THESIS

ABSOLUTE AND RELATIVE CHRONOLOGY OF A COMPLEX ALPINE GAME DRIVE SITE (5BL148), ROLLINS PASS, COLORADO

Submitted by

Kelton A. Meyer

Department of Anthropology

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Master's Committee:

Advisor: Jason M. LaBelle

Michelle M. Glantz
F. Jay Breidt

ABSTRACT

ABSOLUTE AND RELATIVE CHRONOLOGY OF A COMPLEX ALPINE GAME DRIVE SITE (5BL148), ROLLINS PASS, COLORADO

Native American alpine game drive sites are recognized along major mountain travel corridors in Colorado's Southern Rockies. The Rollins Pass project area, located east of Winter Park, represents the densest concentration of alpine game drive sites in North America. Game drives at Rollins Pass vary in terms of size, frequency and diversity of features and artifacts, but also landform context. Past game drive research at Rollins Pass and elsewhere in the Colorado Front Range demonstrates that hunter-gatherer groups reoccupied some sites for centuries and even millennia, creating an amalgamation of material culture over the course of time. However, chronological reconstructions in alpine environments are limited by poor preservation, lacking stratigraphy, and the ephemeral nature of hunter-gatherer occupations at high altitudes. This thesis considers an investigation of the largest game drive at Rollins Pass, 5BL148, with a focus on chronology reconstruction. A relative occupation span is provided with an analysis of chipped stone tools and jewelry. Lichenometry is used to determine the age of lichen colonization events on stone walls, and radiocarbon dates on faunal remains and charcoal are used as absolute chronological measures. A spatial analysis of the artifact and feature assemblage is further used to identify evidence for distinct or temporally overlapping occupation episodes. The results indicate that 5BL148 represents a palimpsest of hunter-gatherer occupations, beginning in the Early Archaic era and ending in the Protohistoric era.

ACKNOWLEDGEMENTS

I am indebted to numerous individuals and organizations for their help in fulfilling this thesis project. Though it goes without saying that the pioneering efforts of Jim Benedict inspired generations of archaeologists to pursue high altitude research, I reiterate here that without his tedious approach and love for mountain archaeology, we would all be lost.

My graduate advisor and mentor, Jason LaBelle, is the constant source of encouragement and enthusiasm which guides my academic career. His devotion to his students and their interests permeates through everyone and everything, and the time I've spent with him and the Center for Mountain and Plains Archaeology provided me with unforgettable experiences. I want to thank Jason particularly for keeping me alive throughout my Master's coursework, with paid leadership opportunities but also loyal and exuberant friendship. Our collaboration on numerous projects fostered my confidence as a student, field and laboratory researcher, and team member with the Center for Mountain and Plains Archaeology. Thank you, Jason. I would also like to thank my other thesis committee members, Mica Glantz and Jay Breidt, for their helpful comments on this thesis manuscript. Jay Breidt provided essential help in reconstructing the Colorado Front Range growth curve for use in lichenometry, and contributed useful insights for statistics.

The Alice Hamilton scholarship, endowed by the Colorado Archaeological Society, paid for field supplies to use in lichenometric measurements and data storage. Thanks are in order, specifically, to the Pikes Peak Chapter of CAS for inviting me to present my research. The Karen S. Greiner Endowment, granted by the Department of Anthropology at CSU, provided me biannual scholarships to pay for radiocarbon dating. Thank you to Mary Van Buren, especially, for reviewing my materials for the Karen S. Greiner Endowment. The Colorado Mountain Club Foundation bestowed a substantial endorsement with the Al Ossinger Fellowship, which also contributed funds for radiocarbon dating. Thank you to Paula Cushing of the Denver Museum of Nature and Science for reviewing my fellowship application. Lastly, I would like to thank Jason LaBelle and the Jim and Audrey Benedict Fund for Mountain Archaeology for financial support of my fieldwork and contributing additional funds for radiocarbon dating.

Dr. Jason LaBelle integrated my interest in Rollins Pass game drives with the 2017 archaeological field school at CSU as well as the overarching Rollins Pass project that he directs, and he made fieldwork for this thesis possible. I am beholden to the efforts of numerous undergraduate and graduate students who attended and participated in the field school, and I appreciate their efforts and due diligence in helping to create the data addressed herein. The Arapaho and Roosevelt National Forest provided the permits to conduct fieldwork, and continue to support the CMPA's efforts in high altitude research.

Lastly, thank you to a number of CMPA graduate students. Hallie Meeker and Aaron Whittenburg initiated me into the CMPA, and without their friendship I wouldn't have known all that a graduate student experience can be. Michelle Dinkel, Ray Sumner, and Marie Taylor provided outstanding assistance during the fieldwork phase of this project, and I will always remember our times spent atop the world at the Continental Divide. My newest office mates, Paul Buckner and Marie Taylor, lent their ears on more than one occasion and they made the end of my time as a Master's student immensely enjoyable. To Michelle Dinkel, thank you especially for everything you do, you made this all the more worthwhile.

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CHAPTER I – INTRODUCTION

Archaeologists once considered the mountains of Colorado as a marginal environment for prehistoric hunter-gatherers. Initial research in the western United States focused on the study of important Ancestral Puebloan sites of the American Southwest and Paleoindian era sites of the Great Plains (Benedict 1992; Cassells 1997; LaBelle and Pelton 2013; Meltzer 2006). However, research undertaken over the last 60 years demonstrates that peoples of the past not only visited Colorado's highest elevations, but intensively utilized some areas to practice key subsistence and social strategies. No such evidence is as thought provoking nor unambiguous as the many compilations of stone hunting features that punctuate the alpine tundra along the Continental Divide in northern Colorado, which are referred to in this thesis as communal alpine game drives.

Game drives are found along several major passes and travel corridors in northern Colorado. Several game drive sites rest at elevations above modern tree limit, or roughly 3500 meters (m) in altitude. At these sites, archaeological research shows that hunter-gatherer groups modified the alpine landscape by building complex arrangements of stone features to optimize the procurement of medium and large-bodied ungulates during seasonal migrations (Benedict 1975a, 1992; Olson 1970, 1971). Linear rock wall alignments, hunting blinds constructed of stone or shallow basin-shaped pits, and inconspicuously constructed cairn lines comprise the essential feature types used for prehistoric alpine game driving. However, game drives exhibit immense variability in the spatial arrangement and spatial structure of stone hunting features, and no single game drive site is constructed in the exact same way or at the same spatial scale as another. Yet, comparative inferences are shared amongst all alpine game drives on the basis of ethnographic analogues and theories concerning hunter-gatherer intercept hunting strategies and pre/post hunt activities (Benedict 1985, 1992, 1996, 2005; Binford 1978a, 1978b; Brink 2005; LaBelle and Pelton 2013; Whittenburg 2017).

