Indians, the "Sheepeater" label was a derogatory term that became synonymous with mountain dwellers in the Yellowstone area, regardless of cultural affiliation, and use of the term served to perpetuate stereotypes of the wilderness and of Indians while romanticizing Yellowstone National Park as a Wonderland, filled with mythical natural features and creatures.

Ethnographic sources also mention several other Indian groups who were at least intermittently present in the Yellowstone area, including the Blackfeet, Sioux, Ute, Flathead, Cheyenne, Arapaho, Modoc, Nez Perce and Kiowa (Hunt 1941). Writing for the Smithsonian Institution, John R. Swanton (1952:384) suggests that the Bannock might have ranged into western Wyoming and the Comanche probably resided in Wyoming before moving south. Despite these ethnographic summations of the many tribes who at one time or another entered Yellowstone country, the myth of an uninhabited region persisted

Archaeology in the GYE: Reinvigorating the Past

During the "Golden Age" of anthropology, no salvage archaeology was undertaken as none of those early anthropologists considered the area significant enough to study (empty, as it was, of inhabitants), especially since the park was by then off-limits to Indians (Nabakov and Loendorf 2004:10-12). Clark Wissler, who was the first to use the "culture area" classification system, originally identified Yellowstone as part of the Plains culture. He later recognized the influence of both the Great Basin and the Plateau native regions. In the 1920s, Alfred C. Kroeber refined this designation by separating Yellowstone National Park into the Intermountain and Plains cultural areas. Julian Steward, who studied Shoshonean groups starting in the 1930s, identified Yellowstone as an area where three cultural regions converged: the Plains, the Plateau, and the Great Basin (Nabakov and Loendorf 2004:8). With each of these classifications, the area was given more complexity, placing Yellowstone at the cross-roads of three major culture areas: the salmon-fishing peoples of the Columbia Plateau to the northwest, the mobile and mounted hunting peoples of the Plains to the northeast and east, and the Great Basin groups to the south (Loendorf and Stone 2006:32). The way in which anthropology has treated this area over time offers further evidence of how this area, perceived historically as empty and inconsequential, has become significant and potentially vital to interpreting past human lifeways.

During the 1940s and 1950s, the Swedish historian Ake Hultkrantz extensively documented the Sheep Eater culture, attempting to interview elders of Sheep Eater ancestry (Weixelman 2001). His work has provided vast amounts of data on the "religious ecology" of the Sheep Eaters. By the time Hultkrantz studied the Sheep Eaters, however, they had been dislocated and living on reservations (primarily on the Wind River Reservation, see Figure 1) for nearly a century; the myths associated with Yellowstone and Indians had been circulating even longer. Thus, when considering the mountain-dwelling Sheep Eaters of the past, anthropologists are “obliged to take a largely ahistorical ‘snapshot’ of Sheep Eater life, to some degree casting them in a timeless amber” (Nabokov and Loendorf 2004:200). In this context, continued ethnographic documentation and archaeology can play a vital role in reconstructing an Indian presence in the Greater Yellowstone ecosystem.

Several key archaeological sites provide a framework for establishing the extent to which the Greater Yellowstone Ecosystem has been used both historically and prehistorically. Located a few miles from Yellowstone National Park along the North Fork of the Shoshoni, Mummy Cave was first excavated professionally by Wilfred Husted in the 1960s. The rock shelter yielded a projectile point sequence and at least 38 distinct cultural layers that range from the historic period to over 9000 years ago (Wedel et al. 1968).

A second site, located approximately 25 miles east of Yellowstone, known as the Dead Indian Creek site was excavated by George C. Frison. This site is a high-altitude, open-air camp nestled in the Sunlight Basin, an intermontane region of the Absarokas. The site includes a half-dozen mule deer skulls apparently ceremonially situated along with a proposed pit house (Frison and Walker 1984). Tooth eruption patterns on the mule deer indicate that they may have been hunted between October and March. The site has been radiocarbon dated to between 4200 and 4500 years ago (Frison 1978; 2004; Nabokov and Loendorf 2001).

A third site, the Horner site, has been excavated and studied by a number of archaeologists dating back to 1949. The Horner site is a multi-component Paleoindian bison procurement and processing site and is considered the type site of the Cody complex. During excavations of Horner I, conducted between 1949 and 1952, over 100 bison skeletons were identified, along with stone tools and hearth areas. Horner II, a second area excavated in 1977 and 1978, yielded the remains of a second bison procurement and processing area (Frison and Todd 1987). Bison tooth eruption at Horner II indicates that these animals were killed in the late fall to early winter.

A final set of sites are located on Boulder Ridge in the Washakie Wilderness east of Yellowstone National Forest at an elevation of nearly 10,000 feet. Archaeological investigation of Boulder Ridge was first conducted in the 1970s by Frison (1978:258-262). Frison documented the remains of the Boulder Ridge sheep trap, a complex of stone and wooden drive lines, cairns, and horseshoe-shaped rock piles. In 2003 Chris Finley, Judson Finley, Dan Eakin and a group of students from Northwest Wyoming College conducted additional survey at Boulder Ridge, identifying six new sites (Eakin 2008; Finley and Finley 2004). These sites include a collapsed wickiup and the remains of a second sheep trap complex, consisting of stone and deadfall timber drivelines, stone cairns, and rock blinds. The six new sites along with the site previously recorded by Frison are all likely associated with Late Prehistoric and Early Historic occupations related to mountain sheep procurement (Eakin 2008; Finley and Finley 2004; Frison 1978). Notably, relatively few artifacts were found in association with these sites during the 2003 project (Loendorf and

Stone 2006). In events that seem to foreshadow experiences from the GRSLE project, the study area was consumed by fire just 10 days after the Finley team departed in 2003 and the archaeological landscape of Boulder Ridge was forever changed. As a result of the Boulder Basin fire, much of the perishable surface artifacts, primarily the wooden features, were incinerated or altered (Loendorf and Stone 2006); however, as seen elsewhere, the fire served to both obliterate and reveal. Fire removed a 10 to 20 cm layer of duff and humus from the forest floor, exposing thousands of bones and artifacts. Artifacts recorded include a steatite vessel, stone and metal tools, Euro-American trade goods, projectile points, Shoshone knives, teshoa, and intentionally positioned sheep crania, indicative of a prehistoric/early historic Shoshean occupation (Eakin 2008; Loendorf and Stone 2006), In combination, the wooden features recorded in 2003 and subsequently destroyed or altered and the tremendous number of artifacts exposed by the fire, form a much more complex overview of Boulder Ridge than either inventory could have yielded independently.

Both Horner and Dead Indian Creek, with evidence of activities during the colder months; and the high-elevation Boulder Ridge sheep procurement complex, with evidence of extensive hunting activities and landuse, strengthens the argument against this being a marginal and under-used environment. Furthermore, each of these sites underscores the antiquity and long-term use of the region and the range of activities that took place on the landscape prehistorically, offering both cultural context and perspective on how ancient the ties are between indigenous people and the Yellowstone.

Archaeology has also served to dispel both the myth of Yellowstone as uninhabited and as a place feared and shunned by Indians in other ways. The Dinwoody petroglyph tradition from Wyoming and Montana, with dates going back to 1100 years ago, has been linked to Shoshone cultural beliefs (Francis and Loendorf 2002; Loendorf and Stone 2006; Nabakov and Loendorf 2004:144). The spatial extent of Dinwoody rock art includes the Absaroka Mountains, the Wind River Mountains, the Owl Creek Mountains, and the adjacent basins (Loendorf and Stone 2006: 34), illustrating the potential range of the Shoshoni based on the rock art distribution alone. An archaeological look at the pre-contact trail system in Yellowstone also makes the argument for an uninhabited region dubious. When roughly the same map is used to plot the location of modern-day geysers, one finds a startling correspondence between the trails and those very geysers described in historic literature as “feared” by the Indian. Oral histories support the above findings with descriptions of the Yellowstone area as a sacred place for some native groups as well as a location used for vision quests and ritual bathing (Nabokov and Loendorf 2004;Weixelman 2001).

The archaeological reconstruction of the Yellowstone area is still very young, representing less than 50 years of study. The first professional archaeological study was not completed in the park until 1964 with the majority of the studies initiated in the last two decades around construction sites in the park. It is estimated that only 20,000 acres of the 1.5 million that comprise Yellowstone National Park have been surface surveyed (Nabakov and Loendorf 2001). Until recently, the GRSLE study area and the Absaroka Mountains in general, had been studied even less.

What is perhaps most evident from my research into the identity of “who was present on the landscape and when?” is that an answer to such a question is intricately bound up in the story of European conquest, the removal of a Native American presence, the founding of a nation, and myth making. The question is as relevant and complex today as it was at the turn of the nineteenth century. This is nowhere more apparent than in the remote and high mountain setting of the Shoshoni National Forest and the Washakie Wilderness, where evidence of human landuse in this montane environment reaches back at least 10,000 years and litters the present-day landscape. In this context, the trees, sometimes 500 years old or older, span the post-contact period. If remnant wood is also considered, the tree-rings collected extend well into the pre-contact period and may offer insight into the environmental conditions past human groups experienced. As a high resolution chronometric of both climate and localized events, trees blur the distinction between categorizations such as historic and prehistoric. Instead, they provide an unfiltered view of the environment from which human behavior, landuse and affiliation can be compared. As such, “talkative” trees and tree-rings offer a very different lens from which the archaeological record can be observed and deduced.

CHAPTER 3: THEORY AND METHOD

An Introduction to Dendrochronology

Dendrochronology, or the science of tree-ring dating, plays a vital role in the reconstruction of regional climate variation, forest dynamics, ecological stasis and disturbance regimes, and most importantly for archaeology, in aligning those ecological patterns revealed by tree-rings to past human behavior. The basic premise of dendrochronology is that trees, particularly those in temperate and high-latitude zones, respond to climate and environment in predictable and statistically quantifiable ways and that those responses, or signals, are evident in the annual growth of tree cambium that form tree-rings. Underlying this premise are four fundamental principles and conditions.

The first principle is that the tree species under study must add one identifiable annual growth ring per year (Nash 1999; Stokes and Smiley 1968). There are exceptions to this rule that must be considered by the dendrochronologist. For example, a tree under extraordinary stress may not produce a growth ring during a particular year and therefore has a *missing ring* in its overall chronology, or the stress might only enable the tree to produce an annual growth ring along a portion or portions of the circumference of a tree (perhaps the south-facing side during a cold year) resulting in a *locally absent ring*. Another exception is a *false-ring* which can, for example, be the consequence of a severe cold spell during the growing season. A tree in this situation might react in a way that mimics shutting down for winter (producing a false complete ring) and then start back up to continue growing for the remainder of the season before shutting down again.

The second, the Principle of Uniformity, proposed by geologist James Hutton in 1785, assumes that the natural laws and processes in operation today are the same biological, chemical and physical processes in operation in the past as well as across space (Brown, personal communication 2008; Fritts 1976). In dendrochronology, this principle leads to a basic assertion: a tree producing an annual growth ring today would have produced a similar annual growth ring in the past if environmental and biological factors are the same. Such an assertion is not meant to imply that the paleoclimate mirrors present day climate. Rather, this assertion suggests that given similar factors that limit tree growth, namely temperature and precipitation, as well as biological, chemical, and physical consistency; tree-ring patterns should be analogous and comparable. Thus, tree-rings can be used as an indirect proxy of past climate, and patterns detected in tree-rings are reproducible and crossdatable.

The third, the principle of limiting factors, is the concept that any biological process such as annual tree growth will be the result of many interacting factors but growth—like all other processes—is, ultimately, constrained by a tree's most limiting factor (Fritts 1976; Stokes and Smiley 1968). This principle requires that one or more limiting environmental factors—generally temperature or precipitation—dominate in sufficient scope and scale (e.g., geographic extent, adequate duration, and perceptible variability) to produce patterns in tree-rings that can be detected in multiple trees. Ring patterns that vary synchronously across many trees are responding to annual climate, and thus these patterns can be distinguished from other interacting factors such as individual genetics, local anomalies, and spatial distribution, providing the foundation for climate reconstructions. This process of identifying patterns in annual growth and matching those patterns to other tree-ring samples is known as *crossdating*. Crossdating begins with the analysis and detection of ring patterns in living trees, matches those patterns to other tree-ring samples, and, working backwards from living trees to dead and remnant wood (logs, stumps, and snags), assigns calendar dates to tree-rings based on those patterns. In this way, annual rings from trees or remnant wood of unknown age can be crossdated and given a calendar year. Furthermore, climatic events—those limiting factors that control annual growth and produce patterns in tree-rings can also be dated.

The fourth, the principle of ecological amplitude, assumes that each species, based on phenotype, is able to grow and reproduce in a specific range of habitats—some species, for example, might be limited to a very small range of conditions because of a very small "ecological amplitude" while others may have a much greater capacity for survival and reproduction in a greater range of habitats which is indicative of a greater ecological amplitude (Fritts 1976). Regardless of amplitude, climate stress is assumed to be the greatest at the margins of a species' range and is thus an important consideration in tree-ring sample and site selection and interpretation of tree-ring patterns. On the one hand, selecting trees at the margins of their natural range might provide a more intense response to climatic factors and therefore provide a sharper or more nuanced response to climate. On the other, trees at the margins may be susceptible to other non-climatic factors such as soil, edge dynamics, or species competition that might also influence tree growth and ring patterns.

Taken together, these fundamental principles form the foundation of the science of tree-ring analysis, and are critical conceptual tools for evaluating tree-ring patterns, including separating the climatic signals found in tree-rings from the "noise" of non-climatic factors. These principles are also crucial considerations in site selection and sampling strategy.

Site Selection

Variability in tree-ring width and other ring characteristics such as density, color, and cellular structure is often described in terms of "sensitivity." Finding trees that are sensitive to the environment, as opposed to "complacent," is an important parameter when selecting a site and the trees to be sampled. For example, an entire stand of trees at high elevation might consistently be limited by temperature, but unless those trees show differences in annual growth, climatic fluctuations may not be reflected in the rings. Selecting trees at the margins, as described above, or near a forest edge may result in tree-rings with intensified patterns; however, trees on the very edge of a forest or environmental margins may also be responding to anomalous forces such as exposure or threshold dynamics. Alternatively, trees that are near a water source or are not otherwise limited by environmental factors, may also fail to show a significant climate response in the rings. The goal in selecting a site and tree-ring samples is to maximize the signal of interest while minimizing the noise (Brown, personal communication 2008). This is best accomplished by selecting trees that in one way or another are slightly stressed (e.g., by slope, aspect, soil, climate, or edge dynamics), but not stressed to the point where the climate signals and dominant limiting factors are obscured (e.g., from fire, insects or blight, extreme climate conditions, etc.).

As will be discussed in the next section, when the purpose of tree-ring dating is archaeological, site selection and sampling strategy is often quite different. While dendroarchaeology adheres to the same basic principles and objectives described above, including crossdating and establishing annual climate/environmental patterns, the final objective of dendroarchaeology is to date the wooden material remains of culture captured in wood. In this regard, the terminal date, or fell/death date of a tree may be far more important to dating a wood artifact than a determination of overall age or climate influence on a tree. Furthermore, many tree-ring samples collected in the service of an archaeological study may not reflect optimal sampling conditions or past environment, especially if the wood artifacts to be sampled were preferentially harvested or adversely impacted by human activity. Finally, dendroarchaeology relies upon the precondition that the wood artifacts to be sampled are sufficiently preserved and provenienced, enabling both accurate crossdates and correlation with past human behavior --regardless of a tree's environmental conformity.

Dendroarchaeology and Site Selection

Tree-ring dating brings three primary contributions to the study of past human behavior and human/environment interaction: 1) dating the material remains of human activities related wood; 2) illuminating cultural practices that involve wood or the forested environment; and 3) reconstructing past climate and environmental conditions influencing past human behavior and adaption (Dean 1996; Towner 2002). Dendroarchaeology provides data on how past people used wood as a resource. In addition to exact calendar dates, tree-ring analysis can shed light on preferential harvesting and species selection, use of deadwood, reuse, stockpiling, construction techniques, transport, and landuse activities (Towner 2002). Scars and cultural modifications observed on both living and dead trees can elucidate other ways in which wood has acted as a resource in the past. Trail blazes and other markings cut into trees have been made to express everything from location and territory identification to storytelling and art.

In addition to these markings, past humans were equally resourceful in using certain parts of a tree. Both the bark and inner cambium from culturally peeled trees were harvested for a wide-range of purposes: as a nutritional source in times of famine and as a delicacy; for medicinal purposes; as an adhesive or waterproofing agent; as roofing material and shelter, bedding or kindling (Collins 1989; Conner 1991; Cushing 1920; Martorano 1981; Stewart 1984; Swetnam 1984; Ticknor and Fields 1856; Wallace 1952). Under the right conditions, particularly if resource use leads to a scar, an alteration or anomaly in tree-ring pattern, or the death of the tree, human activity can be gleaned from wood remains and placed in precise time. For this to happen, however, sufficient preservation of the wood has to have occurred and the sampling strategy must reflect the type and condition of wood remains present and the archaeological questions to be answered.

Dendroarchaeological analysis is generally conducted on four types of wood: architectural/structural remains, culturally modified living or dead trees (CMT's), charcoal remains, and trees that reflect forest dynamics in relation to human activity at known archaeological sites. The number of tree-rings per sample required for accurate and precise crossdating depends on both species and environmental conditions. In the southwest, for example, 50-100 tree-rings per sample are necessary for crossdating (Towner 2002:72). In the Upper Greybull, where temperature and length of growing season appear to consistently limit tree-ring growth and where Engelmann spruce (*Picea engelmanni*) dominates samples with at least 100 annual rings may be obligatory (Brown, personal communication, 2008).

In order to crossdate these samples and deduce climate and environmental influences on human behavior, an existing dendrochronology, or *master chronology*, may be used; otherwise, samples must be collected from living and ecologically representative trees and from remnant wood in order to create an original local/regional dendrochronology. Depending on the type of wood artifact, different sampling methods and strategy are necessary: a habitation structure, for example, will include a set of computations related to dates of construction (e.g., felling dates as well as alteration or reuse episodes) whereas samples taken from a culturally modified tree, especially if still alive, needs to capture rings near the scar as well as enough tree-rings prior to the modification to crossdate the event. The ultimate method of collection will depend on type of wood and different crossdating objectives as well as the condition of wood and the type of instrument used to collect each sample.

Method: Tree-Ring Collection and Analysis

Between 2006 and 2009, as part of the ongoing GRSLE research program, more than 200 tree-ring samples were collected from living and remnant trees, seven historic cabins and associated structural remains, and from culturally modified trees located near the cabins. Several tools were used to collect these samples including a Haglof increment borer (extracts a small, 4.3 mm core from a living tree without harming it), an archaeological borer (a larger gauged borer attached to an electric drill and used to extract a 13 mm core from dry wood), a variety of hand-held saws, and a chain saw. Depending on the type of wood sample, different instruments were used to obtain the tree-ring sample and a different set of characteristics were recorded for each type of wood sample. Each sample was given a five to seven character code: the first two characters of the code referenced the cabin or the drainage closest to the sample, the next character indicated the type of sample taken (a “C” for a core taken from a tree using the Haglof increment borer, an “H” for a sample taken using the larger gauge, archaeological borer, or an “X” for a cross-section or wedge sample taken from a log. The next characters gave the sequential number of the sample, and the final character indicated the side of the tree, when pertinent, from where the sample was taken. For example, JCC01 and JCX01 denoted the first living tree and cross section samples taken at the Jack Creek Cow Camp.

Collection from Living and Remnant Trees

In order to establish an initial, reference dendrochronology for the study area, tree-ring samples were collected in 2006 from both living and remnant trees. As described above, the trees selected for sampling were intended to be representative of forest and climate regimes while also presumed to be under a limited, but not severe amount of stress. In addition to obtaining the tree-ring sample, a predetermined set of characteristics were recorded for each sample. For living trees, characteristics such as location, condition of the wood sample, associated vegetation, diameter of tree at breast height (dbh), aspect, slope, available water, landuse, presence or absence of scaring, tree health, and root exposure were documented (Appendix A). For remnant trees, the goal was often more basic: find a snag or section of wood with adequate integrity and the least amount of decomposition. Recorded characteristics for remnant wood include location, absence/presence of charcoal, diameter and length of sample, and the presence of scars or other defining marks.

When possible multiple samples were taken from each living tree. One reason for this is the principle of repetition, another tenet of dendrochronology, which posits that multiple samples taken from a tree as well as multiple samples taken from a site allows for statistical comparisons of variability, reduces the chance that a false or absent ring will be missed or recorded, and permits averaging for best climatic and environmental indicators (Fritts 1976:23). By sampling more than one radius from a tree, tree-ring patterns related to *reaction* or *compression* wood can also be mitigated. Reaction wood is formed as a physiological response to an event (e.g., an avalanche, mudslide, flood, or an injury) or an environmental condition (e.g., slope) that causes changes in growth somewhere along the circumference (visible in tree-rings) of the tree stem. For example, trees in general strive to grow upright and vertical. On a slope, in an effort to reduce tilt, a tree will produce more growth, known as reaction wood, on the down side and form compression wood on the upper side (Figure 3.1). While reaction wood can be a great tool for precisely dating an environmental event such as a flood or avalanche that causes either an injury or tilts the tree, it can also alter tree-ring patterns. As a result, when sampling a tree, attention was paid to such forces as slope or injury. The effect of slope was mitigated by taking samples parallel to slope and labeled accordingly. When facing a tree upslope, a core taken from the right hand side was labeled "c", from the left hand side, "d" and from the backside, "b." As will be discussed in the next section, when a living tree had been culturally modified, the sampling strategy and naming convention was changed.

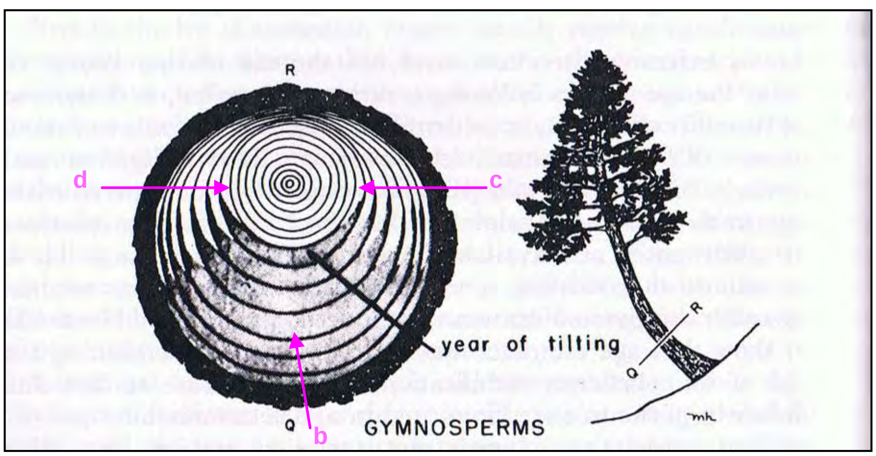


Figure 3.1. An image by M. Huggins of "compression" wood originally modified from (Lawrence 1950) and adapted from Fritts (1976: 220).

For the same reason that several samples are taken from a living tree, a cross-section, or “cookie,” from remnant wood is more desirable than a wedge or core. By having a sample that includes the entire circumference of a tree, tree-ring patterns related to reaction wood can be avoided. Furthermore, false or absent rings are more likely to be detected and the best set of representative and comprehensive rings can be analyzed. Ultimately, of course, the goal of collecting samples from living trees and remnant trees is to work back in time to form the strongest possible dendrochronology for the purpose of crossdating and as a proxy for past climate and environment.

Collection from Culturally Modified Trees

Tree scars are caused by a variety of events, including fire, animal or human activity, and lightning. Often, each of these sources will leave characteristic marks. For example, fire scars usually begin at the base of the tree and travel upwards. They are also found commonly on the upslope side of a tree where duff and other fuels are highest. Culturally modified trees (CMTs) can also have a distinctive look. Trees with peeled bark, for example, will frequently have hatchet marks or axe cuts at the base of the peel and at the top of the peel. The center of the peel is usually found at roughly breast height with overall dimensions are usually consistent with the reach of the peeler. Often, as peeled trees age and bark heals over the scar, a distinctive oval-shaped scar, or “catface,” develops (Figure 3.2a). Other CMTs,--trees with trail blazes, USGS survey markers, attached structures or fencing, for example--may have obvious anthropogenic scars.

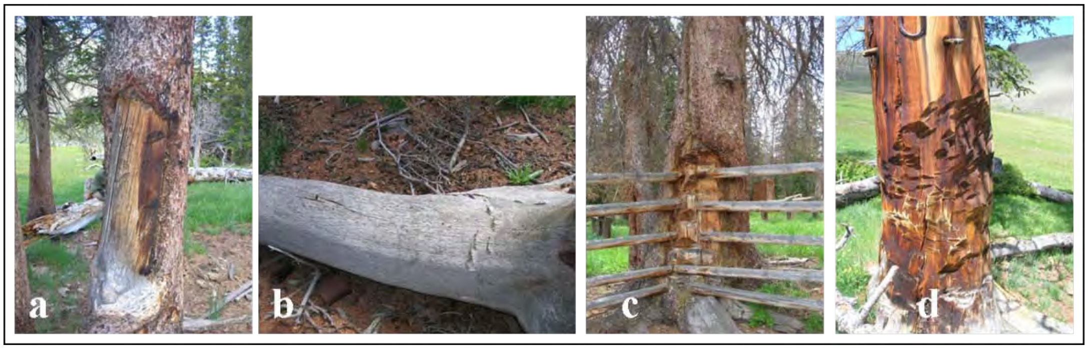


Figure 3.2. Photographs of the many different types of CMTs recorded in the study area: (a) sample JCC02, a tree with a bark peel. The tree has both axe cuts (along the right side of scar face) and hatchet cut marks visible at the top of the scar; (b) hatchet marks around the base of a snag. The peel probably contributed to the death of the tree since few tree-rings appear to have formed after the peel; (c) sample CCC01, a tree that forms part of the corral at Jack Creek Cow Camp; (d) axe cut marks on a tree at Chico's cabin.

The goal is to first identify a CMT, record the archaeological context and characteristics related to this identification, and then to capture the scar itself in a sample. In order to date the scar, sufficient tree-rings on either side of the scar must also be obtained. Many times the tree-rings formed immediately after an injury—especially if the rings are near the injury—will involve reaction wood. Therefore, multiple samples from a CMT, including samples of the scar and samples without the scar are desirable (Figure 3.3). Sampling the face of the scar (side "A") may or may not be useful in this endeavor as the original activity that caused the injury may have removed outside tree-rings or the surface of the scar may have eroded over time. One objective when sampling a scarred tree is to capture the scar with cores from sides C and D. Depending on the injury and where these radial cores hit the scar lobe, the scar, and the tree-rings, a gap in tree-rings on either side of the scar may be present. Taking a sample from the backside of the scarred tree, side B, can aid in isolating the scar date if a gap is present in a scar sample, especially if reaction wood related to the injury is observed and can be accurately crossdated. As with remnant wood, if a cookie or even a wedge can be obtained from the scarred tree, there is a higher likelihood of crossdating the event. If an absolute date cannot be established, samples that capture the scar may at least offer a *terminus post quem*, or the earliest date an event may have occurred and *terminus ante quem*, or the latest possible date of the event.

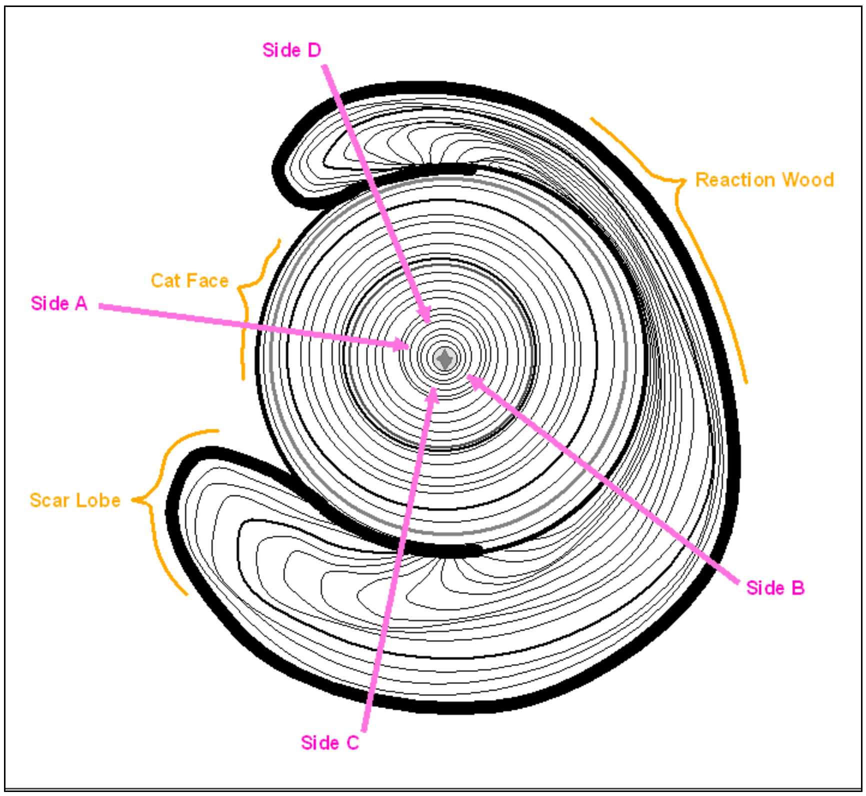


Figure 3.3. The cross-section of a scarred tree with "cat face" and scar lobes. Pink arrows depict the sampling strategy for a scarred tree.

Collection from Historic Cabins and Associated Structures

Oftentimes the most important information needed to crossdate archaeological or architectural features made of wood, like historic cabins and associated structures, is the terminal, or cutting date of the tree. The harvest date of logs used in construction of historic cabins, for example, can be a precise indicator of cabin construction or remodel dates. Stockpiling, reuse, or the use of dead wood can also be deduced by comparing cutting dates to the archaeological context. Attributes that indicate terminal or near-terminal ring date for a sample include the presence of bark, beetle galleries (which occur near the outer layer of a tree, between bark and cambium), a shiny patina (a product of erosion on the exterior of the log), or a continuous ring around the last ring of a sample. In the field, logs and wood that appeared to have one or more of these attributes were sought out and a sample taken from a spot where these attributes and preservation were best. When sampling dead wood and logs, the archaeological boring instrument, with its larger gauge, is often better at obtaining a high-quality sample than the increment borer. As always, a cookie is preferable to a core, especially since dead wood may have areas of rot, erosion or other anomalies that need to be avoided; however, when considering taking a cross-section from a structure, the effect on overall archaeological integrity of the feature was considered. If, for example, taking a cross-cut from the end of a cabin log course would diminish a cabin's overall archaeological significance or otherwise undermine its appearance, samples were not taken. When samples were taken, particularly for the few cross-sections obtained, attempts were made to minimize the visible impact—dirt stain was applied to cross-section ends and cork was inserted into bore holes.

Samples were collected from cabin logs, including logs that showed signs of reuse with older, incongruous notching, axe cut and saw cut stumps, and from other structures and features associated with the cabins (Figure 3.4). Samples were also taken from culturally modified trees in the vicinity of the cabins. The CMT's include trail blazes, trees used as structural support for site features, and culturally peeled trees. The architectural components of the main cabins were recorded, including condition, architectural style, number of courses per elevation, location and presence of doors and windows, orientation, and interior features. At three of the cabins, historic can scatters and trash dumps were also recorded.

Figure 3.4. Jack Creek Cow Camp samples: (a) an example of reuse and modification: a sill log from the main cabin of Jack Creek Cow Camp, showing an incongruous saddle notch adjacent to a more recent structural notch. Sample CCH06 was collected from this log in 2006. In 2009, after a 2007 renovation of the main cabin, this end of the sill log was found on the ground near the cabin (saw cut on the inner end) and unwittingly collected as a new sample, CCX15. Later, sample CCX15 was identified as the sill log based on this photograph, and, ultimately, reinforces the idea of multiple reuse, modification and discard events at this archaeological site. These two samples also provide an internal check of crossdate accuracy—both yielded an independent "end date, " or presumed cutting date of 1889; (b) A cross-section taken from an axe cut stump in 2006. Sample CCX11 was located in a cluster of both axe cut and saw cut stumps.

Evolving Method: Fire, Pestilence, and Climate

During the 2006 field season, 120 tree-ring samples were collected in the study area. More than 75 of those samples were from living and remnant trees, forming the basis of a dendrochronology and new research objectives for subsequent field seasons in the Upper Greybull. In the first year of gathering tree-ring data, samples were also collected from four historic cabin sites: Jack Creek Cow Camp, Webster Creek cabin, “Chico’s” cabin, and Jack Meadow 2 cabin. We stumbled upon Jack Meadow 2 cabin accidentally while searching for another cabin. It was the end of the day, on the last day of cabin sampling. The cabin, which was heavily deteriorated and more rudimentary in construction than others in the study area, was hastily recorded with only a few samples collected due to both time constraints and the degree of deterioration. I was also hesitant to take cross-sections from the ends of the log courses because the ends were axe-cut and the cabin was so degraded that a thicker cross-section was needed. For both reasons, I felt the cabin’s appearance would be adversely affected. A few weeks later, the study area, already devastated by the spruce budworm, burned and several cabins in the GRSLE study area, including Jack Meadow 2 cabin were destroyed in the Little Venus Fire. Thus, the samples collected from both this cabin and from other trees and artifacts in the study area represent more than just a paleoecological proxy or crossdatable sample from a wood artifact, they can become in the flash of a lightning strike, an irreplaceable material record of a montane landscape shaped by fire.

As a result of these events and in assessing my research objectives in a pest-ravaged, post-fire landscape, collection methods and preservation goals changed during the next several field seasons. In retrospect, for example, the in-depth data collected for living trees in 2006 (tree health, crown health, root exposure, etc.) was immaterial—by that 2006 field season, many of the trees in the study area were showing obvious signs of beetle kill. After the fire—with many of the trees burned—documenting the presence of bark and dbh were often equally irrelevant. Samples in 2006 did establish a strong dendrochronology, so in the following three field seasons, focus turned to collection and preservation from archaeological wood remains, including three more historic cabins, culturally peeled trees, and from remnant wood that would hopefully extend the dendrochronology further back in time. For the latter, I returned to locations where the oldest living trees had been found in 2006 and, in 2009, samples were collected from the ghost tree forest first recorded in 2005.

As much of the West contends with infestations from the Rocky Mountain pine beetle, spruce budworm, and pine rust at higher elevations and concomitant factors such as dangerous fire conditions from forest management practices and climate change, the urgency to preserve at-risk archaeological wood samples is ever present. As Dr. Peter Brown from Rocky Mountain Tree-Ring Research, and one of my advisors for this research, has reminded me numerous times, it is probably only a matter of years before many traumatized montane forests like those in the Upper Greybull Watershed will catch fire and, archaeological wood and the stories they tell, lost forever. A case can be made, then, that collection--especially as forests reach their senescence--is more pressing than the ultimate goal of crossdating. A related consideration is whether it is more important to preserve the visual or structural integrity of an archaeological feature or to preemptively collect samples from a feature when the possibility of fire seems imminent. Such considerations influenced my sampling strategy after 2006. As a result, both collection of tree-ring samples in the study area and the future analysis of these samples are ongoing.

Thus, this thesis project should be considered an incomplete encapsulation of ongoing work.

Preservation and Sample Preparation

Once the tree-ring samples, which as of 2009 numbered over 200, were brought back from the field, each sample was preserved and prepared for analysis. During this preparation, it became evident that the very insects wreaking havoc on the forest, were also enjoying my samples, so all samples were placed in a freezer for at least a month. Many samples—especially cores and cross-sections from historic cabins—can break or fragment during the collection process. These pieces were refitted and glued back together. Cores extracted from living trees using the Haglof increment borer sometimes twist during extraction and had to be gently turned using steam to soften the wood and realign the tree-rings. These cores were then glued into wood mounts to stabilize them. For wide or uneven cross-sections or for bulk wood samples, a cross-cut was made using a chainsaw, band saw, or hand saw to produce thinner cross-section for analysis.

Surface preparation for all the samples was done using progressively finer grades of sandpaper (60 to 400 grit) and finishing films. To accomplish this, a hand orbital sander and two belt sanders--flipped on their backs--were fitted with increasingly finer grits of sandpaper and the samples were processed across a sequence of abrasive papers. For cores, the surfacing needs to occur perpendicular to wood grain in order to render the cellular structure and rings visible under a microscope. Each sample was sanded until ring detail was observable. Then, before analysis, each sample was hand-sanded using finishing film to render the cell walls visible within the annual rings (Stokes and Smiley 1968).

The Skeleton Plot

Once the samples were prepared, the samples were placed under a microscope and tree-ring patterns noted using the skeleton plot technique. Skeleton plots are a quick and modifiable way to graphically represent observed patterns in the tree-rings without actually physically measuring each ring (Figure 3.5). This can be a valuable tool for getting an overview of the types of patterns observed in a set of samples and to begin to match these patterns to other samples. The method behind producing a skeleton plot for each sample, or a set of apparently representative samples, is the same as the process and goals of dendrochronology. Starting with a living tree sample (a known last ring date), one can work back in time and plot patterns in the wood on a strip of graph paper. In particular, narrow rings may be indicative of limiting factors, so they become the primary focus when creating skeleton plots. To determine whether a ring is narrow, each tree-ring is compared to its nearest neighbors and the smaller the ring, the longer the line drawn on the plot (a quantitative, vertical scale of 0-10). Other characteristics can be marked as well. For the GRSLE tree-ring samples, the following characteristics were also marked in skeleton plots: unusually large rings; “B”; a high number of resin ducts, “R”; light latewood, “L”; dense latewood, “D”; possible freeze, “F”; false ring, “FR”; and scars, “S”; among others noted in margins Once skeleton plots were created for living tree samples (moving from last ring backwards to pith), undated samples were plotted (starting at pith, or 0, and moving out to the last ring). As skeleton plots were completed, patterns and outliers began to emerge and a composite plot was created which could then be used for pattern matching on undated samples.

By comparing all the skeleton plots--or at least those with pattern correlation--a master chronology can be built that extends back in time, and undated samples can be crossdated. Skeleton plots, however, are based on a visual, subjective assessment of each ring and may lack both accuracy and precision.

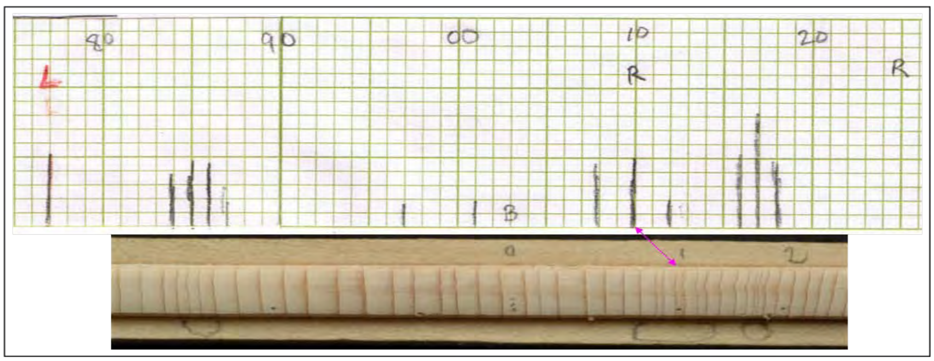


Figure 3.5. A portion of a skeleton plot (1875-1926) and mounted core. Tick marks on the skeleton plot graphically depict smaller rings. Coding for light latewood ("L"), resin ducts ("R"), and large rings ("B") can also be seen in this figure.

In addition, because the data are represented graphically, it is difficult to statistically evaluate the veracity of the results. The benefit of skeleton plots is the swiftness, the familiarity one gains with the patterns, crossdates related to patterns and marker years, and the identification of outlier samples, before turning to the lengthier process of measuring each ring in a sample.

Measuring Ring Widths and Quality Control Analysis

In order to verify the patterns and crossdates first observed in the skeleton plots, ring-width measurements were taken of samples and then run through the crossdating and quality control analysis computer program, COFECHA (Holmes

1983). COFECHA enables the user to build a reference, or “master” chronology (or use an existing reference dendrochronology), crossdate samples of unknown age, and statistically analyze the results. Starting with living samples that appeared to have the strongest representative patterns, tree-ring widths were measured to the nearest .001mm, using a movable- stage Velmex micrometer and Measure J2X software. It was not always necessary or even advantageous to measure every sample taken from a single tree or wood artifact, especially if one sample seemed to exemplify the observed patterns and annual markers. However, sometimes by measuring more than one sample or more than one radial line on a cross-section, anomalies (branch, rot, etc) or reaction wood could be avoided or the statistical potency of an outlier ring diminished through averaging.