Assemblage level analyses of lithic tools and debris, as well as metric and descriptive attributes of stone features, are the most commonly applied methods used to reconstruct on-site activities related to hunting/initial animal butchery at game drives. These same methods are also used to address inter-site level activities related to the seasonal transhumance of hunter-gatherer groups occupying both high and low elevation environments in/near the Colorado Front Range (CFR) during annual subsistence/mobility regimes (Benedict 1975a, 1975b, 1985, 1992, 1996; Cassells 1995; Hutchinson 1990; LaBelle and Pelton 2013; Whittenburg 2017).

Analyses of the form, function, and location of game drive sites, in suite with assemblage level characteristics, allows for in-depth reconstructions of past hunter-gatherer lifeways at high-altitudes, but there are many questions about alpine game drives that remain unresolved. Specifically, researchers are challenged in reconstructing the occupational intensity of game drives as related to a single hunting event at any one time in the past, from multiple events represented across time, or even by association to one of many broadly defined prehistoric eras. Nearly all game drives in the CFR show evidence for reoccupation, but environmental issues related to the low preservation of datable materials as well as the near-absent stratigraphic control of cultural occupation episodes limits how archaeologists can address aspects of time in alpine tundra environments. Past studies incorporated multi-disciplinary efforts and several methodologies to reconstruct the time-depth of prehistoric occupations and subsequent reoccupation episodes at game drives, and the results of such work suggests that hunter-gatherers utilized numerous alpine hunting sites for centuries and even millennia in some cases (Benedict

1975a, 1975b, 1978, 1996; Cassells 1995; Hutchinson 1990; LaBelle and Pelton 2013; Olson 1970, 1971; Olson and Benedict 1970). Radiocarbon dating of bone and charcoal provide the basis for absolute chronologies of most tundra game drives, and relative occupation spans are estimated from the typological cross-dating of time-diagnostic lithic tools such as complete or nearly complete projectile points (Benedict 1975a, 1975b, 1987, 1996; Cassells 1995; Hutchinson 1990; LaBelle and Pelton 2013; Whittenburg 2017). Lichenometry, a method of estimating the growth rate for lichens, also provides relative feature construction dates for the longest stone walls at several game drive sites along Colorado's Continental Divide (Albino 1984; Benedict 1975a, 1985, 1996, 2009; Benedict and Cassells 2000; Cassells 1995; Hutchinson 1990; LaBelle and Pelton 2013).

Thesis Objectives and Organization

This thesis attempts to address many of the complicated factors related to both discrete and broad-scale chronological reconstructions at game drives. The subject of this thesis is the 5BL148 site, situated near Rollins Pass, Colorado. Rollins Pass is located at the convergence of the Indian Peaks and James Peak Wilderness Areas, in Boulder, Grand, and Gilpin Counties (Figure 1). Rollins Pass is notable for its densest concentration of alpine hunting sites in North America, and while there are at least twelve distinct clusters of stone hunting features at the Rollins Pass hunting site complex (LaBelle and Pelton 2013; Pelton 2012; Olson and Benedict 1970; Whittenburg 2017), only the 5BL148 site is considered here. The purpose of this thesis is not to present a traditional report of investigations conducted at the site, but rather to provide a critical methodological and theoretical approach to understanding the complex nature of occupation, reoccupation, and the persistent use of place as reconstructed at a single game drive site in the CFR.