Using the Velmex micrometer, measurements were taken of each ring in a sample, or “series,” starting with the first complete ring after or nearest pith and working to the outermost ring (towards bark). Because skeleton plots had already been created, calendar dates for annual rings on many samples had been inferred so when these dated samples were measured, the first measurement was assigned its respective calendar date and each ring that followed was automatically assigned the next year. Annual rings in an undated series were assigned a relative date, with the innermost ring given a date of “0“and each subsequent ring increased by one. The Velmex and Measure J2X program produce a raw data file that includes tree-ring widths for each of the rings in a series along with the relative or calendar date. When a sample to be measured included a scar or scars—unless both ends of a scar were indisputable in terms of an uninterrupted tree-ring sequence—both the pre-scar and post-scar segments were treated as separate series and each was measured as undated. Throughout the measurement process, exceptional anomalies (scars, dense or lightwood, freeze, etc.) and patterns were once again recorded along with the associated calendar date or relative date assigned during measurement.

After measurements of a sample had been completed, special attention was given to the outermost ring on each sample. The outermost ring, which often provides the most important information regarding a cutting versus non-cutting date, was examined for a specific set of characteristics related to such a determination and assigned a code or codes (Bannister 1962; Nash 1999). The symbols used for ring characters and outermost ring designation (Table 3.1) were

Table 3.1: A list of symbols used to characterize tree-rings, adapted from the LTRR and Nash (1999).

Symbol	Qualification	Description
p	Pith	First ring is at pith or near pith (can provide insight into initiation date of tree)
np	No pith or near pith	First ring is not near pith
B	Bark present	Bark is present indicating that the last ring is a terminal date
G	Beetle galleries present	Beetle galleries are present
L	Patina present	Patina is present
c	Outermost ring is continuous	Outermost ring is continuous around circumference
r	Outermost ring is consistent	Outermost ring appears to be continuous but circumference is incomplete or
v	The date is within a few years	A subjective assessment: terminal, or cutting date is within a few years (based on the presence of galleries, patina or other characteristics)
bv	Date is estimated	No definitive last cell can be identified, but there are indications that the terminal ring is within a few years (very tight rings, for example)
vv	Unknown	Unknown number of missing outermost rings due to fire, cultural activities, a remant tree, missing sample section, etc.
++	Count of tree-rings	After a certain point (often related to an event or injury), a ring count (no pattern match) is the only way to date a specimen
ev	Termination during earlywood	Consistency in cell characteristics suggest that the tree died during growing
evv	Earlywood	Earlywood noted on last ring
+	Last ring is unmeasured	If measurement data is used to calculate the age or "end year" of a sample, a year must be added to the "last ring" to get an "end date"
s, s1, s2, . . .	Scar segment (series)	When a sample has a possible gab between pre- and post-scar rings, the segments are measured as separate series and assigned a relative date of '0" for each "first ring" in a series
+s, +s1, +s2, . . .	First ring unmeasured	Denotes an incomplete ring at the beginning of a post-scar segment. When calculated dates using measurement data, a year must be added to the "first ring" date
N/A	N/A	The outermost ring is not a "last ring" on the tree/log, for example the sample being analyzed is the pre-scar segment

adapted from training I received at the Laboratory of Tree-Ring Research (LTRR) at the University of Arizona, Tucson in 2006 and a chart by Stephen Nash (1999:17). The Outermost code data along with data accumulated from skeleton plots and from measuring samples was then entered into a Microsoft ACCESS database for future analysis.

Once raw data for tree-ring measurements were generated, the computer program COFECHA was used to build a reference chronology, a chronology from which undated archaeological samples could be crossdated and the accuracy of both the reference chronology and the crossdating results assessed. Starting with tree-ring samples from living trees with a known calendar age and moving backwards in time to tree-rings from remnant trees with the strongest corresponding patterns based on skeleton plots, a reference chronology was created. In building a reference chronology, COFECHA removes each individual series and correlates this data with the remaining series, averaged together. Based on COFECHA, those samples that showed little correlation with the rest were omitted from the reference chronology and those with a high degree of inter-series correlation were incorporated. As additional samples were measured, each sample was compared to the developing chronology and its correlation analyzed. Ultimately, the reference chronology, a result of this iterative process, is a compilation of the longest and most highly correlated individual series in the dataset and thus provides the most accurate possible basis for determining crossdates for the undated archaeological samples.

The program COFECHA serves as a tool for both crossdating and identification of dating and measurement errors by enhancing high frequency trends and eliminating low frequency noise (similar to what skeleton plots accomplish). COFECHA uses segmented time series correlation techniques along with a set of detrending procedures (a cubic smoothing spline, autoregressive modeling, and log-transformation) to remove low-frequency variance and persistence and then compares this transformed data to a known chronology--in this case the newly developed reference chronology (Holmes 1983; Grissino-Mayer 2001). Prior to producing an output file in COFECHA, several parameters were set in the program. A 100-year segment with a 25-year lag was selected as the length of time to compare undated tree-rings with the reference chronology. This higher value (the default is 50-years) was selected because of the overall complacency of Engelmann spruce at high altitudes and the small number of tree-rings in many of the historic core samples[5]. The analysis of 100-year segments will tend to filter out false highs and lows (Brown, personal communication 2009; Grissimo-Mayer 2001) By selecting 100-year segments, false highs and lows are filtered out and more subtle and germane patterns tend to be illuminated. A second parameter, the rigidity of the spline, was set to the default, a cubic smoothing spline of 50% cutoff of 32 years. Once these two parameters were set, both the reference chronology data and the undated trees-ring measurements were run through COFECHA, generating an output file.

The COFECHA output file identifies the best-fit scenarios (probable dates) for each undated, or “floating,” tree-ring series along with corresponding

[5] Samples were collected from only two species in the study area, Engelmann spruce (*Picea engelmanni*) and limber pine (*Pinus flexilis*). Not only is Engelmann spruce by far the dominant species in the area but none of the approximately 20 samples collected from limber pine was archaeological in nature; therefore, limber pine samples have been excluded from the current study.

correlation coefficient values for each of the segments in a series. Any segment in an undated series whose correlation values is found to fall below a 99% one-tailed confidence level ($p<.0001$) is flagged in the output file. COFECHA also highlights other potential problems with dates and measurements such as low correlation, divergent year-to-year changes, absent rings, and outliers (Grissino-Mayer 2001; Holmes 1983). The output file also proposes adjustments to problem rings for highest correlations. If a flag or other potential problem was noted in the output file, the series was checked and if necessary re-measured and re-checked. In a few, rare instances where errors could not be resolved or correlation remained low, the sample was excluded from the study results. Chapter 4 presents the reference chronology, the results of crossdating, and discusses how the assigned dates relate to cabin construction and human activity on the landscape.

Ultimately, quite a few archaeological samples showed a higher correlation with the reference chronology than some of the series within the reference chronology itself. This should not be surprising, as many of the tree-rings from archaeological samples, especially those from cabin logs and pre-scar tree-ring segments, may not have been impacted by human activity or any other event prior to cutting or scaring. As a result, the initial reference chronology used for crossdating undated samples, is not considered the final master chronology for the study area. Instead, a master chronology was developed (and is still evolving as more samples are collected and analyzed) from both the reference chronology and archaeological samples with the highest correlation. Chapter 5 introduces data related to this master chronology, compares the climate data gleaned from this chronology with information available in historic documents, and describes future directions for this ongoing preservation and crossdating project.

CHAPTER 4: CROSSDATING RESULTS

Using the methods outlined in Chapter 3, a reference chronology for the Jack Creek study area was developed using 27 of the most highly correlated and longest samples in the data set (Table A.1 in Appendix A). In order to ensure the accuracy and precision of this chronology, any series that did not have an inter-series correlation coefficient at a 99% confidence level was pulled from the chronology. In addition, the average inter-series correlation of each sample had to exceed .475. This high correlation value is based on correlations found in the data set overall and from other dendrochronological studies of Engelmann spruce at high altitude (Brown, personal communication 2008). Archaeological-related samples were excluded from the reference chronology—even when crossdates could be inferred and correlation was high. The statistics in Appendix B provide detail on each series in the reference chronology, including crossdates, sample length, correlation values, and mean sensitivity. It should be noted that prior to the 1700s, correlation values are based on a low number of samples ($n<8$), reducing accuracy and precision. The crossdated interval 1260-1400, in particular, relies on a single sample and therefore any errors in measurement or dating cannot be quantified. Due to the small number of samples analyzed for the early years in this chronology (1260-1450), crossdating results must be viewed with some skepticism. Fortunately, none of the archaeological samples appear to fall within this interval.

As stated previously, crossdating results presented in this chapter represent a snapshot of ongoing tree-ring research conducted in the Greater Yellowstone Ecosystem as part of the GRSLE project. By the end of 2009, well over 200 tree-ring samples had been collected from seven cabins, associated features, and living/remnant trees in the Upper Greybull (Figure 4.1). Samples have also been collected from several other endangered sites in the GYE, including the Stockade Lake site (48PA258) and adjacent culturally peeled tree sites (48PA1318-1320) in the Beartooth Mountains (Conner 1991; Feyhl and Bryant 1991: Rollinson 1942). Crossdating results presented in this chapter focus on tree-ring data collected in 2006 with a few samples culled from more recent efforts—primarily from ghost trees--to reinforce and extend the chronology. Results include crossdates for four of the seven cabins in the study, Jack Creek Cow Camp, Webster Creek cabin, Chico's cabin, and Jack Meadow 2 cabin, and for CMTs found near the cabins.

A total of 89 segments, including both pre and post-scar segments, form the crossdating results. In some cases, more than one sample from a wood artifact was measured and crossdated. Only the series with the highest correlation and most accurate crossdates are presented here. As mentioned above, several ghost trees as well as samples collected in 2009 have not yet been incorporated into this study, but form part of my larger on-going study. Samples from three additional cabins, Upper Jack Creek cabin, Kay Creek cabin, and Upper Piney Creek cabin (Figure 4.1), have not yet been measured or crossdated. Finally, two archaeological samples with no discernible correlation have been removed from the study. Both samples (a cross-section from an axe-cut stump at the cow camp and a rafter from the Webster Creek cabin) have very tight rings that are difficult to discern even under the microscope. The relatively small diameter of both samples may well reflect localized limiting factors rather than climate-related tree-ring patterns. Other samples with low correlation were not removed from analysis. These low correlation samples are primarily post-scar tree-ring segments and a second axe-cut stump from the cow camp. These results are presented below along with analysis for each of the cabin sites, followed by a summary of the culturally modified trees found throughout the study area.

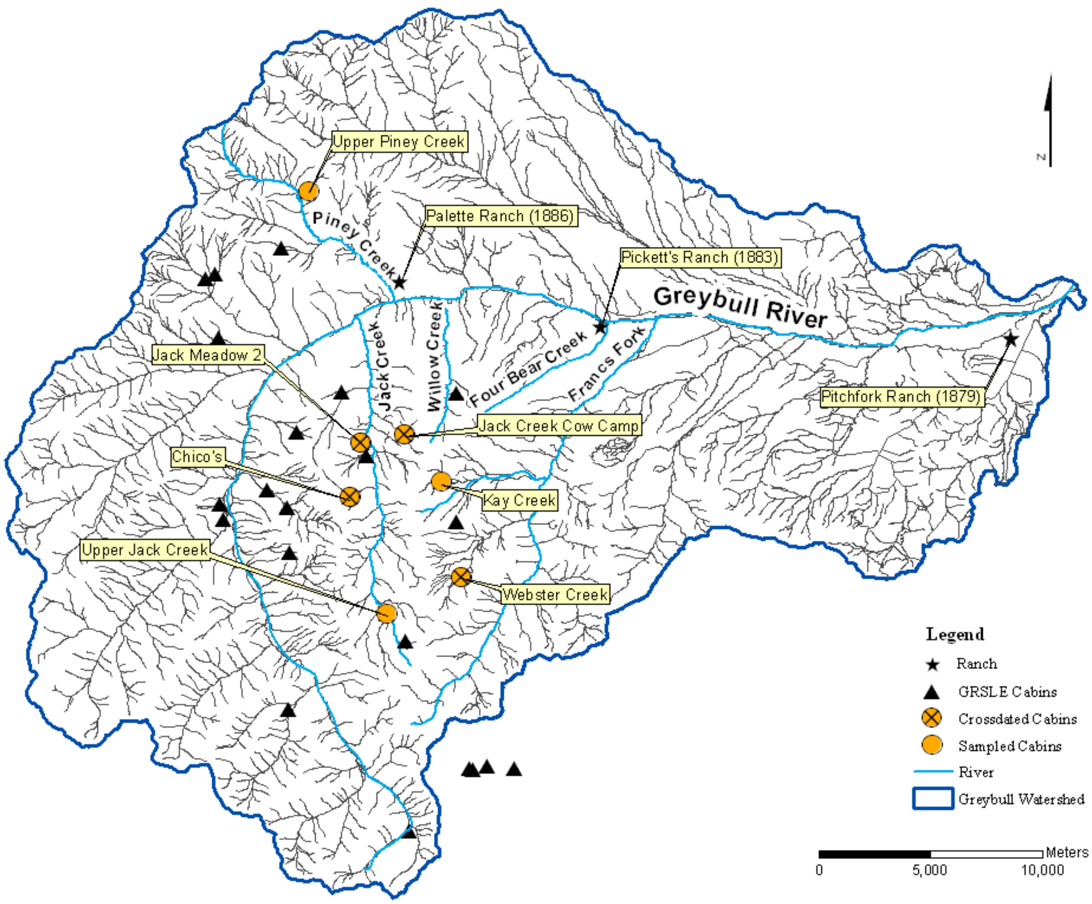


Figure 4.1. Map of cabins documented as part of the GRSLE project and the location of three of the earliest ranches along the Upper Greybull River, based on Government Land Office records, http://www.glorecords.blm.gov/, accessed January 2010).

Jack Creek Cow Camp

Jack Creek Cow Camp has been an active cow camp since at least the 1920s. Until recently, in fact, brands etched into the frame of the main cabin doorway by different ranch hands served as a reminder of more than a century of seasonal ranching in this montane environment. The jam disappeared after the 2007 renovation. Otto Franc, established the first cattle ranch, the Pitchfork, along the

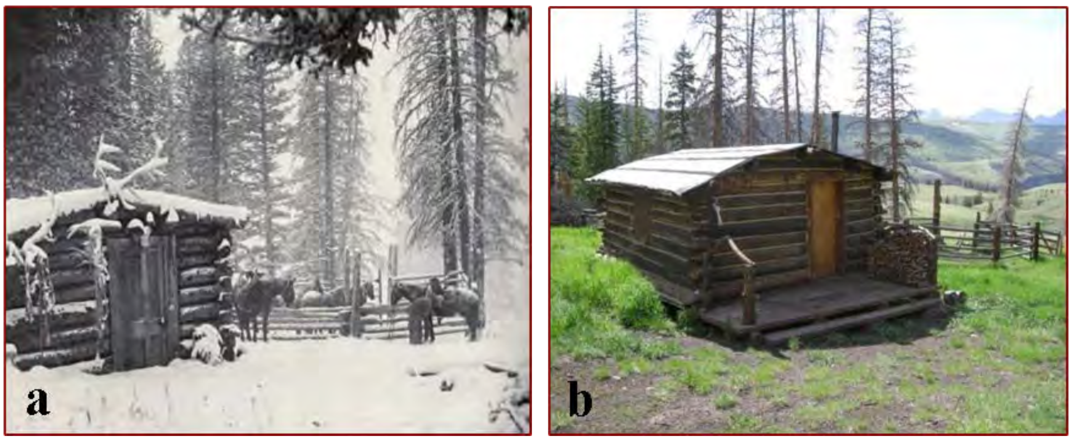


Figure 4.2. Jack Creek Cow Camp: (a) Jack Creek Cow Camp, photograph by Charles J. Belden, circa 1930s, courtesy of Dr. Lawrence C. Todd; and (b) the main cabin and corral in 2009.

Greybull River in 1879 (Figure 4.1). The Pitchfork has long been associated with this cow camp. As recently as 2008, cattle from the Phelps-Belden family, who purchased the Pitchfork ranch after Franc's death in 1903, grazed in the study area on leased national forest land and Pitchfork ranch hands occupied the cow camp during the summer. In his diaries, written between 1886 and 1903, Franc describes hunting trips into the mountains above his ranch, sending men into "the timber" to cut poles, and cow camps set up in "the timber" for summer range (Franc Von Litchenstein 1886-1903).

The Otto Franc diaries also document at least two excursions into the study area. The first, a hunting trip that encompassed at least the southeastern quarter of the Upper Greybull Watershed, including the Jack Creek drainage; and the second, a scouting trip to assess land he wanted to lease along Jack Creek. In the first series of entries, in August of 1889, Franc describes heading up Francs Fork Canon on a hunting expedition. His party camped at 10,000 feet just below Francs Peak and then moved down the canŏn (probably Jack Creek), crossing Jack Creek before setting up camp on “a little creek near the Grey Bull and just above lower canon” (Franc Von Litchenstein 1886-1903). A second set of entries, between July and August of 1893, allude to Franc’s desire to lease land from the government, including a survey of the area with his foreman on August 29, “George Merrill and I go up to the mountains to look over the range with a view of putting some of the cattle there next summer; we camp at the head of Jack Creek.” These two episodes, especially the latter, place Franc and members of his party in the study area in both 1889 and 1893. Given the proximity of these mountains to the Pitchfork and references to both “the timber” and the mountains in his diaries, it is likely that Franc and his men ventured into the area on numerous occasions and could very well be responsible for good portion of the culturally modified wood in this study, especially the archaeological-related wood at the cow camp.

During the field season of 2005, students from the GRSLE project recorded the historic cow camp and associated features (Miller Z. et al. 2005). Figure 4.3 is an overview map of the cow camp created during this field season. The 2005 study, combined with earlier observations, reveals a multi-component site, 48PA2892, which has not only undergone multiple historic modifications, but includes evidence of both a Paleoindian and Late Archaic occupation. The tip of a prehistoric projectile point was also discovered in 2006. The prehistoric component is present, despite significant documented looting of the site, which only serves to underscore the longevity and reuse of this place on the landscape over time. The evidence for multiple modification events and long-term land use activities at the cow camp site (both prehistoric and historic) influenced the strategy for collecting tree-ring samples in 2006 and a brief return in 2009. It was not feasible to collect samples from all structures, features and CMTs at the site, but artifact selection was directed towards obtaining a broad overview of events at the site. To that end, samples were collected from the main cabin (#1 in Figure 4.3)--especially those logs with signs of reuse; the new outhouse (#3); a decayed log, aligned with the edge of a leveled area that may constitute a foundation log from an older structure (#6), a tree that forms a structural element of the corral and was scarred in the process (#8); a tree with a trail blaze; several additional CMTs; and axe-cut stumps located east of the leveled area.