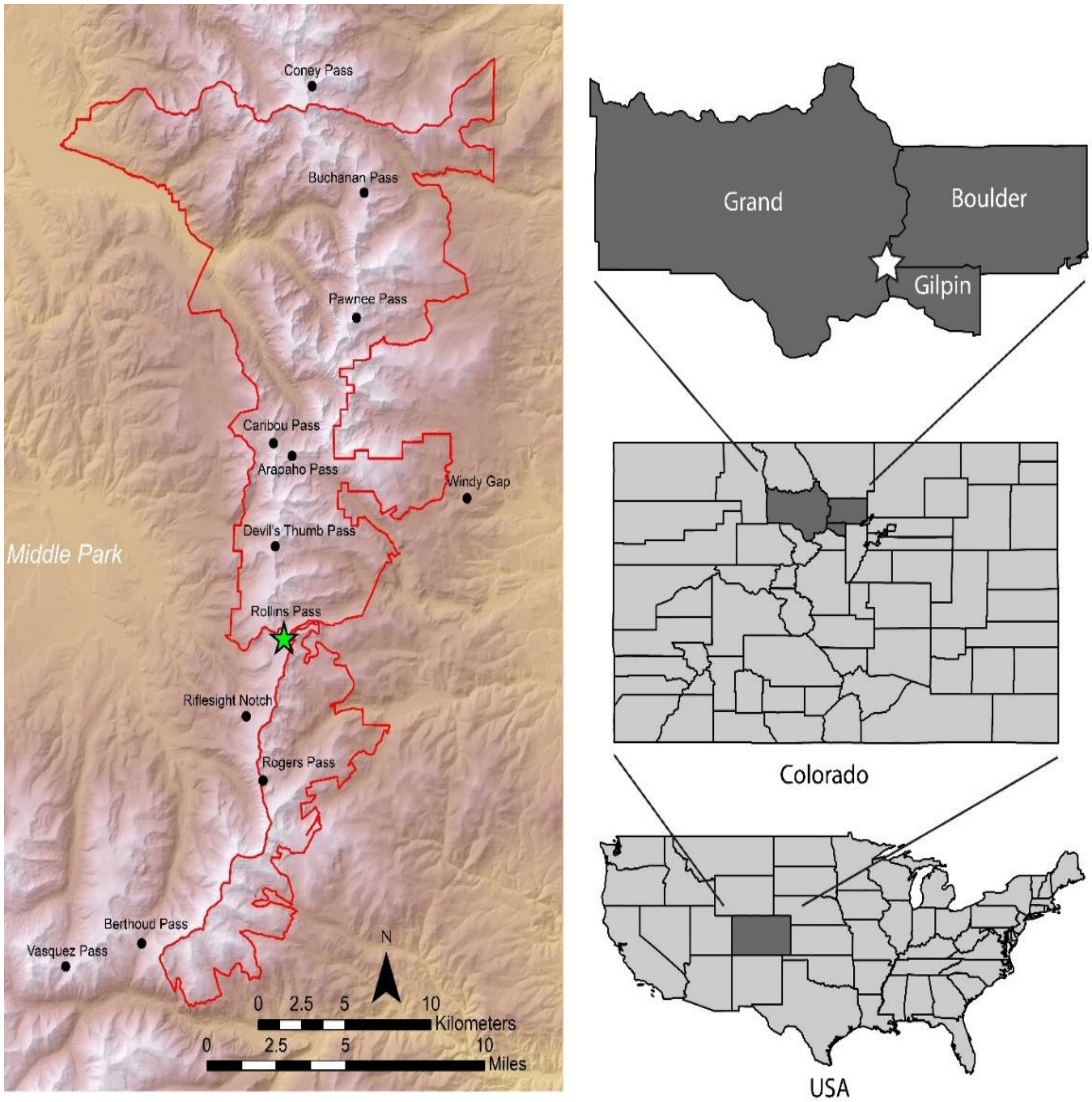

Figure 1. Location of Rollins Pass. Rollins Pass is situated at the junction of Boulder, Grand, and Gilpin County. The map (left) shows the location of the pass at the borders of the James Peak Wilderness (lower, red boundary) and Indian Peaks Wilderness (upper, red boundary). The star illustrates the position of Rollins Pass.

Research Questions

Three major questions are addressed in this thesis, which provide an organizational framework for the study and each of the connecting evidentiary concepts used in chronological reconstructions at 5BL148.

1. ***What is the relative occupation span of 5BL148?***

   This question is provided to address the material culture assemblage collected from the 5BL148 game drive as well as the results of a lichenometric study conducted on stone walls. Chapter 2 of this thesis provides a description of the different classes of chipped stone tools, lithic reduction debris, and Protohistoric era items collected in previous research and from recent survey fieldwork undertaken by the Center for Mountain and Plains Archaeology (CMPA) in suite with this thesis project. Typological cross-dating of time diagnostic projectile points and other items are used to reconstruct a relative occupation span for the site. Additionally, Chapter 3 addresses the lichenometric age of several stone wall features, which are used for estimating the minimum age of feature construction and/or modification events. Lichenometric wall ages are useful for delineating reoccupation events and fine-tuning of the spatial structure of game drive systems over time (Benedict 1985, 1996, 2009; Cassells 1995).

2. ***What is the absolute occupation span of 5BL148?***

   This question is used to explore the results of radiocarbon dating of bone and charcoal samples collected at 5BL148. The CMPA collected animal bones from alongside stone wall features and elsewhere in the tundra environment during recent fieldwork, which are used to determine the absolute radiocarbon age of either 1) natural animal deaths or 2) culturally induced mortalities of animals. The CMPA also conducted soil-core probe tests in several hunting blind features to identify the remains of ephemerally used hearths or warming fires, an adaptation documented at other game drive sites in the CFR (Benedict 1975a, 1996, 1992, 2000; Benedict and Cassells 2000; Cassells 1995; LaBelle and Pelton 2013; Whittenburg 2017). Radiocarbon dates on charcoal samples from 5BL148 are discussed, which provide an absolute measure used to address the potential occupation age of hunting blind features at the site. Chapter 4 of this thesis describes the faunal assemblage in terms of species and bone element representations, the soil-core probe methodology conducted in hunting blinds, and the results of radiocarbon analyses for selected bone and charcoal samples in order to help define the absolute occupation span of 5BL148.

3. ***Does the site represent a single occupation event, a palimpsest of overlapping reoccupation events, or instead spatially distinct reoccupation episodes?***

This question is used to understand the spatial structure of the various types of temporal data generated during the analytical and methodological procedures undertaken in this thesis. Past game drive research shows that temporal data address occupation and reoccupation at multiple temporal and spatial scales. Absolute dating methods applied at game drives are often used to reconstruct the age of feature occupation/construction events. Relative chronological data from time-diagnostic chipped stone tools, other artifacts, and well lichenometric ages of stone wall features, further address time-dependent changes in the spatial scale of hunter-gatherer occupations. Chapter 5 of this thesis is used to delineate the positions of relative and absolutely dated materials at 5BL148, to determine the spatial scale of past occupation episodes. In addition to exploring the provenance of the various forms of temporal data at 5BL148, a discussion of the spatial and functional context of stone feature alignments at the site is used as support of evidence for the presence/absence of reoccupation episodes. Intercept areas are classified and are used to discuss changes or “fine-tuning” of the game drive system over time. Expectations for the spatial structure of temporal data are reviewed to explore whether the site represents a palimpsest of overlapping reoccupation episodes, or instead a compilation of spatially distinct occupations. The implications for this question adhere to underlying cultural factors of hunter-gatherer placemaking and use of “destination drives” as repeatedly occupied, constructed, and modified technological systems (Binford 1978b; LaBelle and Pelton 2013).

Temporal Resolution and Dating Theory

Holistic chronological reconstructions at high altitudes require both relative and absolute dating methods, but it is important to examine how specific dating methods are used to estimate the age of hunter-gatherer activities. There are significant differences in the potential resolution of a relative or absolute dating method (in terms of numerical accuracy and precision), but also how relative or absolute dates from sites represent hunter-gatherer behaviors, occupations, or events in time. Absolute dating methods, such as radiocarbon dating, produce a more precise numeric and probabilistic estimate of an event than relative dating methods, but archaeologists must consider how numeric age estimates relate (or don’t relate) to human behavior. Dean (1978) provides an appropriate description of dating terminology and how dated events affiliate with past cultural processes. Target events are the behavioral episodes that archaeologists attempt to date with various methods at their disposal. Examples of target events at game drives could include specific hunting episodes, stone wall or hunting blind feature construction events, hunter-gather use of thermal features, animal processing and disarticulation events, or any other activities. A dated event, which is the numeric age or relative age produced from a dating method, may or may not be 1) congruent with a target event, or 2) be dependent on cultural processes.

Independent dating methods are techniques applied to materials with dating characteristics (dating potential) that are independent of human behavior or cultural systems (Dean 1978:226). As an example, radiocarbon dating of wood charcoal from a hearth feature is a probabilistic age estimate for the span of time that a sampled group of tree rings interacted with the biosphere. The age produced from radiocarbon dating of wood charcoal is not directly dependent on archaeological context, but instead biological factors and probabilistic observation. Archaeologists must use bridging events (such as spatial context, stratigraphic association, or inferred cultural processes) to tie a radiocarbon dated event to a targeted event (Dean 1978; Figure 2). Radiocarbon dates on wood charcoal are further complicated by factors related to the lifespan of the sampled organism (old wood vs. short-lived wood), and the portion of wood used in dating (tree body versus a branch with fewer tree rings represented), which create disjunctions (gaps) between the dated event (tree ring lifespan) versus the targeted event (age of a hearth feature). In contrast to the potential disjunctions of dating wood, radiocarbon dates of faunal remains are more easily bridged to target events. A radiocarbon date of bone is a high precision estimate of an animal death event (when the animal ceased to interact with the biosphere), and if an archaeologist demonstrates that the death event is related to human processes (like a hunting and processing episode), then there is congruence between the dated event and the target event. Lichenometry is another independent dating technique, where the dating potential of lichens is dependent on biological and taphonomic processes as opposed to behavioral and cultural contexts. The method is used to show the minimum age that a biological growth rate of lichens originated, following the construction of a stone feature. However, lichenometry is subject to potential disjunctions between the dated event (age of a growth rate) and target event (wall construction event) based upon taphonomic and biological issues (discussed in chapter 3).

Dependent dating methods are used to analyze the changes in stylistic and functional characteristics of materials that are the direct result of cultural and behavioral processes throughout time (Dean 1978). Change in the morphological form and function of projectile points, as a result of time-dependent trends in human decision making, technological alterations, and cultural dynamics, is an example of a dependent dating characteristic (Figure 2). Chronologies built upon dependent dating methods are directly affiliated with human behavioral trends, but the temporal resolution of dependent dating with relative techniques is generally coarse and it is difficult to associate culturally-dependent materials with target events at sites without the results of other corroborating dating methods. Artifact chronologies are often used to sequence cultural occupations of sites in a relative sense, termed relative placement by Dean (1978), where numeric and probabilistic estimation of age is not precise, but the relative order of cultural-technological change at site is represented by time-diagnostic artifact types that are built into a regional cultural-historical framework. In this sense, time-diagnostic artifacts are treated like index fossils (O'Brien and Lyman 1999), where the temporal resolution of an artifact chronology is dependent on the span of time reconstructed between archaeological components in a regional sample of sites that are dated by other means, but have the same types of time-diagnostic artifacts that are not dated directly.

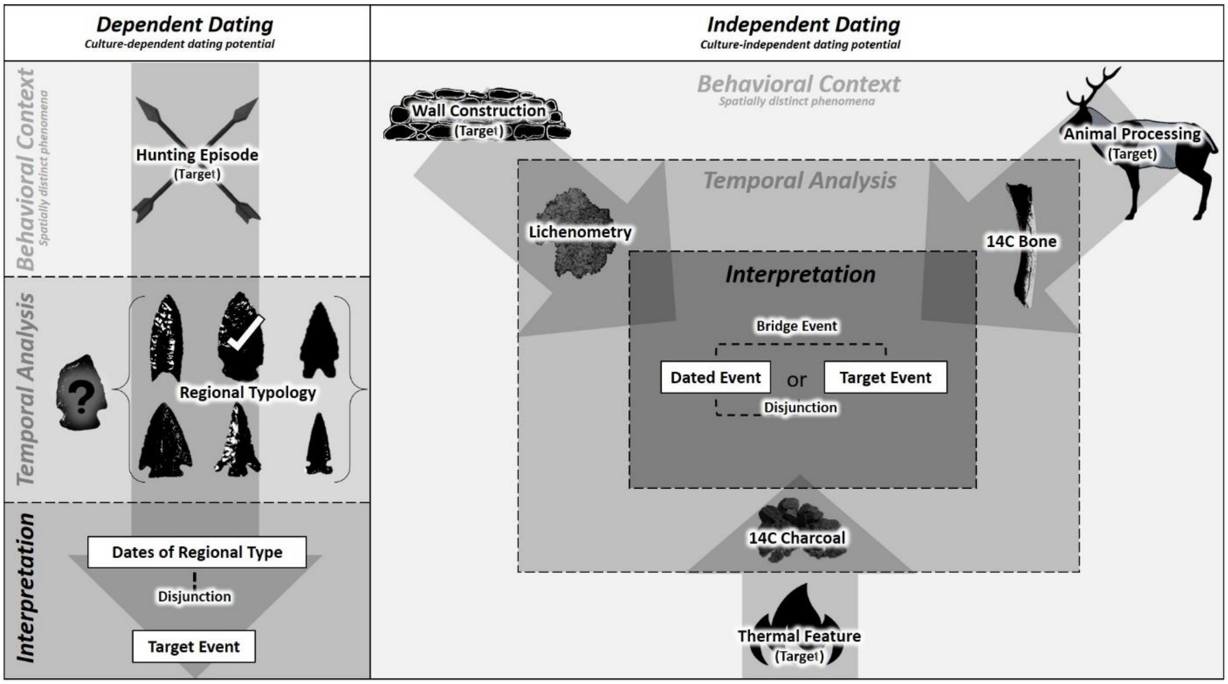

Figure 2. Illustration showing the relationship between hunter-gatherer activity types and the chronological methods (temporal analyses) employed to date each activity at 5BL148.

Location and Setting at Rollins Pass

The physical environment of Rollins Pass is recently summarized in Master's theses and academic publications (LaBelle and Pelton 2013; Pelton 2012; Whittenburg 2017), and geological and ecological descriptions of the area are therefore abbreviated in this section. Rollins Pass (*sensu stricto*) is located at a base elevation of 11,660 feet above sea level (roughly 3550 meters), and divides the drainage system of the South Fork Middle Boulder Creek (a tributary of the South Platte River) to the east, and Ranch Creek (a tributary of the Colorado River) to the west (Figure 3). Rollins Pass is long recognized as a major mountain travel corridor between the foothills east of the Continental Divide, and west into the Middle Park area, and this is exemplified by the presence of numerous prehistoric and historic campsites and isolates located both on the pass and in the surrounding glacial cirque basins (Benedict 1971; Pelton 2012; Olson 1970, 1971; Benedict and Olson 1970; LaBelle and Pelton 2013; Whittenburg

2017). Descriptions of historic Native American trail systems (Ives 1942; Toll 2003), as well as Euro-American use of the Boulder Wagon Road and the Moffat Railroad via the Denver, Northwestern, and Pacific Railway (LaBelle and Pelton 2013; Whittenburg 2017; Wright and Wright 2018), demonstrate the importance of Rollins Pass throughout time.