Crossdating results from the Jack Creek Cow Camp (Table 4.1) corroborate the 2005 assertion that multiple construction events, reuse, and land use activities occurred at the site. A total of fourteen samples were collected from the main cabin, and 8 of those samples appear to have cutting dates or near-cutting between 1914 and 1916. One additional log has a cutting date of 1911, and another log (reportedly a foundation log removed during renovations in 2007, but provenience cannot be verified) has a harvesting date of 1919. Three additional samples,

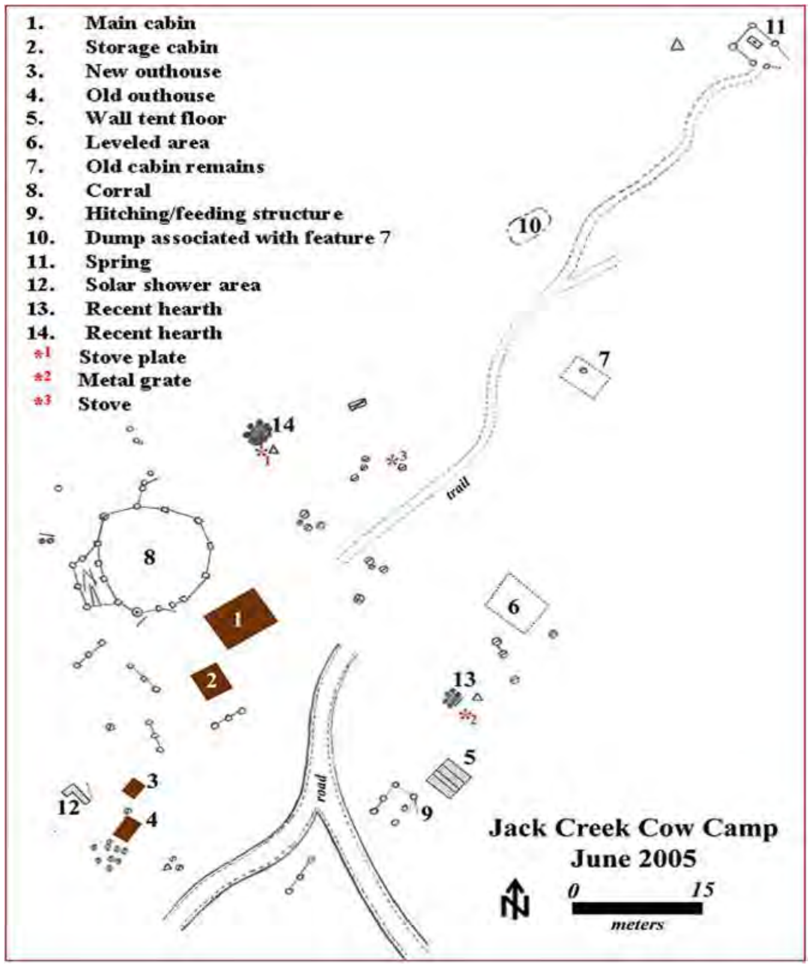


Figure 4.3. Sketch map of Jack Creek Cow Camp, created as part of the GRSLE project (Miller Z. et al. 2005).

including two from the same log, show earlier cutting dates of 1888 and 1889. Both of these logs show evidence of older notching, suggesting they are reuse logs. The final cabin sample, CCH10, (Figure 4.4), indicates a cutting date of 1938, and thus may represent a crossdating error, despite a very high inter-series correlation of .65 (Table 4.1). Another explanation, however, for this outlier date might be that this log is a replacement. This log does not span the entire northwest-facing elevation, ending instead less than halfway along the course, where it abuts a window. Therefore, it is not implausible that this course section could have been replaced

Table 4.1. Descriptive results and statistics for the Jack Creek Cow Camp produced by COFECHA with correlation values generated from a comparison with the Jack Creek reference chronology. Crossdating results have been modified to reflect unmeasured rings and are listed in the "First Date," "End Date," "s" and "s1" fields. The outermost ring code, or "OR Code," indicates the proximity of the "End Date" to a terminal, or cutting date for the tree.

Jack Creek Cow Camp Crossdated Samples										
Sample Name	Structure Feature	Element	Comments	Corr. with Ref	First Date	s	Corr. with Ref	s1	OR Code	End Date
CCC01	CMT		Living tree cut into as part of the corral	0.58	1839	**1926**	0.52	**1927**	B	2006
CCC06	CMT		Blaze with axe marks, tree next to trail	0.65	1772	**1899**	0.49	**1920**	B	2006
CCH01	Outhouse	8th course, SE elevation		0.55	1795				B	**1934**
CCH02	Outhouse	9th course, SE elevation		0.68	1803				v	**1934**
CCH03	Outhouse	1st course, NW elevation		0.67	1777				vv	**1934**
CCX01	Outhouse	Ridge pole, NE elevation		0.48	1699				v	**1890**
CCX02	Outhouse	2nd course, NW		0.69	1716				B	**1935**
CCH04	Cabin	8th course, SE elevation	Sample includes fire scar lobe, square notched, saw cut end	0.69	1786	**1883**			v	**1916**
CCH05	Cabin	5th course, SE elevation	Square notched	0.72	1800				B	**1915**
CCH06	Cabin	9th course, plate log, SE elevation	Has older axe notch	0.62	1767				B	**1889**
CCH07	Cabin	5th course, SW elevation	Rounded notch next to window, miscut? or older notch?	0.61	1799				B	**1911**
CCH08	Cabin	6th course, SW elevation	Rounded notch next to window, miscut? or older notch?	0.47	1782				B	**1916**
CCH09	Cabin	10th course, plate log, SW elevation	Possible new plate log	0.57	1820				v	**1916**
CCH10	Cabin	5th course, NW elevation		0.65	1840				v	**1938**
CCH11	Cabin	6th course, NW elevation		0.39	1837				v	**1916**
CCH12	Cabin	9th course, plate log, NW elevation	Plate log has older notch	0.50	1763				v	**1888**
CCH13	Cabin	9th course, SW elevation	No extra notches	0.61	1756				B	**1914**
CCX09	Cabin	1st course, sill log, SW elevation	W corner of SW elevation, atop stone foundation	0.38	1799				v	**1916**
CCX10	Cabin	3rd course, NW elevation		0.51	1774				v	**1915**
CCX12	Cabin	Foundation log	Foundation log was collected after 2007 renovation, exact location unknown, has axe cut notch	0.47	1795				B	**1919**
CCX15	Cabin	9th course, sill log, SE elevation	Same log as CCH06, found on ground in 2009 after 2007 renovation, has older saddle notch and scar	0.60	1714	**1863**			v	**1889**
CCX04	Stump		Axe cut	0.53	1686				v	**1898**
CCX05	Stump		Axe cut	<.31	1677				v	**1892**
CCX06	Stump		Axe cut	0.62	1687				B	**1941**
CCX11	Stump		Axe cut	0.41	1686				v	**1887**
CCX13	Stump		Axe cut, in the interior of possible old foundation.	0.59	1722	**1860**			B	**1950**

* s = pre-scar segment (pith to scar); s1 = post-scar segment; B = bark is present at outer ring, indicating a probable cutting date; v = outer ring is within a few years of cutting date; vv = cutting date cannot be determined. See Table 3.1 for code details.

without impairing the structure. In addition, a stove pipe above this western portion of the northwest-facing elevation is clearly visible in Figure 4.4. If a repair had been made to the cabin, a fire near the stove is a logical culprit. Without revisiting the site, it is impossible to determine the veracity of the 1938 crossdate, but a repair cannot be ruled out. Based on all the samples, then, construction of the main cabin appears to take place in 1916 or possibly as late as 1919 and included reuse logs that were cut in 1889-1890; with a possible repair to the cabin in 1938.

Figure 4.4. Sample CCH10, collected from the 5th course, northwest-facing elevation of the main cabin at the Jack Creek Cow Camp. The location of the sample is to the left of the shuttered window.

Crossdates from the “new outhouse” at the cow camp indicate a solid construction date as well. Four of five samples taken from courses of the outhouse have probable cutting dates of 1934 and 1935, suggesting construction occurred in 1935. A fifth sample from the outhouse, CCX01, is a ridge pole, which has been crossdated with a near cutting-date of 1890. Given that this ridge pole constitutes a portion of the roof, this log could easily represent reuse or a later renovation fromavailable dead wood. Perhaps not incidentally, the 1890 near-cutting date for this log corresponds with the two presumed cutting dates for the “reuse” logs on the main cabin (1889 and 1890).

In addition to the two structures sampled at the cow camp site, tree-rings from several other features were collected. Samples were taken from two living trees with known cultural modifications: a tree constituting a structural element of the corral and a tree with a trail blaze that was located adjacent to the main trail that runs through the site. The historic corral is captured in both a circa 1930s photograph by Charles J. Belden and a photograph taken in 2009 (Figure 4.2a and b). The samples collected from the corral were taken from a tree that clearly has a scar associated with corral construction (Figure 3.2c). The scar on this tree indicates a construction date between 1926 and 1927. The scar from the second living tree with a trail blaze does not crossdate as precisely as the corral but still offers a time-frame for the creation of the trail blaze dating between 1899 and 1920. As described in chapter 3, the gap between the pre and post-scar rings is often related to the injury itself and the date when the scar was healed over by annual growth. Assuming that the injury did not involve the removal of tree-ring layers, the pre-scar end date of 1899 may be a closer to the actual injury date than 1920.

Two samples were also taken from a leveled area that may constitute the remains of an older structure, CCX08 and CCX13. The first sample, a log thought to have formed part of the foundation, is so degraded that thus far no tree-ring analysis has been performed on it. The second sample, CCX13, was a cross-section taken from a large axe-cut stump located in the middle of the leveled area. If, indeed, the leveled area represents the footprint of a structure, the stump or tree was located within the structure's interior. This stump also has a scar that begins several feet off the ground (probably not fire) and extended beyond the axe-cut top of the stump. Although only a portion of the scar remains and no hatchet marks are visible on the two samples we collected, the scar has characteristics indicative of a peeled tree. CCX13 has a death date of 1950 and a scar date of 1860. CCX13 will also be discussed as a cultural peel in the final section of this chapter.

Webster Creek Cabin

Figure 4.5. The west elevation of Webster Creek Cabin

Webster Creek cabin is situated adjacent to Webster Creek, a tributary of Francs Fork and a drainage approximately 8 km east of Jack Creek and Jack Creek Cow Camp, which also feeds into the Greybull River. The creek is named after Charles A. Webster, who established a ranch near the Greybull River in the 1890s. Up until the 1970s, the Webster family maintained a sheepherding operation from their ranch near the Greybull River (Hicks 1980:213). The Webster Creek cabin was constructed as one of a series of summer outposts above the Greybull for sheepherding. Pencil inscriptions on the inside of the cabin are a testament to the numerous visitors to the cabin, including signatures on the walls and ceiling with discernible dates between 1947 and 1951. Like most cabins in this study, the Webster Creek cabin has an expansive viewshed: in this case, the cabin faces east and overlooks the Bighorn Basin. Less than 600 meters northwest of the cabin, spread across an undulating, open and northeast-sloping plain is a large prehistoric site recorded in 2005 and 2006, site 48PA2874. This site includes both a Late Paleoindian and Prehistoric component (Bechberger 2010). Similarly, the Webster Creek cabin is part of a multi-component site, 48PA2875, which includes both a Late Archaic and historic component. Like all of the cabins sites in this study, the historic component of site 48PA2875 is only the most recent indication of long-term landuse and resuse of optimal settings—settings that include not just a broad viewshed but access to water, game corridors and foraging potential, topographic location, and the resources found at forest edges.

In 2006, more than 30 samples were collected from the Webster Creek cabin site. These included samples from the cabin, a feature associated with a trash scatter, and living and scarred trees. Due to rot, a number of samples were excluded from analysis even before preparation. Like much of the study area, a spruce budworm infestation had taken its toll on living trees in this drainage, and by 2006 it was hard to find a tree that was healthy. Several samples collected from the cabin had such tiny rings towards the outside that these samples were given an outermost ring code of “v,” or “within a few years of cutting,” rather than a proposed cutting date even when bark was present.

In the end, thirteen tree-rings samples were analyzed from the Webster Creek cabin. One of those samples, SCX02, a small-radius cross-section of a rafter collected from the ground, showed no correlation with the reference chronology and was therefore excluded from the results. A second sample, SCH02, came from the same log as SCH01. This sample was taken from the face of a fire scar on the log and the crossdate for the fire scar (1907) was incorporated into the results for SCH01. Crossdating results for the eleven remaining samples from the cabin and six samples from scarred trees are presented in Table 4.2.

The results do not offer a definitive construction date for the cabin. The end dates range quite widely from 1848 to 1935. It is possible that the cabin was constructed from dead wood, sections rebuilt, or even that the crossdating is in error. Most of the samples in this study come from an area closer to Jack Creek. The Webster Creek cabin is situated on a south/southeast-facing slope at the southeastern extent of the study area. Perhaps these trees are responding to local conditions or stresses and falsely correlate with the reference chronology. As a further test, these samples were run through COFECHA separately to assess their inter-series correlation. Six samples collected from living trees near the cabin were used as a mini reference chronology and compared to the undated samples. COFECHA produced the same best fit dates for each of the cabin samples as it had using the Jack Creek reference chronology, raising the likelihood that the crossdating results are accurate.

Table 4.2. Descriptive results and statistics for Webster Creek cabin produced by COFECHA with correlation values generated from a comparison with the Jack Creek reference chronology. Crossdating results have been modified to reflect unmeasured rings when applicable.

Webster Creek Cabin Crossdated Samples										
Sample Name	Structure Feature	Element	Comments	Corr. with Ref	First Date	s	Corr. with Ref	s1	OR Code	End Date
SCH01	Cabin	4th course, N elevation	Square notch, forms part of window; log has fire scar. The scar date was obtained from a second sample, SCH02, that was taken from the face of the scar	0.65	1794	**1907**			v	**1923**
SCH03	Cabin	7th course, E elevation		0.66	1801				r	**1899**
SCH04	Cabin	5th course, S elevation		0.53	1755				v	**1891**
SCH05	Cabin	Ridge pole	Ridge pole from inside (west end), ends sawed	0.44	1684				v	**1863**
SCH06	Cabin	3rd course, W elevation	Bark was near core	0.64	1760				v	**1921**
SCH07	Cabin	Rafter	Rafter w/"Peggy Sharp" inscription at axe cut end attached to ridge pole	0.63	1751				v	**1894**
SCH08	Cabin	Rafter	Rafter N side, bark on opposite side of core, 7th rafter remaining from NW corner	0.42	1748				v	**1848**
SCH09	Cabin	7th course, plate log, N elevation		0.60	1745				v	**1866**
SCH10	Cabin	Bed frame	NW corner and along N elevation	0.63	1836				v	**1960**
SCH11	Cabin	Fire box	2nd course of fire box, NW side (under N-facing window)	0.42	1669				v	**1875**
SCX01	Cabin	7th course, plate log, S elevation		0.61	1735				v	**1894**
SCX03	Cabin	3rd course, S elevation		0.59	1751				v	**1935**
SCC01	Living		Living tree with unknown scar	0.66	1872	**1887**	0.48	**1938**	v	2006
SCC03	Living		Mostly healed scar, origin unknown, hit scar and then rot, no pre-scar rings				0.61	**1849**	B	2006
SCC04	CMT		This sample captured 2 scars: the intended peel scar and an unexpected scar at the opposite end of the core, past pith (see below). The portion of the sample from bark to the 1st scar was lost during preparation.	0.72	1765	**1865**			N/A	
SCC04	CMT?		Second scar from opposite side of peeled tree, captured when collecting peel scar sample. Origin of scar unknown. Core broke off at this second scar. Second scar was not noted in field.	0.53	1759	**1893**			N/A	
SCC05	CMT		No photo-insufficient notes, assumed to be a sample of a peel scar	0.63	1824	**1865**	<0.38	**1872**	N/A	2006
SCC06	CMT		Tree forms N corner of trash pile, scar had no axe mark; no accurate crossdate could be found for the post-scar tree-rings, but # of rings fits w/scar date	0.61	1846	**1945**	no corr.		B	

* r = outermost ring appears continuous, but circumference is incomplete (Table 3.1).

In addition to the cabin, six samples from living trees captured scars. The scar on SCC01 was captured unintentionally and its origin is unknown. SCC03 also has a scar of unknown origin and a pre-scar segment with so few rings that the crossdate cannot be validated. The remaining samples captured scars from culturally modified trees. Sample SCC06 was collected from a living tree that formed the north corner of a can scatter with two logs stacked vertically next to the tree, forming a low wall. The scar on the tree above these logs dates to 1945 (the post-scar segment did not correlate). Samples were also collected from two culturally peeled trees. These trees were part of a larger group of peeled trees that were discovered as we were departing the site. The peels had distinctive 40-60 mm hatchet marks at both the base and top of the scars. Although we did not have time to record or even get a count of the trees, peels were noted on both living trees and trees that had died as a result of the injury (no evidence of healing after the peel). Several attempts were made to capture the peel scar and two were successful (SCC04 and SCC05). In both cases, the pre-scar segments have a crossdated end date of 1865. The post-scar segment for SCC04 was lost during preparation, but the post-scar sample from SCC05 provides a gap between the pre- and post-scar segments of 1865 to 1872, a tidy bracket. The sample taken from SCC04 included a second scar on the opposite side of the sample (past pith). This scar, not recorded as a peel in the field, dates to 1893.

All three of these scars are provocative. The two peels, with strong dates of 1865 confirm activities in the forest prior to cabin construction. In addition and perhaps not coincidentally, two samples from the cabin have end dates within a couple of years of 1865, and three more logs have an end date within a couple of years of the second scar on SCC04 in 1893. While these scar dates confirm nothing regarding cabin construction dates, there could reasonably be a connection between trees that died as a result of bark peels and an increased number of suitable dead logs available for cabin construction.

The peel dates and scar characteristics for samples SCC04 and SCC05 are compelling in a second, more tangible way. The early crossdates for these peels, combined with the small size of the hatchet marks and the method of bark removal are indicative of Native American bark procurement practices. The 40-60 mm hatchet marks on these trees and on others documented in the study area are noteworthy. A report produced by the Archaeology Branch, B.C. Ministry of Small Business, Tourism and Culture of Canada (2001) suggests that Native American peels can often be distinguished from other historic CMTs by narrow tool marks and blade curvature. An adze, or curved hatchet, found near a contact period site in the study area, 48PA2772, has a blade width of 42.5 mm and is typical of the type of tool likely used to peel trees (Figure 4.6). The adze, along with a handful of glass trade beads and stone tools found at the site as well as the 1865 peel dates from

Figure 4.6. A metal adze blade found near site 48PA2772.

the Webster Creek Cabin site affirm the presence of Native Americans on this landscape during the contact and post-contact periods. Furthermore, the peel dates, although preliminary, help to anchor specific activities during these periods in precise time.

Chico's Cabin

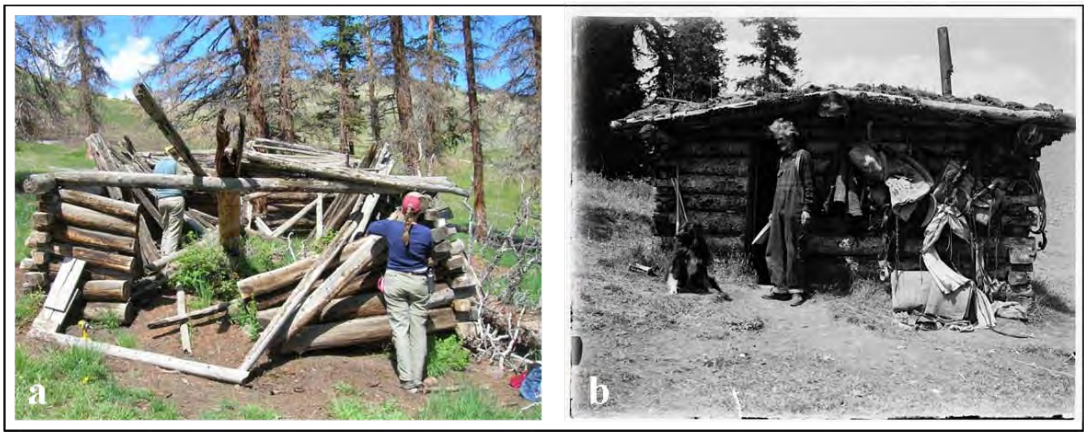


Figure 4.7. Chico's cabin: (a) a photograph taken of Chico's cabin in 2006 while sampling; and (b) a photograph, circa 1930s, entitled, "Snake River Bill outside sheep camp cabin at Jack Creek (MS 3, Charles Belden McCracken Research Library, Buffalo Bill Historical Center, Cody, Wyoming, PN.67.381a).

Chico's cabin is located just below timberline along a major historic trail, the Haymaker Timber Creek Trail, which connects Upper Jack Creek to the Upper Greybull River to the west. The cabin is part of a multi-component site, 48PA875, which also includes an unknown Prehistoric component. Little is known about Chico's Cabin, such as who built the cabin and when. A photograph taken by Charles J. Belden circa 1930 titled, "Snake River Bill outside sheep camp cabin at Jack Creek" shows a cabin that resembles Chico's cabin (Figure 4.7a and b), and perhaps provides a clue to both construction and inhabitants. Ten samples were collected from the cabin itself with an additional sample collected from a culturally modified tree (Table 4.3). Seven out of ten samples from the cabin have a cutting date of 1925 and 1926--all but one with bark. The other three samples all crossdate earlier, reinforcing a date for cabin construction between 1925 and 1926.

Table 4.3. Descriptive results and statistics for Chico's cabin produced by COFECHA with correlation values generated from a comparison with the Jack Creek reference chronology. Crossdating results have been modified to reflect unmeasured rings.

Chico's Cabin Crossdated Samples										
Sample Name	Structure Feature	Element	Comments	Corr. with Ref	First Date	s	Corr. with Ref	s1	OR Code	End Date
CHH01	Cabin	7th course, W elevation	Log forms window lintel	0.48	1795				B	**1925**
CHH02	Cabin	Ridge pole, W elevation	Collapsed & broken in center	0.61	1810				B	**1866**
CHH03	Cabin	Bed frame	Part of bed frame, has 2x4's on end acting as a leg, bed against SW corner and walls	0.47	1787				B	**1926**
CHH04	Cabin	6th course, N elevation	Sample taken from inside structure	0.74	1786				v	**1909**
CHH05	Cabin	Sill plate, N elevation	Partially collapsed inside cabin	0.51	1807				B	**1925**
CHH06	Cabin	8th course, E elevation	Has hinge attached near door opening	0.67	1871				B	**1925**
CHH07	Cabin	2nd course, E elevation		0.73	1880				B	**1926**
CHH08	Cabin		No notes on this sample, but was with samples from Chico's cabin and name on core looks correct	0.69	1832				v	**1920**
CHX01	Cabin	5th course, N elevation		0.66	1791				v	**1925**
CHX02	Cabin	5th course, W elevation	Has fire scar	0.48	1709	**1805**			B	**1926**
JCC02	CMT		Near Chico's cabin, has hatchet marks	0.70	1749	**1865**	0.55	**1875**	v	1992

In addition to the cabin, several culturally modified trees were also observed nearby. The CMTs include a standing dead tree with significant chunks of wood removed by an axe (Figure 3.2d) and several with oval-shaped scars—at least some of them showing signs of a peel or axe-cut injuries. Because bedding material found inside the cabin included a layer of bark underneath a layer of burlap, the peeled trees were assumed to be associated with the historic cabin; however, a sample taken from a peeled, living tree, JCC02, yielded a bracketed scar date of 1865 to 1875—surprisingly similar to the peeled trees at the Webster Creek cabin. Both JCC02 and a second, bleached snag located nearby are shown in Figure 3.2a and b. Figure 3.2b shows the peel marks as well as a the thin layer of tree-rings that formed before the tree died.

Jack Meadow 2 Cabin

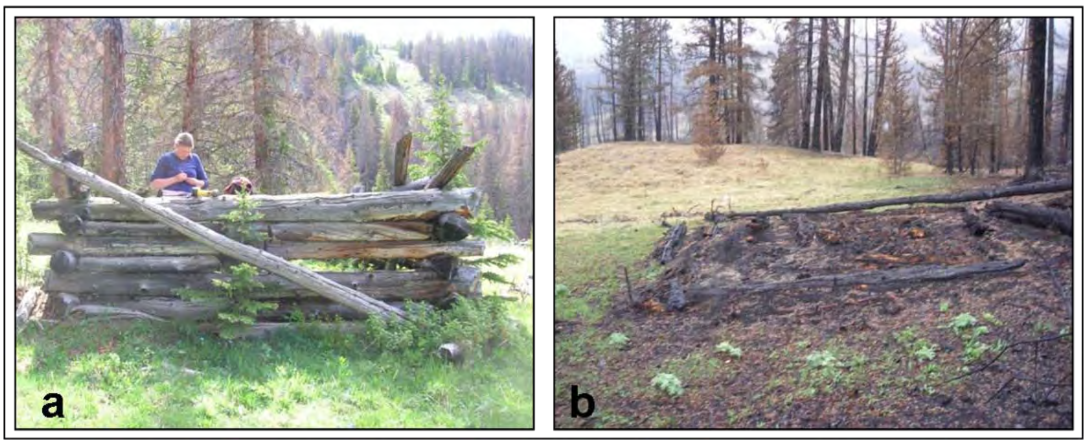


Figure 4.8. Jack Meadow 2 cabin: (a) a photograph of Jack Meadow 2 cabin taken in June 2006; (b) the charred remains of the cabin taken in the fall of 2006, photograph courtesy of Dr. Lawrence C. Todd

Discovering Jack Meadow 2 cabin was unexpected and fortuitous. We found this unrecorded cabin as we looked for a known cabin near Jack Creek, on the last day set aside in 2006 for collecting tree-ring samples. The cabin was located approximately 300 m west of Jack Creek in a small meadow surrounded by trees. The cabin is part of the multi-component site recorded in 2004, 48PA2794, which also includes an unknown Prehistoric component. Compared to other cabins in the study, Jack Meadow 2 cabin was unique. The doorway faced west rather than east;

the viewshed was minimal; the ends of the cabin courses were axe cut as opposed to saw cut; no nails appeared to have been used in construction, and the unusually large gaps between log courses had been chinked with timber poles nearly the size of the courses themselves. The only cabin window observed was a small, rectangular portal cut out of the 5th course and chinking poles of either side of this course. In addition, no can scatter or historic artifacts were found at the site. The construction of this cabin appeared both expedient and, based on the high level of deterioration, to predate the other cabins. Due to both time constraints and the condition of the logs, only six samples were collected from the structure. We had hoped to return to the cabin to record it more fully, unfortunately, a few weeks later, the cabin burned to the ground in the Little Venus Fire (Figure 4.8a and b). Thus, the six samples now constitute all that remains of the cabin and its history.All six tree-ring samples from the cabin were measured and run through COFECHA. Crossdating correlation results for these samples when compared to the Jack Creek reference chronology are not conclusive. Not only do the best-fit crossdates vary widely in the COFECHA output, but credible crossdates (terminal dates within the last 200 years) are the best-fit adjustment, or “1st correlation,” in only 2 of the 6 samples. Table C.1 in Appendix C displays the results from part 8 of the output file, which provides the top 11 best-fit “adjustments” (first date) for each segment of a sample and its associated correlation value. All of the samples had a small number of rings, n=52-111, so only one 100-year segment was analyzed for each sample.

In order to assess the validity of these best-fit adjustments, the terminal date of the sample is more important than the first date. This is especially true for this cabin because all logs were axe cut and, therefore, felled intentionally, presumably for cabin construction. By adding the total number of tree-rings to each proposed adjustment, a last ring date can be ascertained. By doing so, some adjustments can be ruled out. For example, since all logs were axe-cut, the use of older deadwood is highly unlikely. Also, the cabin is almost certainly Euro-American in design and thus would have been built no more than two hundred years ago. The cabin was also heavily deteriorated, especially in comparison to other cabins in the study, so terminal dates later than the early 1900s are viewed with great skepticism.

Once obvious invalid adjustments are excluded, two clusters of terminal dates stand out: 1882-1887 (n=6) and 1942-1945 (n=4). The related adjustments, or "first dates" are highlighted and the cluster dates distinguished in Table C.1 in Appendix C. Even though 1942-1945 seems too recent, the four samples with dates in this cluster have a total average correlation value of .37. The total average correlation value for the second cluster, 1882-1887, is also .37 (based on all six samples). Because both clusters share the highest overall correlation of any in the output file, neither cluster has been ruled out.

The Jack Meadow 2 cabin samples proved the most difficult of the archaeological samples to crossdate. One reason for poor correlation is simply the result of the low number of tree-rings in each sample. There were just 52 and 53 tree-rings respectively for two of the samples and no more than 111 tree-rings in a sample. Strong correlation is hard to obtain on any sample with few rings, but it is made more difficult with a complacent species, where high frequency patterns can only be detected when enough tree-rings are present, preferably >100. It was not surprising, then, that altering the COFECHA input criteria of number of years compared for each segment from 100-years to 50-year segments provide no noteworthy change in correlation results.

As mentioned previously, crossdates for most of the archaeological samples in the study are very strong. In fact, many times, crossdates for the undated samples produce higher correlation values than those in the Jack Creek reference chronology. As a consequence, the inconclusive Jack Meadow 2 cabin samples were re-run through COFECHA as undated and compared to a "master chronology" that combined measurements from both the original reference chronology and those undated samples that have been confidently crossdated with no flags. This compilation chronology compared 105 tree-ring samples from the study, including independent pre and post-scar samples to all six undated samples from the cabin. The results give further credence to the clustered crossdates between 1882 and 1887. Table C.2 in Appendix C highlights the correlation values for both the 1882-1887 and the 1942-1945 clustered dates. This table shows an increase in the total average correlation value for the 1882-1887 cluster to .47. In addition, three out of the six samples now have a 1st order correlated terminal date between 1882 and 1887, and two more have a 2nd order correlation. The sixth, the sample with the least number of rings, has a date within this cluster, but as the 9th order correlation. Based on this second set of statistics, and using compilation chronology, the 1882 through 1887 terminal dates emerge as strong crossdates and are summarized in Table 4.4.

Table 4.4. Descriptive results and statistics for Jack Meadow 2 cabin produced by COFECHA with correlation values generated from a comparison with the Jack Creek reference chronology. Both the First Dates and End Dates presented here are provisional and based on a comparison of inconclusive crossdates, observed characteristics, and a process of elimination. The First Date and End Date fields have been modified to reflect unmeasured rings.

Jack Meadow 2 Cabin								
Sample Name	Structure Feature	Element	Comments	No. Years	OR Code	Corr. with Ref	First Date	End Date
MCH01	Cabin	4th course, E elevation	Notched where window might have been	105	B	0.31	1779	**1885**
MCH02	Cabin	3rd course, E elevation		52	B	0.33	1831	**1884**
MCH03	Cabin	2nd course, N elevation		86	v	0.52	1797	**1884**
MCH04	Cabin	5th course, S elevation		111	vv	0.26	1771	**1882**
MCH05	Cabin	1st course, E elevation		53	v	0.47	1833	**1887**
MCX01	Cabin	2nd course, E elevation	Sample taken from angle notched end	91	v	0.41	1796	**1887**

The tentative dates outlined in Table 4.4 for the construction of Jack Meadow 2 cabin are further corroborated by historical documents. Some of the earliest documented visitors to this area are Otto Franc and Colonel William D. Pickett. Otto Franc entered the Bighorn Basin in 1877 on a hunting trip and in 1878 built a log cabin along the Greybull (Edgar 1978). Col. Pickett chronicled his hunting expeditions into the Greybull beginning in 1879 in his memoirs for the book of the Boone and Crockett Club (Pickett 1913). Col. Pickett describes months-long big game hunting expeditions in the Greybull area and the surrounding mountains; his party often carried little rations with them, relying instead on hunted meat. In 1882, Col. Pickett describes venturing into the valley of a large creek, later known as Jack Creek on his first foray "over the mountains to the west," placing him in or near the study area in 1882. In 1883, Col. Pickett established a cattle ranch along the Greybull River, several miles up from Otto Franc, and continued to hunt big game in the area. Not only do the tentative dates for Jack Meadow 2 cabin coincide with Col. Pickett's hunting expeditions, the cabin's characteristics are suggestive of a hunting outpost. These characteristics include an expedient design, its location about 300 meters above Jack Creek atop a secluded shelf, a small portal facing Jack Creek, and no associated can or artifact scatter. While one can only speculate, the parallels are compelling.

Culturally Peeled Trees

Figure 4.9. A culturally peeled tree in the study area: (a) peeled tree near Kay Creek cabin. A sample was collected from this tree in 2009; however, this sample has not yet been crossdated; (b) a close-up of hatchet marks that are a classic indicator of a cultural peel.

At six of the seven cabin sites, culturally modified trees (Figure 4.7) were present and sampled. The seventh cabin, Upper Jack Creek cabin had no nearby trees to sample; although stumps could be seen to the northwest. Quite a few of the CMTs in this study are clearly associated with either the cabins or other obvious land use activities, such as the corral, trail blazes, structural elements, and survey markers. Not all of the culturally modified trees at any cabin site were sampled;

instead, an overview was selected. Most of the culturally modified trees analyzed are described above in the results sections for each of the crossdated cabins. A final category of CMTs are the culturally peeled trees found at Webster Creek cabin, Chico's cabin, Kay Creek cabin, and, possibly, at Jack Creek Cow Camp. At least eight peeled tree samples collected in 2009 from Kay Creek cabin (7) and Jack Creek Cow Camp (1) have yet to be measured and crossdated. One peeled tree from Kay Creek cabin, sample KCC01s and KCC01s1, was analyzed and crossdated for context. Figure 4.13 shows the location of the cultural peeled trees.

In addition to the peeled trees at the four cabin sites, several other scarred trees were found in the study area with a distinctive oval-shaped scar several feet above the ground. These include sample CCX13 from the axe cut stump at Jack Creek Cow Camp; samples from a group of at least 11 scarred trees that were burned in 2006, but are still standing; and a scarred ghost tree. This group of scarred trees were discovered in 2009 while trying to relocate the oldest living tree in the study (JCC01), which was alive in 2006, but appears to have most certainly perished in the Little Venus Fire. The scarred trees were located in an area approximately 30m x 40m on a northeast-facing slope just above an ephemeral drainage. These trees are fire damaged and any evidence of hatchet marks was erased. As a result, the origin of these scars is only conjecture (Figure 4.10). One other distinctive scar presented in the results is from a ghost tree, JCX38, sampled in 2009. The scar, which was located on the underside of this fallen ghost tree, was initially observed while cutting a cross-section. After the sample had been collected, the ghost tree stump was set upright for a photograph. Only recently, while looking

Figure 4.10. A possible peeled tree, sample JCC33, one of at least 11 similarly scarred trees that burned in the Little Venus Fire, 2006.

at two photographs of the tree, was the distinctive character of the scar revealed (Figure 4.11a and b). Based on crossdates (Table 4.5), this scar dates to 1573, which places it outside of most documented cultural peels in the Rocky Mountains. With no evidence of hatchet marks, this scar cannot be considered a peel with any certainty; nevertheless, the photographs of the scar are enticing.

Figure 4.11. Ghost tree with possible peel: (a) sample JCX38, after a cross-section was taken in 2009 from this ghost tree; and (b) a scar that is a possible cultural peel.

Of all the samples taken since 2006, the tree-rings from both verified and possible cultural peels were collected the least systematically. When sampling was initiated in 2006, these CMTs were presumed to be a product of land use activities related to each of the cabins. It was only after analysis was performed on some of the scars with hatchet marks that a more complex history began to emerge. In addition to this bias on my part, many of these particular trees were found as we departed a site, so sampling was directed towards obtaining a quick representative sample for later analysis and research. Table 4.5 presents the preliminary crossdating results from 12 of those trees.

The crossdates for these scars are compelling. For all but two trees, both the pre-scar and post-scar crossdates indicate the scarring event occurred in the mid-1800s. Only JCX38, the single ghost tree in the results, and JCC32, from the group

Table 4.5. Descriptive results and statistics for both verified and potentially culturally peel trees produced by COFECHA with correlation values generated from a comparison with the Jack Creek reference chronology. Crossdating results have been modified to reflect unmeasured rings.

Possible and Verified Culturally Modified (Peeled) Trees										
Sample Name	Structure Feature	Comments	Corr. with Ref	First Date	s	Corr. with Ref	s1	OR Code	End Date
CCX13	CMT?	Axe cut stump , in the interior of possible old foundation.	0.59	1722	**1860**			B	**1950**
SCC04	CMT	This sample captured two scars. This date represents crossdates for the peel scar, post-scar tree-rings during preparation.	0.72	1765	**1865**			N/A	
SCC05	CMT	No photo-insufficient notes, assumed to be a sample of a peel scar	0.63	1824	**1865**	<0.38	**1872**	N/A	2006
JCC02	CMT	near Chico's cabin, has hatchet marks, 2nd peel was not sampled	0.70	1749	**1865**	0.55	**1875**	v	1992
KCC01	CMT	Peel has hatchet marks	0.40	1764	**1830**	0.53	**1937**	B	2005
JCC30	CMT?	Standing burned, dead tree, found after 2006 fire, in a cluster of more than 11 scarred trees, with distinctive oval shapes and at ~ breast height	0.76	1763	**1840**	0.62	**1858**	vv	1915
JCC31	CMT?	same notes as JCC30; opposite side of core was used to obtain pre-scar correlation crossdates due to very few rings pre-scar (n=6) on scar side and n=92 uninterrupted rings on opposite side of scar	0.62	1836	**1842**	0.53	**1844**	vv	1977
JCC32	CMT?	same notes as JCC30	0.57	1550	**1617**	0.65	**1758**	vv	1986
JCC33	CMT?	same notes as JCC30	0.48	1771	**1845**	0.75	**1896**	vv	2006
JCC34	CMT?	same notes as JCC30	0.47	1775	**1855**	0.72	**1855**	vv	1973
JCC35	CMT?	same notes as JCC30	0.68	1777	**1841**	0.76	**1923**	vv	1974
JCX38	CMT?	ghost tree with oval shaped scar at ~ breast height	0.40	1500	**1573**			vv	1730

of scarred trees discovered in 2009, are obvious outliers. It should be mentioned that all of the samples, except from the ghost tree, were obtained using an increment borer; thus, the gap between the pre-scar end date and the post-scar first date is not unexpected due the time it sometimes takes for a scar to heal over. As a result, the “s” scar date in Table 4.5 and Figure 4.12 is generally assumed to be closer to the actual scar date than the “s1” date.

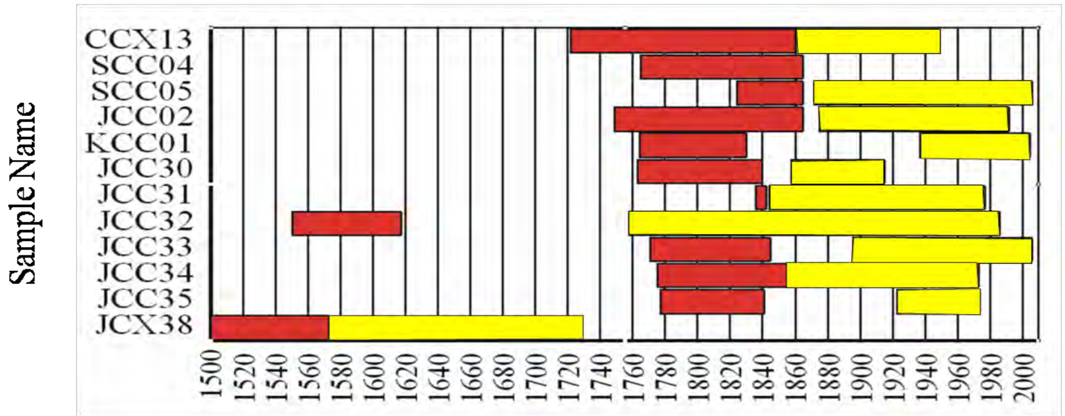


Figure 4.12. Culturally peeled trees (tentative), showing both the pre-scar and post-scar segments and the gap between.

In reviewing the photograph of JCC32, one of the outliers, it seems quite plausible that the sample taken from this tree missed the intended scar and hit a second, earlier scar, which may be the result of fire. Removing these outliers from analysis, the remaining tree-ring samples collected from the scarred trees consistently indicate injuries that took place in the mid-1800s events. Even though large gaps exist between the pre-scar and post-scar segments for the majority of these samples, crossdate correlation values are some of the highest of any among all the samples collected from the study area and thus appear to represent valid dates. In fact, 11 out of the 19 series in the COFECHA analysis have correlation values that exceed the inter-series average from the Jack Creek reference chronology, .587, presented in Appendix B.

The preliminary results from peeled trees add a layer of depth to both the historical and archaeological record that is not otherwise attainable. The peel dates give further support for the idea that historic places such as those where the cabins are situated often have a much longer and richer story to tell about human presence and land use. Figure 4.13 is illuminating. The cabins as well as the peels are clearly located near the edges of the forest as well as near water sources. The exception is the group of scarred trees found in 2009. The discovery of peeled trees at the cabin sites is not surprising; after all, a water source is a water source; a viewshed, a viewshed; and good summer grazing is as favorable to domesticated animals as it is for big game. The fact that a group of potentially peeled trees has been located deep within the forest just 40 meters from the oldest, living trees in the study (now burned) hints at an even more complex relationship between humans, land use activity, and the forest in this high montane ecotone.