Geology and Ecology

The Southern Rockies of northern Colorado are shaped by complex geomorphic and Quaternary glacial processes, lending to a diverse landscape with productive ecozone distributions. Ridges, faults, and dykes in the Indian Peaks and James Peak Wilderness Areas, which surround the Rollins Pass project area, are comprised primarily of Precambrian biotitic gneisses, granites, and grandiorites (Benedict 1985, 1992; Cassells 1995; Pelton 2013). U-shaped valleys and cirques that bound high elevation alpine-tundra ridgelines along incised escarpments are the principal result of Pleistocene and Holocene glacial advances, which are now in-filled with productive montane, sub-alpine forests, and a forest-tundra ecotone with permanent and perennial lakes. Though Rollins Pass itself straddles the modern extent of forest-tundra ecotone, which exhibits great biological diversity suitable for prehistoric human use as demonstrated in ecological and archaeological studies in the CFR (A. Benedict 1991; Benedict 1992, 2007; Cassells 1995; Marr 1961; Pelton 2013), the numerous game drive features that embody prehistoric hunting adaptations at the pass are located more so in the alpine-tundra environment and highest elevation settings along the Continental Divide.

Periglacial processes are the primary geomorphic variables that impact landform surface composition and the raw material availability for stone feature construction at alpine game drives near Rollins Pass, and elsewhere in the CFR. Direct glacial actions are less prominent (Cassells 1995; Clark 1988), but intense freeze-thawing causes sediment and rock displacement as well as vegetation purging. Rocks available for anthropogenic stone feature constructions are often displaced by frost action into recognizable periglacial arrangements called patterned ground, such as hummocks, polygons, circles, stripes and sorted nets (Benedict 1985; Cassells 1995:16-18). Patterned ground is apparent in the form of sorted nets and stripes on a highly exposed east and north-facing slope at 5BL148, which likely conditioned the placement of many hunting blind features and stone walls. This process is thoroughly documented elsewhere in the CFR (Benedict 1985, 1996; Cassells 1995), where hunter-gatherers removed rocks from the interior of sorted nets to create circular depressions without the need for excessive digging.

Mountain biota that persist at 5BL148 and elsewhere in the CFR include low grasses and shrubs, lichens, mosses, sedges, and rushes (Figure 4). Harsh winds and temperature fluctuations permit only the hardiest of flora in the alpine-tundra, but at least 300 species are documented and roughly 120 are unique to the alpine (A. Benedict 1991; Cassells 1995:25; Holtmeier 2003). Severe climate in the form of powerful Westerlies winds, low effective mean temperatures, and highly pervasive moisture adversely limits annual vegetation growth, but also contributes to the low rate or near absence of sediment accumulation (Benedict 1985, 1992, 1996; Holtmeier 2003; Whittenburg 2017). The combination of these geological and ecological factors, in suite with an understanding of soil acidity (Benedict 1992), show the lacking preservation characteristics that create a sparse record of datable archaeological materials in alpine settings.

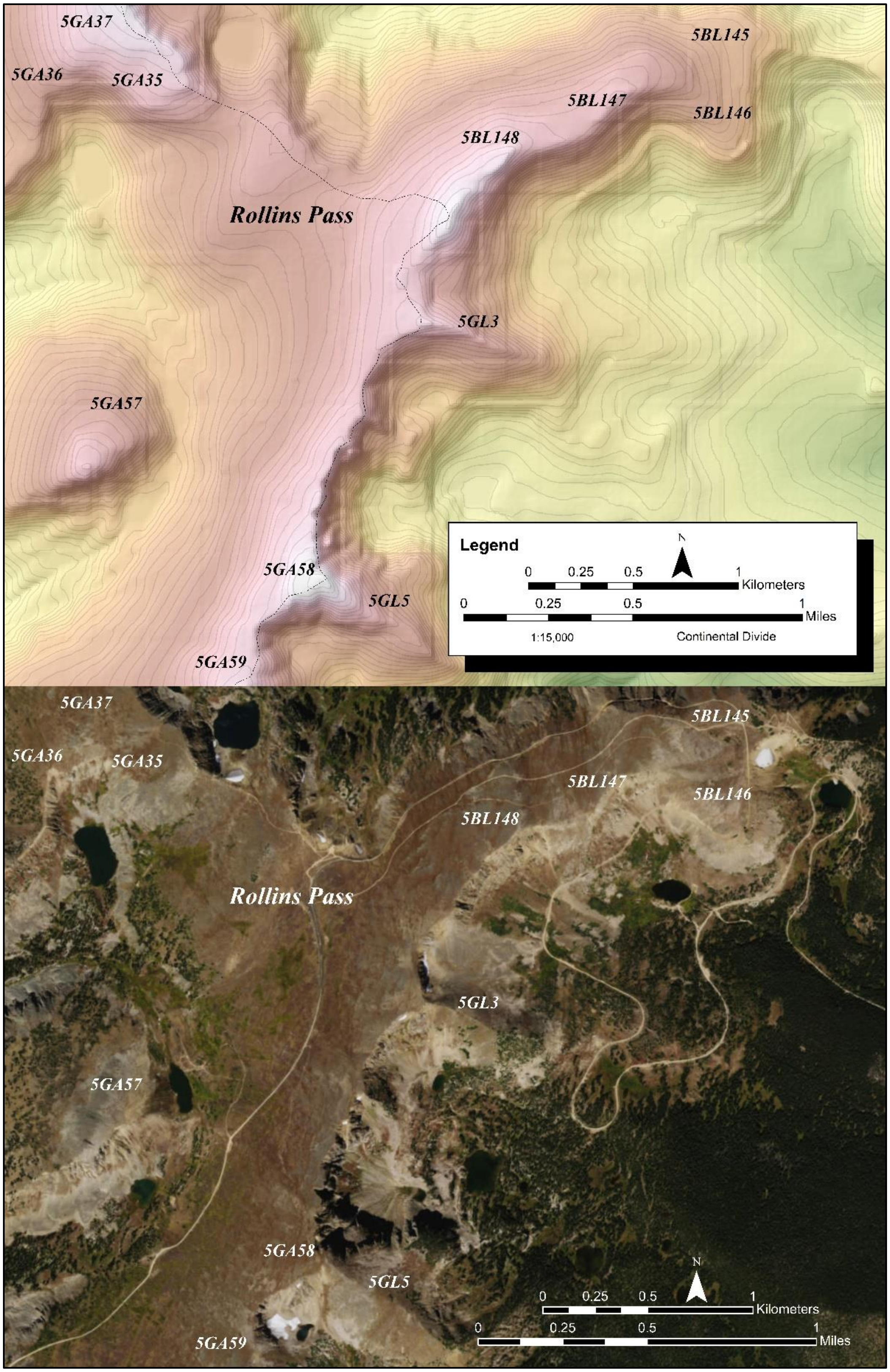

Figure 3. Terrain and aerial view of the Rollins Pass project area. General location of game drive sites depicted by site numbers.