If these trees, especially those with the oldest scars, are indeed the result of cultural peels, they imbue another blank spot on the map with added relief, extending the archaeological record from the tree-rings deeper back in time. These peels provide another “newly” discovered aspect of the protohistoric/contact period. This period is still poorly understood in the region and has only come to light in the study area after the Little Venus Fire exposed artifacts such as trade beads and metal objects at a number of sites. When viewed as a whole, crossdating results from confirmed cultural peels and from the four historic cabins and associated features provide invaluable and precise calendar dates for events and activities that took place on this landscape. These results illustrate the range of behaviors and landuse patterns that can be detected in trees, and, ultimately, give an overview of the type of activities and resource use that occurred in this high montane environment during the recent past.

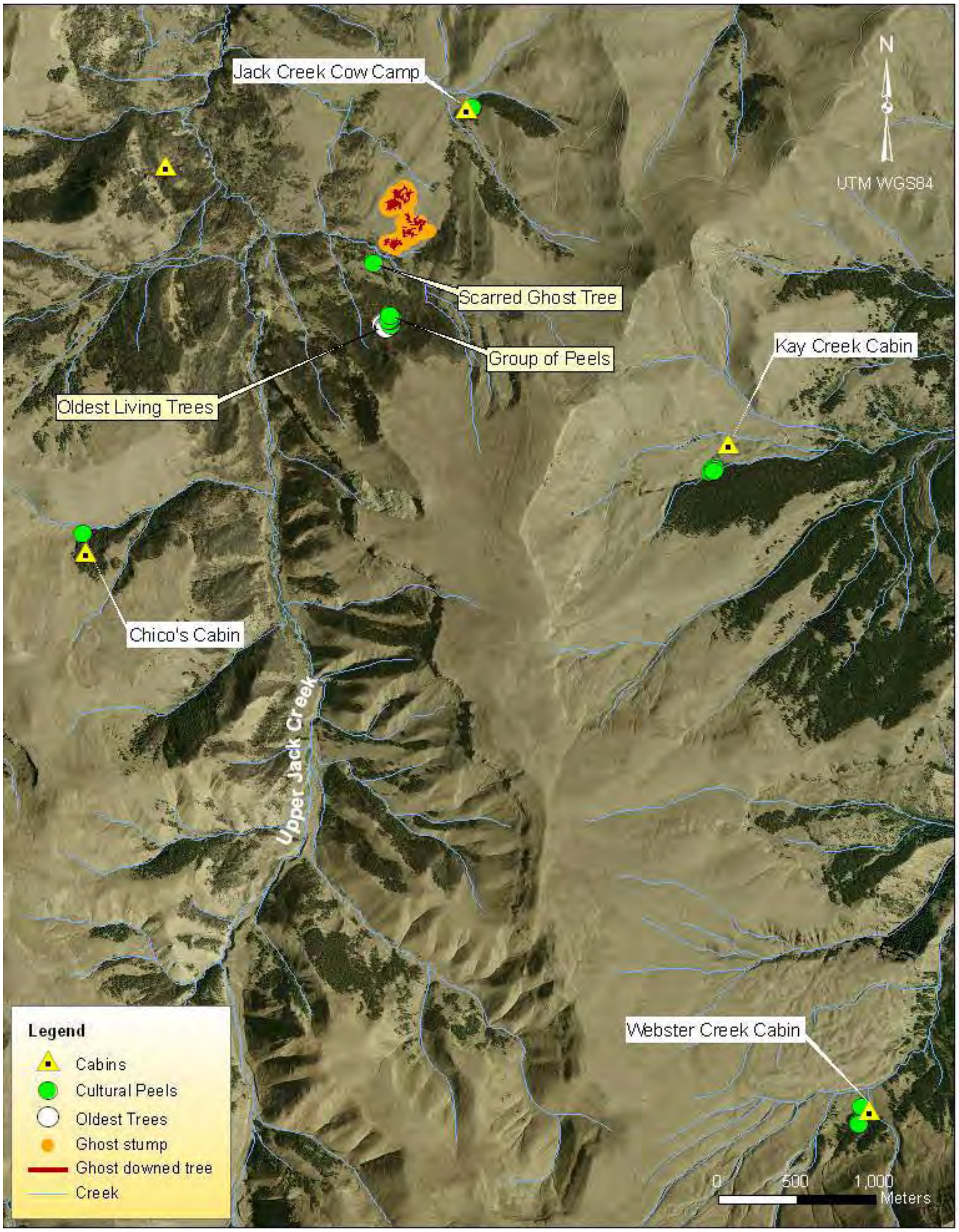


Figure 4.13. Map of cabins, culturally peeled trees, ghost trees, and oldest trees in the study area. National Imagery Program (NAIP) data imagery from 2006 for east Park County, Wyoming was used as a background layer (WyGIS 2009).

CHAPTER 5: CONCLUSIONS AND FUTURE DIRECTIONS

Emptiness to Richness: Coloring in the Detail

The Upper Greybull Watershed and the GRSLE project offer a unique opportunity to compare conceptions of the wilderness as marginal and uninhabited with lines of evidence such as historic documents and the archaeological record that uncover an elaborate, complex, and evolving story of human behavior and landuse. This evidence as well as the the Little Venus Fire of 2006 underscore a landscape in constant flux and transformation—one that resorts, reduces, or reveals the cultural record. Finally, this chapter and the study attempt to reinforce the idea of a cultural and climatic record in jeopardy, where the remnants of past human activities and environment, especially those related to the proto-historic period, are vanishing.

As outlined in Chapter one, the primary objectives of this study were four-fold: 1) Collect, preserve, and crossdate archaeological-related tree-ring samples; 2) Explore culturally-embedded notions of “emptiness” related to wilderness and investigate a regional “blank spot on the map;” 3) Illuminate past cultural practices related to wood and the forested environment; and 4) Compare historic documents and first-hand accounts of the region to a tree-ring chronology. This final chapter summarizes results related to these four objectives and discusses future considerations and directions for ongoing research. This chapter begins with the development of a master chronology, reexamines notions of “emptiness” and concludes with a comparison of the tree-ring chronology to historic documents. Future directions are mentioned throughout the chapter.

COLLECTION, PRESERVATION AND CROSSDATING

The Creation of the Jack Creek Master Chronology

To date, well over 500 tree-ring samples have been collected as part of the GRSLE project (over 200 for the research presented here, and another 300+ for another, on-going MA thesis project). This thesis includes samples from historic structures, prehistoric features, culturally modified trees, as well as living and remnant trees. This study focuses on crossdating a portion of these samples, primarily those samples collected in 2006 as part of a larger archaeological survey of the Jack Creek area. The broad goal of this study was to collect and crossdate enough tree-ring series to build a master tree-ring chronology from which future regional tree-ring samples can be crossdated and baseline climate patterns deduced and interpreted. With these goals in mind and to further explore the relationship between the modern proxies listed above and past human landuse, a master chronology was developed from the tree-ring series dataset.

Based on statistics generated in COFECHA, raw tree-ring measurements from 80 series with the highest correlation values and strongest crossdates were selected and run through the computer program ARSTAN (Cook 1985; Holmes 1983). In ARSTAN, a cubic smoothing spline of 250 years was applied to the data, which has the effect of removing low frequency trends, specifically age-related growth. In other words, as a tree ages and grows, the diameter of a tree increases and more mass is required to produce a tree-ring of comparable size to the last. This age-related growth curve is considered low frequency “noise” since it is related to each tree’s increasing circumference over time rather than climate or stand dynamics. By applying a cubic smoothing spline, this low frequency “noise” can be removed, or “smoothed out.” Once these age-related trends have been removed, the tree-ring measurements are standardized using ARSTAN to a common mean of 1.0. These detrended, standardized tree-ring measurements are considered a “dimensionless” index of growth for each year that better reflect a set of measurements related to climate and stand dynamics (Fritts 1978; Brown, personal communication 2010). Once data from all 80 samples were standardized, a master chronology was created in ARSTAN and the results plotted (Figure 5.1).

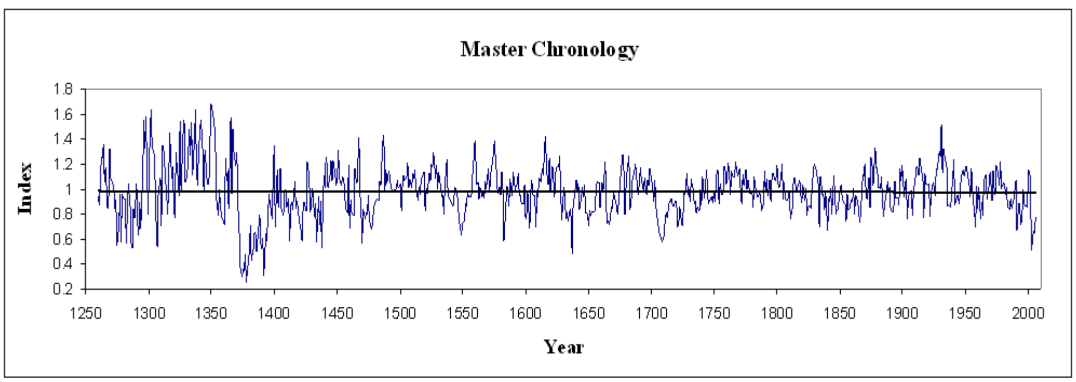


Figure 5.1. The Jack Creek master chronology, composed of 80 best-fit crossdates. The growth index for each year has been standardized to a common mean of 1.0, using ARSTAN (Cook 1985).

Several issues related to the development of this master chronology need to be addressed. The year interval 1260-1399 in the master chronology is based on only one ghost tree sample, JCX45, and the year interval 1400-1449 includes an additional sample, JCC21—hardly sufficient number of series to consider the results for 1260-1449 representative of the larger environment. A time plot of all series in this master chronology is presented in Appendix D and a summary of the master chronology samples is provided in Appendix E. Out of the six samples collected from ghost trees, four are part of this master chronology, CCX14, JCX45, JCX38, and JCX46. Two of these, JCX38 and JCX46, have low inter-series correlation with the rest of the series in the master chronology, .347 and .393 respectively, but they are included in the master chronology in order to add depth to the early part of the chronology. Despite the lower correlation values, crossdates for these two samples appear to be correct.

Even though the standardized indices for the years 1260-1399 are derived from a single tree, the patterns in Figure 5.1 exhibited by this tree are noteworthy. From 1260 to 1373, JCX45 has comparatively large ring widths and a high degree of variability, followed by a substantial dip in ring width starting in 1374. With only one tree-ring series represented, standardization through averaging will not remove any age-related variance. At least part of the low frequency noise in this one series is probably related to the growth pulses of a young tree. On the other hand, this tree might also be exhibiting growth pulses related to stand dynamics, or exogenous disturbance. For example, as a shade-tolerant species, it is quite possible that an Engelmann spruce sapling might thrive in the understory of a forest but show a decrease in growth once the tree becomes part of the overstory. ARSTAN includes a number of statistical computations and analytical tools to investigate stand-related dynamics. However, such analysis is outside of the scope of this current study. A logical next step in exploring landscape change, forest dynamics and tree-line fluctuations in this montane environment would be to further analyze climate and stand dynamics using ARSTAN.

The Master Chronology, Ghost Trees, and Fire

Figure 5.2. Remains of the ghost forest.

In general, the ghost trees have proven difficult to crossdate to the 99% confidence threshold and often required re-examination and re-measurement. The two ghost tree samples left out of the master chronology have flags in the COFECHA output file that could not be resolved. Future research will include collecting and analyzing additional remnant samples to improve overall correlation and crossdating for the early part of the chronology. A future step will also likely be to go back and analyze these ghost trees as a separate and undated, or "floating," series. As undated series, the raw measurements can be run through COFECHA to establish inter-series correlation rather than potential crossdates. This may help to identify missing or absent rings or other pattern anomalies that have thus far prevented high correlation and confidence.

Although the tree-ring measurements for the ghost trees have produced less reliable "best match" crossdates in COFECHA, provisional dates have been given to all six samples based on inter-series correlation with the master chronology (Table 5.1). Due to outer wood degradation, the outer ring, or “End Date” is unlikely to be a death date for the trees; however, the end dates for the ghost trees are consistent, falling between the early-1600s to early-1700s.

Table 5.1. Descriptive results and statistics produced by COFECHA for the ghost trees with correlation values based on average inter-series correlation within the master chronology. Crossdating results have been modified to reflect unmeasured rings.

Ghost Trees								
Sample Name	Structure Feature	Comments	Inter-series Correlation	First Date	s	OR Code	End Date	No. of Years
CCX14	Ghost Tree		0.584	1474		vv	1644	171
JCX38	Ghost Tree/ CMT?	Ghost tree with possible peel scar	0.347	1500	1573	vv	1730	231
JCX43	Ghost Tree		0.480	1265		vv	1629	365
JCX44	Ghost Tree		0.239	1198		vv	1612	415
JCX45	Ghost Tree		0.563	1260		vv	1719	460
JCX46	Ghost Tree		0.393	1495		vv	1653	159

Since they were first recorded, the ghost trees have been assumed to be the remains of a stand-clearing fire. This assumption is based on four observations: 1) most of the ghost trees show a similar degree of decay consistent with a single disturbance event; 2) many of the downed trees have the same orientation, toppled after death by prevailing winds from the northwest; 3) scar patterns are apparent on some of the trees, indicative of fire; and 4) the presence of charcoal on at least one of the ghost trees. The charcoal sample, JACKGF01, collected from a ghost tree in 2004 has yielded a charcoal date that falls between 1474 and 1649 CalAD with a 95.4% probability (Figure 5.3). The radiocarbon results from this sample provide a conventional date for the death of this tree that fits well with the end dates for four out of six of the crossdated ghost trees (Table 5.1). Lending further support for a

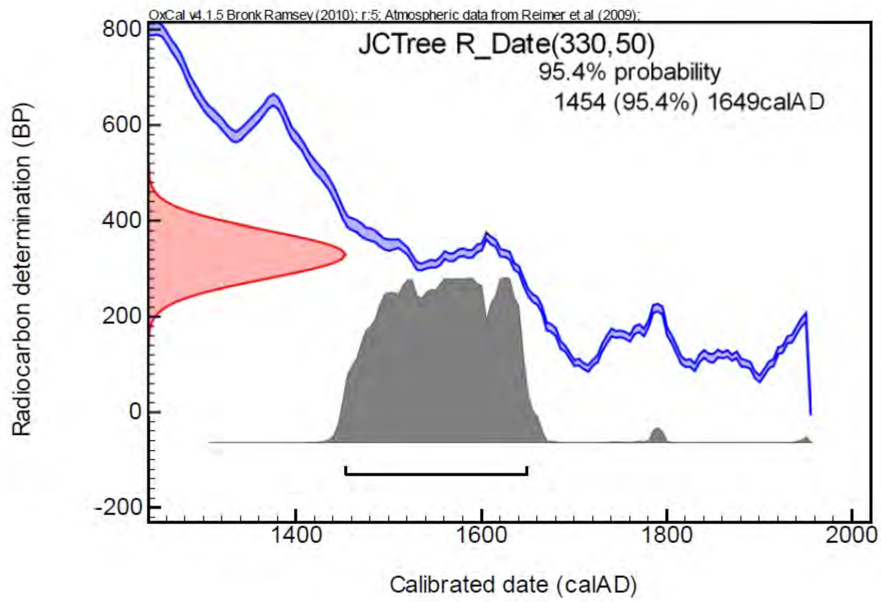


Figure 5.3. Calibrated radiocarbon dates with a 95.4% probability for a charcoal sample, JACKGF01, collected from a ghost tree based on OxCal v4.1.5 (Ramsey 2009) and atmospheric data from Reimer et al. (2009).

stand-clearing fire, followed by seedling initiation are the results presented in Figure 5.4 for all the crossdated samples. These tree-ring samples were not collected randomly and therefore do not necessarily reflect stand dynamics as much as archaeology; nevertheless, Figure 5.4 clearly shows a dramatic increase in first year dates starting in the 1650s. If the ghost trees are disregarded, the exception is the cluster of oldest living trees that bridge the 1600s to early 1700s. These trees, nestled against a rocky, steep slope and adjacent to an ephemeral drainage might have been protected from the fire. If indeed the ghost trees are the relics of a stand-clearing fire, the ghost trees serve as a physical reminder of the transmutability of the forest-grassland divide, the ephemeral nature of trees, and a dynamic landscape shaped by fire.

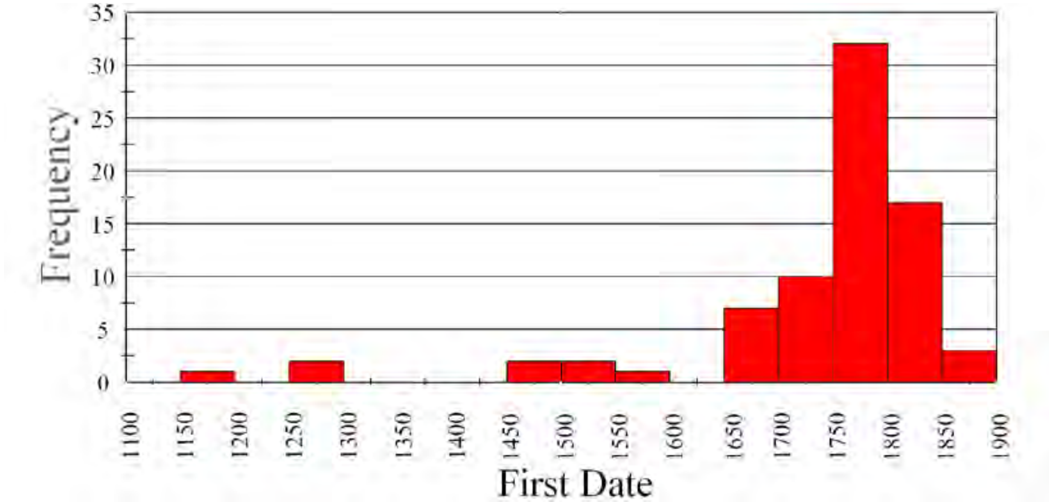


Figure 5.4. Distribution of "First Dates" for tree-ring samples based on crossdates in this study (n=77). Post scar segments and samples with missing early rings due to collection error were removed for the purposes of this analysis.

NOTIONS OF EMPTINESS

Chapter two explores how historic notions of the wilderness as pristine and empty of inhabitants reinforced conceptions of this remote, high montane region as inaccessible and marginal, while minimizing the long-term interactions of Native Americans with the landscape. Such historic narratives of the land as uncivilized and newly discovered, also served to legitimize a quite literal "emptying out" of the Big Horn Basin. By the late 1800s, Native Americans had been relegated to reservations just as settlement of the Big Horn Basin began in earnest.

When settlers arrived in the Big Horn Basin, they found a landscape littered with evidence of past human landuse. In a personal account of the Big Horn Basin, George C. Frison recalls exploring the range on the western slopes of the Big Horn Mountains where his paternal grandparents built a ranch in 1901 and finding evidence of Plains Indians "everywhere" (Frison 2008). He describes the many wood artifacts and features he observed, including lodge and horse travois poles found on his grandparents property and adjacent to “a well-defined, post-horse, Indian trail.” Many wood artifacts like these, Frison writes, were collected as suitable firewood by early homesteaders. He also describes Plains Indian burials in ponderosa, juniper, and cottonwood trees as a common discovery (Frison 2008).

Archaeologists, including Frison, have documented numerous types of prehistoric wood artifacts in the region, including sheep traps, wooden drivelines, wickiups, cribbed lodges, cultural peels, blazes, burial platforms, and sagebrush traps. The historic use of wood has been just as extensive. These fragile but “talkative” relics of the past offer an exceptional and limited opportunity to illuminate cultural practices and crossdate past human activities. They help to frame past landuse patterns in the region.

ILLUMINATING CULTURAL PRACTICES

Trees and the forest can have the effect of obscuring past human activities, yet as this thesis outlines, ample evidence can also be found related to wood that illuminates cultural practices. Wooden artifacts and features in the study area range from historic cabins, trail blazes, and bark peels to documented wickiups and sheep traps. When considered as a whole, the samples collected and crossdated for this study begin to fill in the story about how this montane environment has been used and reused by past human groups. Cultural practices and past landuse are undoubtedly related to the abundance and diversity of resources found at this ecotone. Trees and forest-grassland dynamics play a vital role in this. For example, open meadow provides both grazing and foraging potential while trees and the forest offer shelter and wood resources.

The ghost trees, as vestige of past tree-line, reinforce the idea of a dynamic landscape and fluid forest-grassland boundaries. They also highlight the role that climate has played in shaping a landscape that has attracted humans to this area since the onset of the Holocene. It is therefore not surprising that the historic cabins in the Upper Greybull Watershed are often located adjacent to or just within extant forest and that almost all of these cabins sit atop or adjacent to older, prehistoric components. Afterall, the edge between two ecosystems is an optimal location for humans and wildlife, alike, to reap the benefits of converging resources.

COMPARING THE CHRONOLOGY TO HISTORIC ACCOUNTS

Since the beginning of this project, a main goal has been to compare the physical to the anecdotal: to discover what tree-rings can tell us about history, climate, and the environment and what first-hand historic accounts can tell us about tree-rings, climate, and the landscape. An accurate comparison was not possible until after a master chronology had been developed, and this happened late in the thesis process. Thus, the comparison of climate using tree-rings and historic documents is a work in progress, especially as climate-related data continues to be assessed in the chronology. Despite this caveat, initial comparisons are both provocative and illuminating. A few, including the winter of 1886-1887, temperature and climate data from the Otto Franc diaries, and speculations on the relationship between peeled trees and the climate are briefly discussed below.

The Winter of 1886-1887

By all accounts the winter of 1886-1887 was exceptionally severe; often credited with hastening the demise of the burgeoning cattle industry in the region and killing up to 90% of the cattle in some parts of Wyoming and Montana (Edgar and Turnell 1978; Larson 1965; Woods 1997). First-hand accounts from the area attest to the devastation and offer insight into the events leading up to this harsh winter. The following historic accounts come from Otto Franc (Franc Von Litchenstein 1886-1903) and Victor Arland (Arland 1872-1889):

From the Otto Franc Diaries:

> Jan. 28, 1887
> ". . . the snow drifts are on a level with the roofs of the sheds. "
>
> Feb. 4, 1887
> ". . .a number of Crow Indians call and dig out the guts and heads of the cows which we have slaughtered from under a snowdrift."
>
> Feb. 6, 1887
> ". . .Ham Oldis has probably been frozen to death on his way from Billings

From Victor Arland to Mr. Dadant:

> December 19, 1886
> "Up till now we have not had much snow but in certain areas so much snow has fallen that the roads are impassable which makes supplies very scarce. . .If, however, we have a harsh winter the livestock will suffer greatly because the drought last summer kept the grass from growing as it usually does."
> Letter from Victor Arland to Mr. Dadant
>
> January 31, 1887
> ". . .since the middle of last month the winter has been very severe; lots of snow and the roads are impassible."
> Letter from Victor Arland to Mr. Dadant

March 26 1887
“. . . . . .We have had in the north of Wyoming and in Montana an exceptionally severe winter. Several persons were frozen to death, of whom there were two about 15 miles from here. The cattle suffered very much, especially in Montana, where the losses are about 50%. In our area the losses will not exceed 15 % . . . . very few cattle would have survivived.

Letter from Victor Arland to Mr. Dadant

March 12, 1988
“Business wasn’t good last year because of the loss of cattle during the winter of 1886-87. The whole far West has felt it; several big cattle-raising companies have gone bankrupt. The part of Wyoming where I am felt it the least, and even here the losses were close to 50%. In Montana and in other parts of Wyoming the losses have been from 60-90%. Consequently you can judge the depression that this has caused in these areas where raising of cattle is the only resource.”

Letter from Victor Arland to Mr. Dadant

How Tree-Rings Compare to Historic Accounts

One of the strongest visual patterns in the tree-rings reflects the severe winter of 1886-1887. This pattern was, in fact, used as a marker when creating the original skeleton plots and verifying crossdates. Despite the apparent synchronicity between tree-rings and historic accounts for this winter, the tree-ring data tells a slightly different climatic story overall, especially when compared to first-hand accounts from other years. Based on additional comparisons between historic accounts and the master chronology, a more nuanced interpretation of the forces at play during the winter 1886-1887, as well as other years, can be hypothesized. For example, the years preceding the deadly winter of 1886-1887—the years 1884, 1885, and 1886–appear as small rings in many of the tree-ring series (Figure 5.3). Lag must be considered when interpreting these smaller rings and annual growth response in general. For instance, tree-rings would probably not reflect the winter of 1886-1887 any earlier than 1887, unless other climatic forces were at play prior to the very brutal months recorded in January and February of 1887. Trees might also respond as much as several years later to the winter of 1886-1887, depending on available and stored resources. Lag, in fact, is a critical consideration when interpreting climate from tree-ring data, but, unfortunately, such an investigation is outside the scope of this discussion.

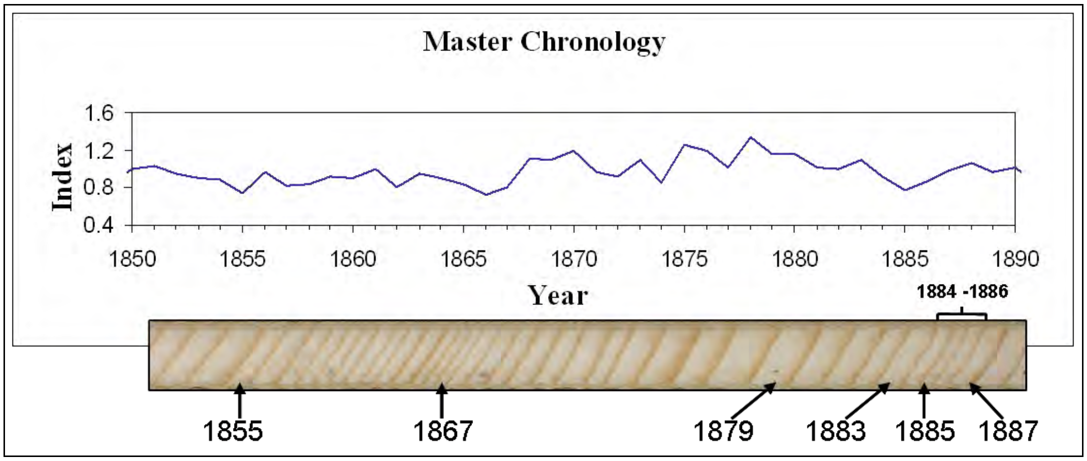


Figure 5.5. The master chronology paired with a photograph of tree-rings from sample CCC01, a living tree collected at Jack Creek Cow Camp.

Despite unknown patterns related to lag and response, the cluster of small rings observed in many of tree-ring series between 1884 and 1886 is illuminating. The year 1885 is consistently the smallest of these tree-rings. These tree-rings also correspond to historical accounts. For example, in a letter dated January 3, 1885, Victor Arland describes the winter of 1884-1885 as the worst he has ever seen: “If it doesn’t thaw soon,” he writes, “the cattlemen will lose many cattle” (Arland 1872-1889). Earlier historical accounts from the region provide further insight into events leading up to the devastating winter of 1886-1887. For example, in his memoirs, Colonel Pickett describes both the winter of 1879 and 1881 as mild (Pickett 1913). This depiction of climate by Col. Pickett is reflected in the tree-rings, with growth rings from 1878-1890 that are particularly large. These tree-rings along with the historic accounts cited above, imply that the winter of 1886-1887--while extraordinarily severe--was merely the culmination of a number of factors and not unprecedented.

Rather than an isolated event, I believe several factors likely played a role in the 1886-1887 winter that devastated the cattle industry--not all of which were weather-related. The tree-rings as well as Col. Pickett's descriptions indicate that the years centered around 1879 were mild and tree-ring growth was relatively high. This coincides with the arrival of the first cattle into Upper Greybull country. This lush period appears to end a few years later, just as the cattle industry is taking hold and range capacity is beginning to be impacted. In a letter dated March 1, 1882, describing the previous winter, Victor Arland writes, "We have had almost no snow up to now." Here too, the 1882 tree-ring correlates with this account and may be a precursor to the deadly winter of 1886-1887. Later that year, on December. 20, 1883, Arland writes, "Up to now we have had splendid weather. The game is still high. . . ." (Arland 1872-1889).

Based on tree-ring data and these additional first-hand accounts, it may be that cattlemen overestimated range capacity just when access to the open range and resources were closing off. This miscalculation may have been based on a lush period in the late-1870s and further exacerbated by an underestimation of the concomitant effects of little snow in 1883, followed by a series of very cold and snowy years. In a letter dated December 19, 1886, Arland writes, "Up till now we have not had much snow but in certain areas so much snow has fallen that the roads are impassable which makes supplies very scarce. . .If, however, we have a harsh winter the livestock will suffer greatly because the drought last summer. This letter seems to indicate that in addition to environmental and range conditions, people may also have been wholly ill-prepared for the freezing temperatures and heavy snows that hit in early 1887.

Climate Data from the Otto Franc Diaries

For much of his time along the Upper Greybull River, Otto Franc maintained a diary (Franc Von Litchenstein 1886-1903). His diaries include records and comments related to temperature and climate. For example, Franc often recorded daily temperature at the Pitchfork Ranch at 7am during fall, winter and spring months. His diary also records other indicators of climate and the environment, including references to exceptional weather events and climate proxies such as when the Greybull River first "breaks up" in the spring and the first sighting of birds each spring. As a way of concluding this last chapter and initiating a discussion on future directions, climate-related data from the Otto Franc diaries is depicted graphically and compared to the Jack Creek master chronology below (Figure 5.6a, b, c and d).

As mentioned previously, an in-depth analysis of climate and lag in the master chronology using ARSTAN is a future research goal and without such an analysis, it is hard to draw solid conclusions regarding the relationship between these four sets of climate proxies. However, these graphs hint at a tantalizing and fun future direction, especially since alignment can be observed between all four plots. Take, for example, the year 1890. The master chronology, as depicted in Figure 5.6a, shows a larger ring for this year compared to neighboring rings. This ring would be a reflection of growing season during the summer months of 1890. Figure 5.6b indicates that mean temperature for the winter of 1890, December 1899 to March 1890, was exceptionally high compared to other years. Given the high winter temperatures of 1890, it is not surprising to discover that the Greybull River “breaks up” (Figure 5.6c) quite early in 1890 and bluebirds make one of their earliest appearances that spring (Figure 5.6d).

These graphs are a guidepost for future research and an instructive visual aid for reflecting on issues related to response and lag in all climate proxies. Take, for example, that severe winter of 1886-1887: by all accounts, it wasn’t until January or February when temperatures in the region plummeted. Obviously these temperatures could have affected when the Greybull River broke up and also the arrival of birds. The trees, on the other hand, might instead show a growth increase the following year based on accumulated snow or growth might decrease as a result of a shortened growing season. ARSTAN can help to unravel tree-ring lag and response. Figures 5.6a, b, c and d are meant to show how historic documents and a set of climate proxies from the Otto Franc diaries may also provide clues related to past climate and tree-ring response.

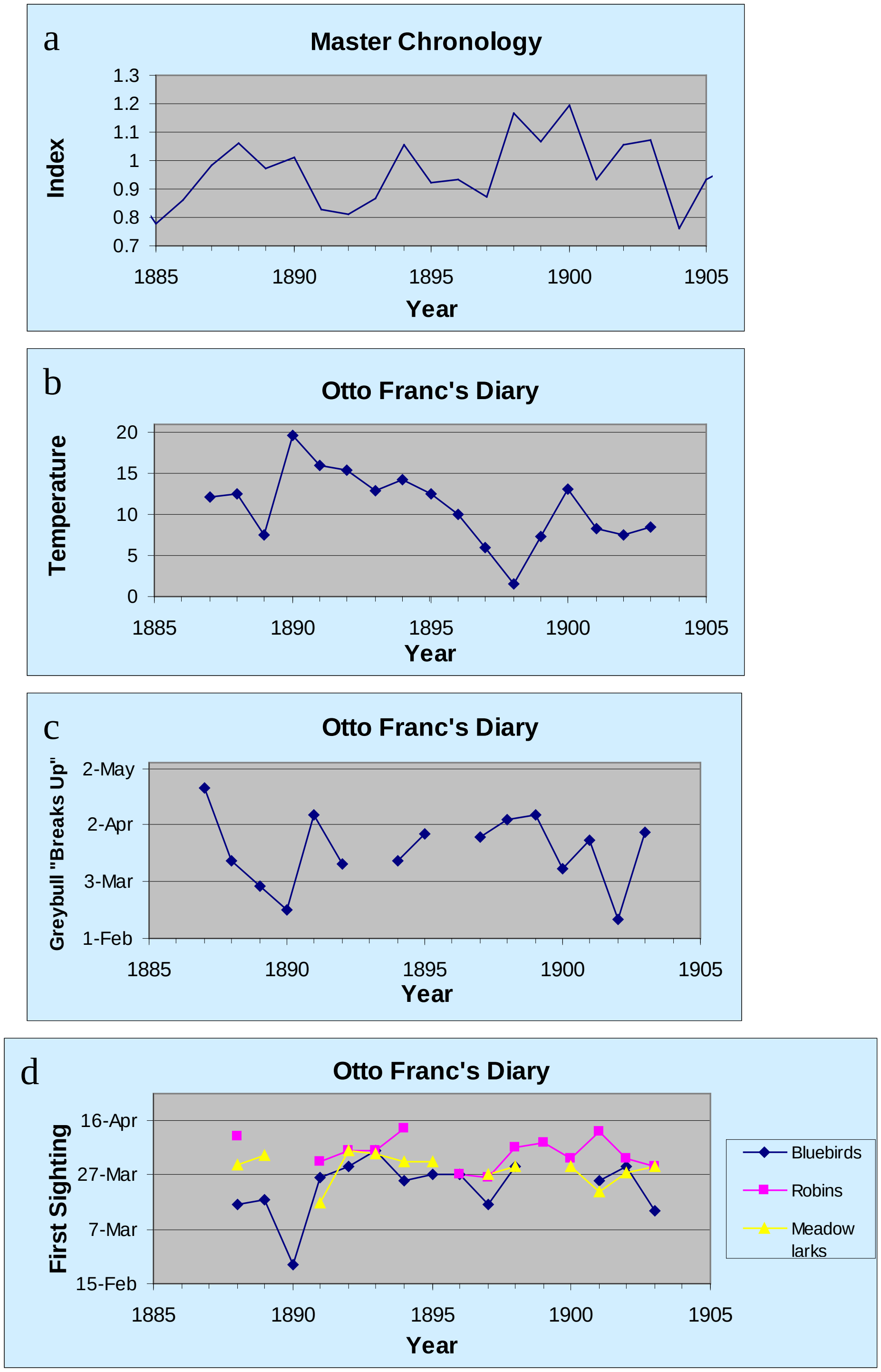


Figure 5.6. Climate proxies: (a) standardized index of annual growth for the Jack Creek master chronology (1885-1905); (b) The mean temperature for December through March of each winter from the diaries of Otto Franc (1887-1903); (c) First mention of the Greybull River "breaking up" in the diaries (1887-1903); and (d) First spring sighting of bluebirds, robins and meadow larks in the diaries (1888-1903).

FUTURE DIRECTIONS

Climate and Peels

Perhaps the most exciting and unexpected result of this project is the discovery of culturally peeled trees and the associated crossdates, which date these peels to earlier than the construction of the historic cabins. The procurement of bark by Native Americans as a food source is often cited in the literature as an adaptive strategy in times of scarcity (Devoto 1953; Dillingham 1907; Opler 1941; Swetnam 1984). Alternatively, the inner bark and cambium of ponderosa pine has been described as a sweet fiber and important nutrient source harvested in the spring when sap is flowing (Cushing 1920; Martorano 1981; Martorano and Beardsley 1993; Ostlund et al. 2009; White 1954). Ponderosa pine and cedar are most commonly linked to cultural peels (Collins 1989; Martorano 1981; Martorano and Beardsley 1993; Perry 1923; Stewart 1984; Swetnam 1984; Vestal 1952). Almost no literature exists that references cultural peels on Engelmann spruce.

With so few samples collected from peeled trees for this project, little more than bracketed crossdates for the scars can be surmised. Future research will include a more systematic study of culturally peeled Engelmann spruce in northwestern Wyoming. Collection of samples also will need to include cross-sections or wedges in order to determine actual peel dates. Obtaining actual peel dates is particularly important in inferring whether these trees were peeled in a time of stress. Certainly, the mid-1800s through the 1870s, as historians point out, was tumultuous for Native American groups (Larson 1965; Woods 1997). Peels that cluster in the same year can often be indicative of a particular event or stress rather than a traditional procurement activity. In terms of stress, it is interesting to note one other strong pattern in the tree-rings that was used to visually situate the tree-rings in time. In many of the samples, the tree-rings 1855-1867 were smaller (Figure 5.3). Not all the rings widths for these years are small, but when considered as a whole, they are comparatively much smaller than their neighbors. This span of dates coincides with some of the most precise crossdates obtained for the peeled trees (Table 4.5), and suggests a compelling future direction for this research.

A Resource in Peril

As we witness the consequences of a massive bark beetle epidemic in forests across much of the West, the effort to collect and preserve wood artifacts and tree-rings samples has never been more urgent. This imperiled resource is not only unique as a proxy for both climate and human behavior; it is also irreplaceable. Future goals include crossdating samples from the three remaining cabins and associated features in the project area. Plans for additional collection efforts are also underway, including along the Front Range of Colorado and at the Stockade site in the Beartooth Mountains.

CONCLUSION

This study has only begun to investigate the relationship between tree-rings, historic documents, climate, archaeology, and past human behavior in this high montane environment. In addition to investigating culturally peeled trees, future analysis will focus on identifying climate response in the tree-rings. Disassembling the environmental factors influencing tree-rings requires not just attention to scale but the ability to differentiate between patterns related to climate and other factors such as feedback loops, lag, landscape structure and topology (Graumlich et al. 2005; Levin 1989; Lyford et al. 2003). The climate information can then be compared once again to historic documents and other modern proxies of climate and past human activity to fill in places on the map like this high montane landscape with greater time-depth and detail. Without immediate attention, however, the risks are great that this unique set of data will be lost forever.

APPENDIX A
Living Tree Sample Data

Table A.1. Data recorded for living tree samples.

2006 Living Tree Samples																
Sample #	Side	Type or Structure	Species	Slope	Aspect	Water 1=low 2=med 3=high	Land Use 1=low 2=med 3=high	Sample species acroynm and associated vegetation	Visibility (0-100%)	dbh (cm)	Duff (cm)	L=Lightng B=Bark G=Gallery F=Fire H=Human P=Patina	Other	Tree Condition 100%= Dead	Root Exposure	Comments
Test 1	d					2	1	PIEN; s. grass	0%							Hit rot
Test 2							1	PIEN; s. grass	0%							Hit rot
CCC01	b, c, ca & d	CMT-Corral	PIEN	3°	325°	2	3	PIEN; s. grass, gooseberry	999	267		B, H	N	100%	exposed	Corral, also wrote "B = 185°"
CCC02	b, c & d		PIEN	9°	290°	2	3	PIEN; s. grass, gooseberry	20%	149		B	N	80% (bottom)	some	
CCC03	b, c & d		PIEN	9°	287°	2	3	PIEN; s. grass, gooseberry	0%	152	10	B	N	30% (crown death)	partial	
CCC04	c & d		PIEN	5°	305°	2	3	PIEN; s. grass, gooseberry	0%	243	10	B	N	100%	partial	
CCC05	c & d		PIEN	5°	290°	2	3	PIEN; s. grass, gooseberry	0%	178	10	B	N	100%	none	
CCC06	b, ba, c, & d	CMT-Blaze	PIEN	9°	302°	3	3	PIEN; s. grass, gooseberry	0%	198	5	B, H	N	100%	partial	2 small trees on either side w/metal ax marks; blaze on NE (42°), tree next to trail, scar captured on C&D?
CCC07	c, d, da & db		PIEN	6°	299°	2	3	PIEN; s. grass, gooseberry	0%	203	5	B	N	100%	10%	
SCC01	c & d		PIEN	4°	45°	2	3	PIEN; s. grass, gooseberry	0%		10	B		20% dead	N	
SCC02	c & d		PIEN	4°	45°	2	3	PIEN; s. grass, gooseberry	0%		5	B		80% crown alive	N	
SCC03	b, c & d	CMT	PIEN	7°	50°	2	2.5	PIEN; s. grass, gooseberry	5%	205	5	B, H?		20% (alive tip/bottom)	N	mostly healed scar, seemed to hit it cause hit rot (before rot? Didn't get in far), see p. 40
SCC04	b, c & d	CMT	PIEN	3°	35°	2	2.5	PIEN; s. grass, gooseberry	0%	140	5	B,H		alive, top NE side	5%	
SCC05	b, c & d	CMT	PIEN	9°	18°	2	2.5	PIEN; s. grass, gooseberry	0%	161	5	B,H		alive, top NE side	N	
SCC06	a, b, c, cb & d	CMT	PIEN	3°	30°	2	3	PIEN; s. grass, gooseberry	0%	181	5	B, H?		100%	Y	N corner (NE) of trash pile, scar had no ax marks but would be on the side of structure
CHC01		CMT	PIEN													
JCC01	c & d			12°	335°	2	1	PIEN; s. grass	0%	200	15	B	two nails	100%	downslope	"70° (west-facing)"
JCC02	c & ca		PIEN	8°	35°	2	2	PIEN; s. grass	0%	107	5	B, F?,H		100%	50%	
JCC03	c & d		PIEN	5°	45°	2	2	PIEN; s. grass	0%	216	5	B,G		100%	N	
JCC04	c, ca & d		PIEN	11°	330°	2	1	PIEN; s. grass	0%		5	B, G		100%	20%	says tagged "w/CC8"
JCC05	c & d		PIEN	7°	6°	2	1	PIEN; s. grass	0%		5	B		75%	No	
JCC06	c		PIAL	20°	270°	1	1	PIAL; sage	40%		1	B		Good	30%	
JCC07	c		PIAL	20°	270°	1	1	PIAL; sage	10%		1	B	several small scars	Good	No	2 PIAL, 3 PCEN together is small cluster
JCC08	b, c & d		PIAL	13°	275°	1	1	PIAL; sage	70%		<1	B, L?	strip bark	Good	several large	less veg, more rocks (than JC7), loamy grey soil, lots scars--strip?
JCC08	x		PIAL	13°				PIAL; sage								x-section of broken branch ?, like JCX2 says, "Branch from JC8"???
JCC09	b, c & d		PIAL	23°	235°	1	1	PIAL; sage	80%		<1	B	>strip than JC8	Good	>50%	kept hitting rot

APPENDIX B

Jack Creek Reference Chronology Statistics

Table B.1. Jack Creek reference chronology.