Figure 4. A view of the alpine-tundra landscape on the Continental Divide at the 5BL148 game drive site, Rollins Pass, Colorado.

History of Investigations at Rollins Pass

C.A. Deane, a government surveyor, first described the stone features atop the Continental Divide near Rollins Pass in 1869. He mistook the many alignments for Moundbuilder monuments or sepulchers, as was the normative antiquarian view for time (LaBelle and Pelton 2013:48). Four years later in 1873, John Q.A. Rollins provided more in-depth but still abbreviated descriptions of the many features at the pass during his construction of a historic wagon road between Rollinsville and Middle Park, and enamored readers of the *Rocky Mountain News* (and present-day archaeologists) with details of an enigmatic wooden bow assumingly recovered from rocky slopes at one of the game drive sites (LaBelle and Pelton 2013; Rollins 1873; Whittenburg 2017). John Q.A. Rollins' wagon road crosses directly through the 5BL148 site.

Professional archaeological investigations at Rollins Pass took place roughly a century after C.A. Deane first described stone features there. Byron L. Olson and James B. Benedict initiated research at Rollins Pass as one part of an all-encompassing mountain survey project concerning the high-altitude adaptations of hunter-gatherers in the CFR (Benedict 1971, 1972; Olson 1970, 1971; Olson and Benedict 1970), funded by the National Science Foundation (grant number GS-3052) and supported by the Arapaho and Roosevelt National Forests. Jim Benedict and his crew members investigated many other passes and valleys in the CFR beginning in the late 1960's (Benedict 1975a, 1975b, 1981, 1985, 1996; Benedict and Cassells 2000; Benedict and Olson 1978), but Byron Olson primarily directed the Rollins Pass project (LaBelle and Pelton 2013; Whittenburg 2017).

The work conducted by Olson and Benedict at Rollins Pass focused on systematic mapping of the many stone features that comprise the entirety of the hunting complex at the pass. They also undertook small scale excavations of hunting blinds at several of the individual game drive sites (Benedict 1971; Olson and Benedict 1970; Pelton 2012; LaBelle and Pelton 2013; Whittenburg 2017). In 1969, Byron Olson and Jim Benedict used intensive theodolite surveys and early methods of photogrammetric georectification to map and plot stone features (walls, blinds, and cairn lines) at several of the larger game drives at Rollins Pass (Olson 1971; Pelton 2012; Whittenburg 2017:12). The products of these old but accurate mapping systems applied at Rollins Pass (and elsewhere in the CFR) continue to be used in the present day (LaBelle and Pelton 2013; Pelton 2012; Whittenburg 2017). From 1969 through 1971, Olson and Benedict excavated at least 27 hunting blinds at the four largest game drive complexes at the pass, including 5BL148, 5BL147 or the Olson site (LaBelle and Pelton 2013), 5BL146, and the complex of sites surrounding 5GA35 (Whittenburg 2017). Olson and Benedict also excavated at least two trenches along some stone walls at Rollins Pass, and while descriptions of their excavation methodologies and the general quantities of items are described in a series of short annual reports to the Smithsonian and Forest Service, no final report of this work was ever completed.

Center for Mountain and Plains Archaeology

Researchers recognized the significance of the Rollins Pass hunting complex during the earliest fieldwork (Benedict 1971, 1992; Olson 1968, 1970, 1971; Olson and Benedict 1970), but the lack of a final publication or report on the area prohibited its inclusion into the comprehensive body of high-altitude archaeological research. In 2009, Jason LaBelle and the Center for Mountain and Plains Archaeology (CMPA) at Colorado State University (CSU) revitalized fieldwork at Rollins Pass (Pelton 2012; LaBelle and Pelton 2013; Whittenburg 2017). The CMPA developed a systematic recording procedure to redocument previously known game drives, campsites, and isolated finds located throughout the Rollins Pass project area.

Site revisits at game drives included the application of new methodologies to estimate site structure, patterns in feature location and size, inter-site visibility and viewsheds, as well as fine-grained pedestrian surveys to document previously unrecorded artifacts. The CMPA also conducted new surveys at Rollins Pass in high-probability areas, given that the extent of previous surveys by Olson and Benedict are not known. Landscape investigations and siteless surveys are routinely applied to understand the provenience of individual artifacts at the pass and the distribution of past activities throughout time. The CMPA's research at Rollins Pass produced novel research articles (LaBelle and Pelton 2013), Master's thesis projects (Whittenburg 2017; this thesis), as well as student and volunteer archaeological training via field schools and summer field projects. A recent Master's thesis authored by former CSU graduate student Aaron Whittenburg provided a cohesive study of the prehistoric use of the 5GA35, 5GA36, and 5GA37 game drive sites near Rollins Pass with an emphasis on the use of space during different stages of hunting preparation, active hunting, and post-hunt activities (Whittenburg 2017). Another upcoming master's thesis by CSU graduate student Michelle Dinkel will evaluate the presence of non-hunting sites at Rollins Pass to aid in a synthetic understanding of prehistoric mobility and landscape use of the pass, throughout prehistory.