Jack Creek Reference Chronology																					
Series	**Scar**	**Crossdated Interval**		**Length**	**No. Segments**	**Average Interseries Correlation**	**First Order Autocorrelation**	**Avgerage Mean Sensitivity**	**1400-1499 n=2**	**1450-1549 n=4**	**1500-1599 n=6**	**1550-1649 n=9**	**1600-1699 n=9**	**1650-1749 n=8**	**1700-1799 n=12**	**1750-1849 n=20**	**1800-1899 n=23**	**1850-1949 n=23**	**1900-1999 n=21**	**1950-2049 n=16**
CCC01		1792	2005	214	5	0.508	0.837	0.195								0.62	0.61	0.49	0.39	0.42
CCC02		1794	2003	210	5	0.651	0.824	0.191								0.70	0.69	0.61	0.58	0.59
CCC03		1727	2006	280	6	0.558	0.770	0.193							0.49	0.62	0.67	0.64	0.63	0.47
CCC04		1757	2005	249	5	0.639	0.726	0.200								0.55	0.67	0.71	0.69	0.68
CCC05		1776	2005	230	5	0.573	0.800	0.169								0.64	0.64	0.60	0.49	0.48
CCC07		1735	2005	271	6	0.591	0.720	0.187							0.51	0.56	0.70	0.72	0.56	0.55
CCX14		1474	1644	171	3	0.583	0.900	0.192		0.43	0.67	0.70								
JCC01		1527	2003	477	10	0.683	0.823	0.159			0.80	0.84	0.74	0.65	0.52	0.49	0.60	0.71	0.71	0.73
JCC03	s	1630	1670	41	1	0.580	0.359	0.227					0.58							
JCC03	s1	1803	2004	202	4	0.601	0.820	0.179									0.66	0.65	0.52	0.56
JCC04		1752	2005	254	5	0.483	0.738	0.170								0.42	0.51	0.50	0.57	0.59
JCC05		1761	2003	243	5	0.705	0.881	0.170								0.65	0.74	0.73	0.77	0.78
JCC21		1400	1861	462	9	0.576	0.904	0.169	0.43	0.44	0.64	0.73	0.59	0.52	0.65	0.65	0.65			
JCC24		1738	1990	253	5	0.600	0.769	0.169							0.43	0.48	0.65	0.71	0.68	
JCC25		1804	2001	198	4	0.585	0.873	0.211									0.54	0.60	0.66	0.65
JCC26		1543	1965	423	9	0.630	0.951	0.204			0.68	0.72	0.69	0.49	0.40	0.65	0.73	0.68	0.67	
JCC27		1554	2003	450	9	0.670	0.734	0.188				0.75	0.72	0.59	0.49	0.56	0.70	0.74	0.69	0.69
JCC28		1450	1983	534	10	0.559	0.652	0.193		0.24	0.62	0.82	0.74	0.57	0.50	0.55	0.62	0.56	0.52	
JCC29		1587	1922	336	7	0.576	0.905	0.145				0.52	0.51	0.55	0.53	0.63	0.63	0.66		
JCC36		1554	1946	393	7	0.516	0.883	0.227				0.44	0.44	0.45	0.48	0.60	0.69	0.59		
JCX01		1729	1997	269	5	0.519	0.802	0.164							0.34	0.46	0.51	0.62	0.63	
JCX45		1260	1718	459	6	0.578	0.800	0.241	0.49	0.56	0.63	0.62	0.64	0.57						
SCC01		1912	2006	95	1	0.487	0.527	0.198											0.50	
SCC02		1725	2005	281	6	0.481	0.899	0.175							0.36	0.48	0.48	0.43	0.65	0.65
SCC03		1860	2005	146	3	0.561	0.739	0.187										0.70	0.58	0.53
SCC04		1750	2005	256	5	0.640	0.768	0.192								0.61	0.68	0.66	0.63	0.65
SCC05B		1761	2005	245	5	0.572	0.866	0.188								0.59	0.66	0.57	0.53	0.52
Total or Mean:				**7642**	**151**	**0.587**	**0.808**	**0.188**	**0.46**	**0.42**	**0.68**	**0.68**	**0.63**	**0.55**	**0.48**	**0.58**	**0.64**	**0.63**	**0.60**	**0.60**

APPENDIX C
Jack Creek Meadow 2 Cabin Correlation Data

Table C.1. Jack Meadow 2 cabin correlation: (a) correlation based on the reference chronology; and (b) correlation based on a reference chronology compilation

Table C.1. Jack Meadow 2 Cabin Correlation based on the Jack Creek Reference Chronology

Series	Length of Segment	Corr. #1		Corr. #2		Corr. #3		Corr. #4		Corr. #5		Corr. #6		Corr. #7		Corr. #8		Corr. #9		Corr. #10		Corr. #11	
MCH01	0-99	1638	0.33	1677	0.33	**1839**	0.31	1775	0.30	1779	0.30	1538	0.30	1456	0.27	1877	0.27	1391	0.26	1504	0.26	1347	0.26
MCH01	100-105																						
MCH02	0-52	1265	0.51	**1891**	0.47	1313	0.45	1691	0.44	1507	0.38	1662	0.38	1838	0.37	1404	0.37	1831	0.31	1919	0.31	1436	0.30
MCH03	0-86	1797	0.51	1711	0.36	**1857**	0.33	1694	0.33	1540	0.31	1907	0.30	1695	0.29	1473	0.27	1678	0.26	1409	0.26	1877	0.25
MCH04	0-99	**1831**	0.37	1763	0.28	1767	0.28	1869	0.27	1301	0.27	1761	0.25	1771	0.25	1530	0.24	1881	0.24	1407	0.24	1447	0.23
MCH04	100-111																						
MCH05	0-53	1576	0.54	1833	0.47	1747	0.38	1509	0.35	1531	0.33	1267	0.33	1367	0.31	1910	0.31	1865	0.31	1897	0.30	1494	0.29
MCX01	0-91	1492	0.42	1796	0.40	1410	0.34	1743	0.29	1656	0.29	1369	0.27	1873	0.25	1710	0.24	1472	0.23	1908	0.23	1517	0.22
1882-1887		Total average correlation of 4 samples = **.37**																					
1942-1945		Total average correlation of 4 samples = **.37**																					

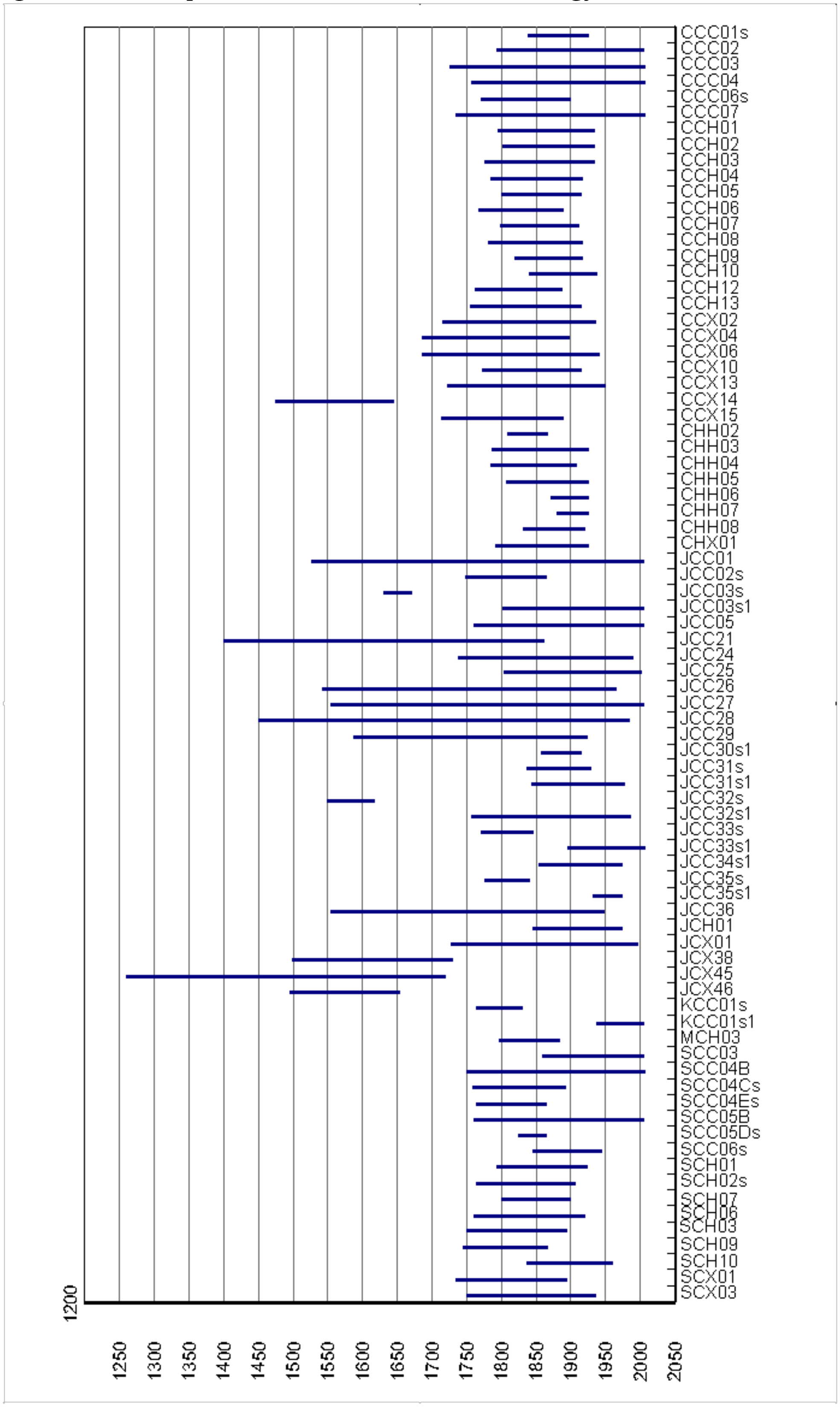
Table C.2. Jack Meadow 2 Cabin Correlation based on a Reference Compilation

Series	Length of Segment	Corr. #1		Corr. #2		Corr. #3		Corr. #4		Corr. #5		Corr. #6		Corr. #7		Corr. #8		Corr. #9		Corr. #10		Corr. #11	
MCH01	0-99	1779	0.38	**1839**	0.33	1877	0.29	1638	0.29	1538	0.28	1456	0.27	1677	0.27	1391	0.26	1347	0.26	1328	0.26	1504	0.25
MCH01	100-105																						
MCH02	0-52	1265	0.51	**1891**	0.48	1313	0.45	1662	0.39	1831	0.37	1404	0.37	1521	0.36	1838	0.36	1691	0.35	1507	0.35	1821	0.34
MCH03	0-86	1797	0.56	**1857**	0.33	1711	0.32	1695	0.30	1540	0.29	1907	0.28	1409	0.26	1877	0.26	1640	0.26	1678	0.26	1694	0.25
MCH04	0-99	**1831**	0.38	1771	0.34	1869	0.28	1767	0.28	1763	0.27	1301	0.27	1530	0.25	1407	0.24	1761	0.24	1447	0.23	1859	0.22
MCH04	100-111																						
MCH05	0-53	1576	0.54	1833	0.44	1531	0.39	1897	0.35	1747	0.35	1267	0.33	1756	0.32	1367	0.31	1951	0.29	1275	0.28	1930	0.28
MCX01	0-91	1796	0.44	1492	0.37	1410	0.32	1743	0.31	1656	0.27	1369	0.27	1873	0.26	1771	0.24	1894	0.24	1539	0.22	1472	0.22
1882-1887		Total average correlation of 4 samples = **.37**																					
1942-1945		Total average correlation of 4 samples = **.48**																					

APPENDIX D

Time Plot of Jack Creek Master Chronology

Figure D.1. Time plot of Jack Creek master chronology.



APPENDIX E

Table E.1. Summary of the Jack Creek master chronology

Sample Name	Outermost Ring Code	Structure Name	First Date	End Date	No. of Years
CCC01s	N/A	CMT-Corral	1839	1926	88
CCC02	v	Living Tree	1794	2004	211
CCC03	B	Living Tree	1727	2006	280
CCC04	B	Living Tree	1757	2006	250
CCC06s	N/A	Living Tree	1772	1899	128
CCC07	B	Living Tree	1735	2006	272
CCH01	B	Outhouse	1795	1934	140
CCH02	v	Outhouse	1803	1934	132
CCH03	w	Outhouse	1777	1934	158
CCH04	v	Main Cabin	1786	1916	131
CCH05	B	Main Cabin	1800	1915	116
CCH06	B	Main Cabin	1767	1889	123
CCH07	B	Main Cabin	1799	1911	113
CCH08	B	Main Cabin	1782	1916	135
CCH09	v	Main Cabin	1820	1916	97
CCH10	v	Main Cabin	1840	1938	99
CCH12	v	Main Cabin	1763	1888	126
CCH13	B	Main Cabin	1756	1914	159
CCX02	B	Outhouse	1716	1935	220
CCX04	v	Stump	1686	1898	213
CCX06	B	Stump	1687	1941	255
CCX10	v	Main Cabin	1774	1915	142
CCX13	B	Stump interior of old foundation?	1722	1950	229
CCX14	w	Ghost Tree	1474	1644	171
CCX15	v	Main Cabin	1714	1889	176
CHH02	B	Main Cabin	1810	1866	57
CHH03	B	Main Cabin	1787	1926	140
CHH04	v	Main Cabin	1786	1909	124
CHH05	B	Main Cabin	1807	1925	119
CHH06	B	Main Cabin	1871	1925	55
CHH07	B	Main Cabin	1880	1926	47
CHH08	v	Main Cabin	1832	1920	89
CHX01	v	Main Cabin	1791	1925	135
JCC01	B	Living	1527	2004	478
JCC02s	N/A	CMT-peel	1749	1865	117
JCC03s	N/A	Living	1630	1670	41
JCC03s1	v	Living	1803	2005	203

Table E.1, (continued)

Sample Name	Outermost Ring Code	Structure Name	First Date	End Date	No. of Years
JCC05	B	Living	1761	2004	244
JCC21	w	Remnant	1400	1862	463
JCC24	w	Remnant	1738	1990	253
JCC25	w	Remnant	1804	2002	199
JCC26	w	Remnant	1543	1965	423
JCC27	w	Remnant	1554	2004	451
JCC28	w	Remnant	1450	1984	535
JCC29	w	Remnant	1587	1923	337
JCC30s1	w	CMT?	1858	1915	58
JCC31s	N/A	CMT?	1836	1929	94
JCC31s1	w	CMT?	1844	1977	134
JCC32s	N/A	CMT?	1550	1617	68
JCC32s1	w	CMT?	1758	1986	229
JCC33s	N/A	CMT?	1771	1845	75
JCC33s1	w	CMT?	1896	2006	111
JCC34s1	w	CMT?	1855	1973	119
JCC35s	N/A	CMT?	1777	1841	65
JCC35s1	w	CMT?	1932	1974	43
JCC36	w	CMT? But missed scar	1554	1947	394
JCH01	v	Remnant	1846	1973	128
JCX01	B	Remnant	1729	1997	269
JCX38	w	Ghost and CMT?	1500	1730	231
JCX45	w	Ghost	1260	1719	460
JCX46	w	Ghost	1495	1653	159
KCC01s	N/A	CMT-peel	1764	1830	67
KCC01s1	B	CMT-peel	1937	2005	69
MCH03	v	Main Cabin	1797	1884	88
SCC03	B	Living	1860	2005	146
SCC04B	B	CMT-peel	1750	2006	257
SCC04Cs		CMT-peel	1759	1893	135
SCC04Es		CMT-peel	1765	1865	101
SCC05B	B	CMT-peel	1761	2005	245
SCC05Ds	N/A	CMT-peel	1824	1865	42
SCC06s	N/A	CMT-part of feature?	1846	1945	100
SCH01	v	Main Cabin	1794	1923	130
SCH02s	N/A	Main Cabin	1765	1907	143
SCH03	r	Main Cabin	1801	1899	99
SCH06	v	Main Cabin	1760	1921	162
SCH07	v	Main Cabin	1751	1894	144
SCH09	v	Main Cabin	1745	1866	122
SCH10	v	Main Cabin	1836	1960	125
SCX01	v	Main Cabin	1735	1894	160
SCX03	v	Main Cabin	1751	1935	185

APPENDIX F

Figure F.1. Radiocarbon results for JACKGF01.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.4:lab. mult=1)

Laboratory number: **Beta-209064**

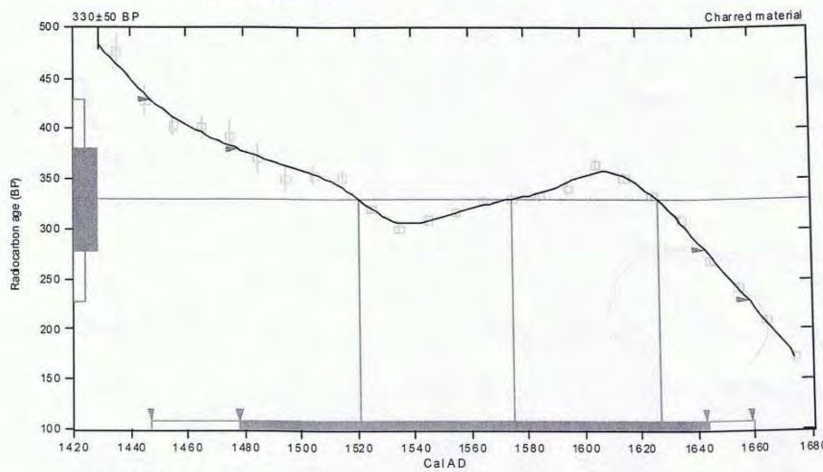
Conventional radiocarbon age: **330±50 BP**

2 Sigma calibrated result: **Cal AD 1450 to 1660 (Cal BP 500 to 290)**
(95% probability)

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1520 (Cal BP 430) and
Cal AD 1580 (Cal BP 380) and
Cal AD 1630 (Cal BP 320)

1 Sigma calibrated result: Cal AD 1480 to 1640 (Cal BP 470 to 310)
(68% probability)



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Database used
INTCAL98

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

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W.74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

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