The 5BL148 Site

Olson and Benedict (1970) mapped 2,080 linear meters (m) of stone wall alignments, approximately 60 hunting pits, and one small line of cairns (approximately 20 m in length) along a tundra slope and ridgeline escarpment at the 5BL148 site. The features are situated on a long, northeast trending hill grade that descends from Rollins Pass to a low-lying U-shaped valley around Yankee Doodle Lake and the South Fork of Middle Boulder Creek (Figure 5). The Olson site (5BL147), 5BL146, and 5BL145 are also located on this same northeast trending ridgeline, but the 5BL148 site is the first in a line of hunting sites leading eastward from the Rollins Pass area. In terms of elevation, the 5BL148 site is at the pinnacle of game drives in the Rollins Pass hunting complex at just over 12,000 ft. (3658 m) and it is also the largest site in terms of the length of walls and the frequency of hunting blinds per game drive site at the pass (Olson and Benedict 1970; Pelton 2012). The 5BL148 site is situated immediately adjacent to and partially connected with the system of features mapped at the Olson site, by a linear wall segment that abuts the edge of the ridgeline cliff, overlooking the U-shaped valleys by Jenny Lake to the southeast.

Olson and Benedict excavated eleven hunting blinds at 5BL148 during the 1970 field season (Olson 1971). There are no existing records to indicate which of the blinds Olson, Benedict, and their field crews excavated at the site, but Olson (1971:Table 3) shows metric and descriptive characteristics of the selected blind features which provides some added clarity to past fieldwork procedures. Surviving records for the Olson site (LaBelle and Pelton 2013), as well as 5GA35 at Rollins Pass (Whittenburg 2017), contain map annotations that help denote the provenience excavated blinds. Olson and Benedict did not sequentially number excavated hunting blinds at 5BL148 (Table 1), likely suggesting that the researchers dug and/or identified and mapped hunting blinds from several other game drive sites at Rollins Pass, simultaneous to work being conducted at 5BL148. Olson and Benedict provided measures to minimize degradations to the integrity of hunting blind features during excavations, and excavators dug only half of the hunting blinds in most of the reported cases (Olson 1971; Whittenburg 2017). Only two of the eleven blinds excavated by Olson at 5BL148 contained artifacts. Pit 190 and Pit 280 both contained lithic debitage and chipped stone tools. Pit 280 also contained a small Protohistoric period trade bead of Euro-American origin. The excavations in Pit 190 are significant in that indications of hearth activity are presented in the reports of Olson (1971:15), with descriptions of two stratigraphic layers of scattered charcoal and a third layer elaborated as a charcoal concentration, though these details cannot be further verified without the excavation records and additional testing. In total, Olson and Benedict collected 135 chipped stone artifacts and one trade bead during excavations at 5BL148.

Table 1. Adapted from Olson (1971:Table 3). Descriptive and metric attributes of excavated hunting blinds at the 5BL148 site. There are no maps or records to indicate the provenience of excavated blinds at 5BL148.

Pit Number	Max Exterior Diameter (m)	Max Interior Diameter (m)	Height of Exterior Pit Wall (cm)	Height of Interior Pit Wall (cm)	Preservation
182	3.3	1.7	20	60	Fair to poor
190	3.2	1.8	-	73	Fair
259	-	1.2	-	-	Fair
280	-	1.5	60	100	Fair
297	3.1	1.5	30	40	Fair to poor
300	3.3	2.4	45	50	Fair to poor
317	3.6	2.0	60	100	Fair
318	4.0	2.0	60	70	Fair
334	4.4	2.0	20	70	Poor
358	2.6	1.6	20	20	Poor
381	4.0	1.6	10	30	Poor

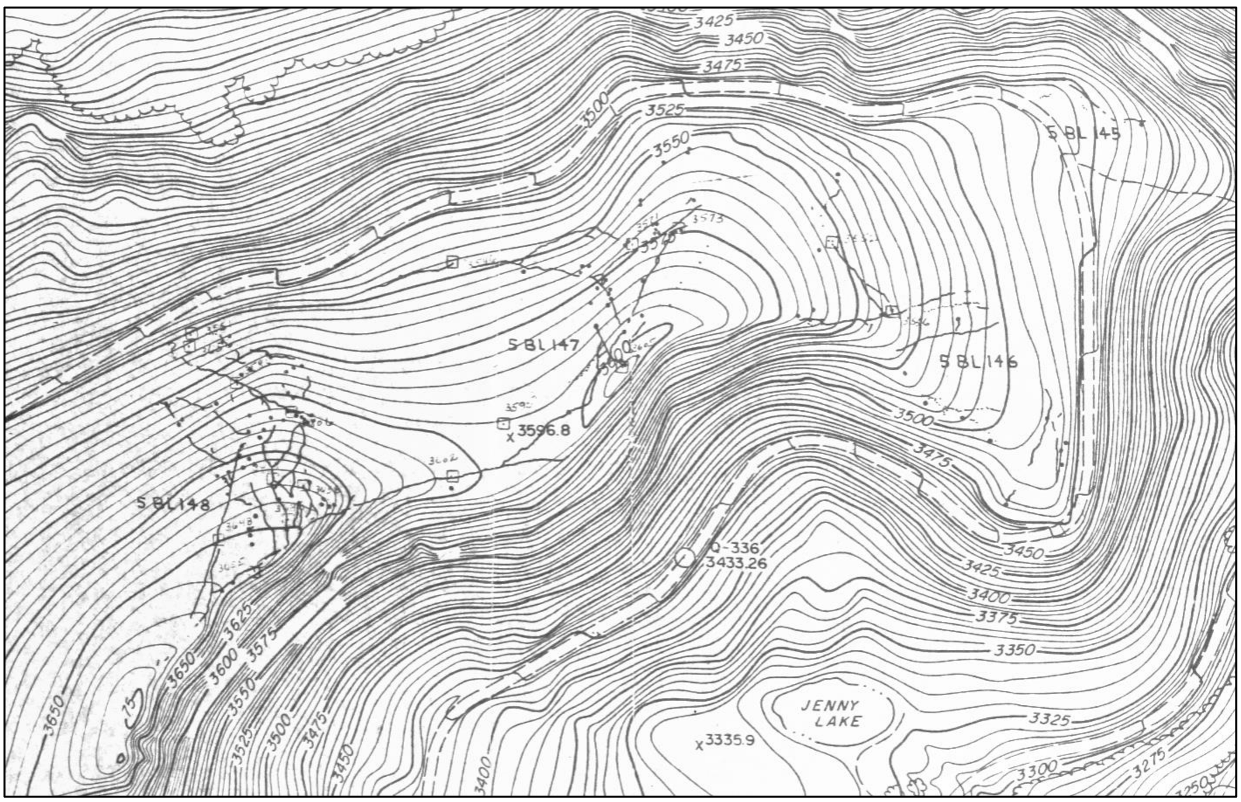

Figure 5. Scan of Olson and Benedict's topographic map with stone features plotted from 5BL148, 5BL147 (Olson site), 5BL146, and 5BL145. Three of the four largest game drive sites mapped by Byron Olson and James Benedict in the Rollins Pass hunting complex are located on the northeast trending slope, depicted here. Map on file with the CMPA's collections.

Recent Fieldwork at 5BL148

The CMPA reinitiated studies at 5BL148 in 2012, beginning with a comprehensive georeferencing and landscape study of the Rollins Pass project area (Pelton 2012) which assisted subsequent fieldwork at the site in the summers of 2012 and 2013 with CSU's archaeological field school crewmembers. Pelton (2012:Table 1) described 2046 m of stone walls, 46 hunting blinds or pits, and roughly four cairns at the 5BL148 site, demonstrating the high frequency and extent of stone features. The CMPA performed informal pedestrian surveys or "noodling" surveys at 5BL148 in the summers of 2012 and 2013, and crew members mapped eight chipped stone artifacts and one bone with a Garmin Rino GPS, to an accuracy of about 2-3 m. The CMPA collected all artifacts for additional analysis. Similar to the first professional descriptions of the site (Benedict 1971; Olson 1968, 1970, 1971; Olson and Benedict 1970), the CMPA's initial observations confirmed the complicated and extensive arrangements of stone game driving features.

The spatial arrangement of stone features at 5BL148 provided the basis of inquiry for this thesis project, and the author proposed a series of field and laboratory methods in order to address aspects of site chronology and site structure at the game drive. The author and CMPA crew members implemented a formal pedestrian survey protocol at 5BL148, adhering to survey methods first performed at 5BL147 (LaBelle and Pelton 2013), and during investigations at 5GA35, 5GA36, and 5GA37 (Whittenburg 2017). The author scanned, digitized, and georeferenced the original Olson and Benedict topographic map of Rollins Pass to situate the known extent of stone features on the landscape at 5BL148 (Figure 5), which produced minor differences from Pelton (2012) in the frequency and dimensions of features at the site. The author's georeferencing of the original site map yielded 2,085 meters of stone walls, 50 hunting blinds, and a line of cairns about 8 meters in length. The author's reconstructions of the site extent at 5BL148 is more analogous to Olson's (1971) descriptions, but slightly different counts of hunting blind features (n=56) are also presented in Benedict (1992:5). The variable reporting of feature frequencies provided greater cause for ground-truthing methods and field surveys, to better understand site composition at 5BL148.

The author generated an alpha-numeric grid of 25 x 25 m survey blocks set to the Universal Transverse Mercator in the NAD 83 Datum, following the creation of a site map scanned from Olson and Benedict's initial work. The author then created a priority classification scheme for survey coverage to guide onsite investigations. Survey blocks with one or more stone walls or hunting blind features comprised the highest priority survey areas. Survey blocks with only one mapped feature attributed a mid-level survey priority, as did survey blocks that yielded previously identified chipped stone artifacts in 2012 and 2013. Survey blocks with no previously mapped features and artifacts provided the lowest survey priority.

Over the period of a ten-day field session at Rollins Pass in 2017, the CSU archaeological field school crew intensively surveyed 26,785 square meters (or roughly 6.6 acres) at 5BL148 (Figure 6). CSU undergraduate students, graduate student teaching assistants, and the principal investigator (LaBelle) surveyed 43 of the 25 x 25 m survey blocks during the 2017 field school. Crew members individually surveyed each of the survey blocks with narrow transect spacing, at roughly 1-2 m intervals, with approximately 15-20 transect passes per survey block (see also Whittenburg 2017). Crew members filled out survey forms for each surveyed block with descriptions of the immediate site setting, the presence or absence of stone features and artifacts, and any factors contributing to the visibility of archaeological materials such as vegetation cover, sunlight or shade, and walking speed. Crew members mapped all artifacts and bone identified during surface surveys at 5BL148 with a Trimble Geo7x GNSS GPS system at a submeter accuracy level, and collected items for additional analyses. The CMPA mapped and collected 16 chipped stone artifacts, and 9 faunal specimens (1 additional faunal specimen mapped but not collected) in 2017. The CMPA also identified two previously unrecorded hunting blind locations and several cairns, bringing the total number of features closer to what was previously described by Olson and Benedict (1970) and Benedict (1992) (Table 2). Crew members hand sketched wall features encountered during surveys within predesignated blocks, but did not provide formal descriptions and metric attributes for most walls in the field due to time constraints and the strong reliability of Olson and Benedict's previous wall mapping procedures. The CMPA provided a greater standard of feature recording for hunting blinds, as the metric and descriptive attributes of blinds are key to understanding the social and functional relationships of hunters or groups of hunters that occupy the features at specific positions within the game drive (LaBelle and Pelton 2013; Whittenburg 2017).

The author initiated a supplementary set of recording procedures to collect temporally informative data at 5BL148. The author implemented size-frequency lichenometry to assess the minimum age of stone wall feature construction at the site, which coincided with the CMPA's pedestrian surveys during the ten-day field session in 2017. A team of 2-3 crew members conducted in-field lichen thalli measurements on four of the largest stone wall alignments at the game drive over the course of the field school field session. Further, the author used a low-invasive soil-core probe methodology to conduct subsurface sediment testing of the interior pit floors in hunting blind features at 5BL148, to search for evidence of hunter-gatherer feature occupancy, construction of interior thermal features, or chipped stone tool maintenance activities as documented at other game drives in the CFR. The author and a CMPA graduate student crew member (Michelle Dinkel) led subsurface tests at the site during a short, four-day field session following the completion of the CMPA ten-day field school at 5BL148. In total, the soil-core probe crew tested 19 hunting blinds features, and the author processed each of the sediment samples following the completion of fieldwork. In sum of the CMPA's field work at 5BL148, crew members surveyed 6.6 acres of land (out of 6.5 hectares of site area), collected a total of 34 cultural artifacts and bones, took thalli diameter measurements on four stone wall features, and provided low-impact subsurface sediment collection in 19 hunting blind features.

Table 2. Summary data for site investigations at the 5BL148 game drive.

Year	Acres Formally Surveyed	Frequency of Artifacts Mapped	Frequency of Bones Mapped	Frequency of Blinds Mapped	Length of Walls Mapped (m)
1969-1971	-	136	-	56-60	2080
2017	6.6	16	10	52	2085

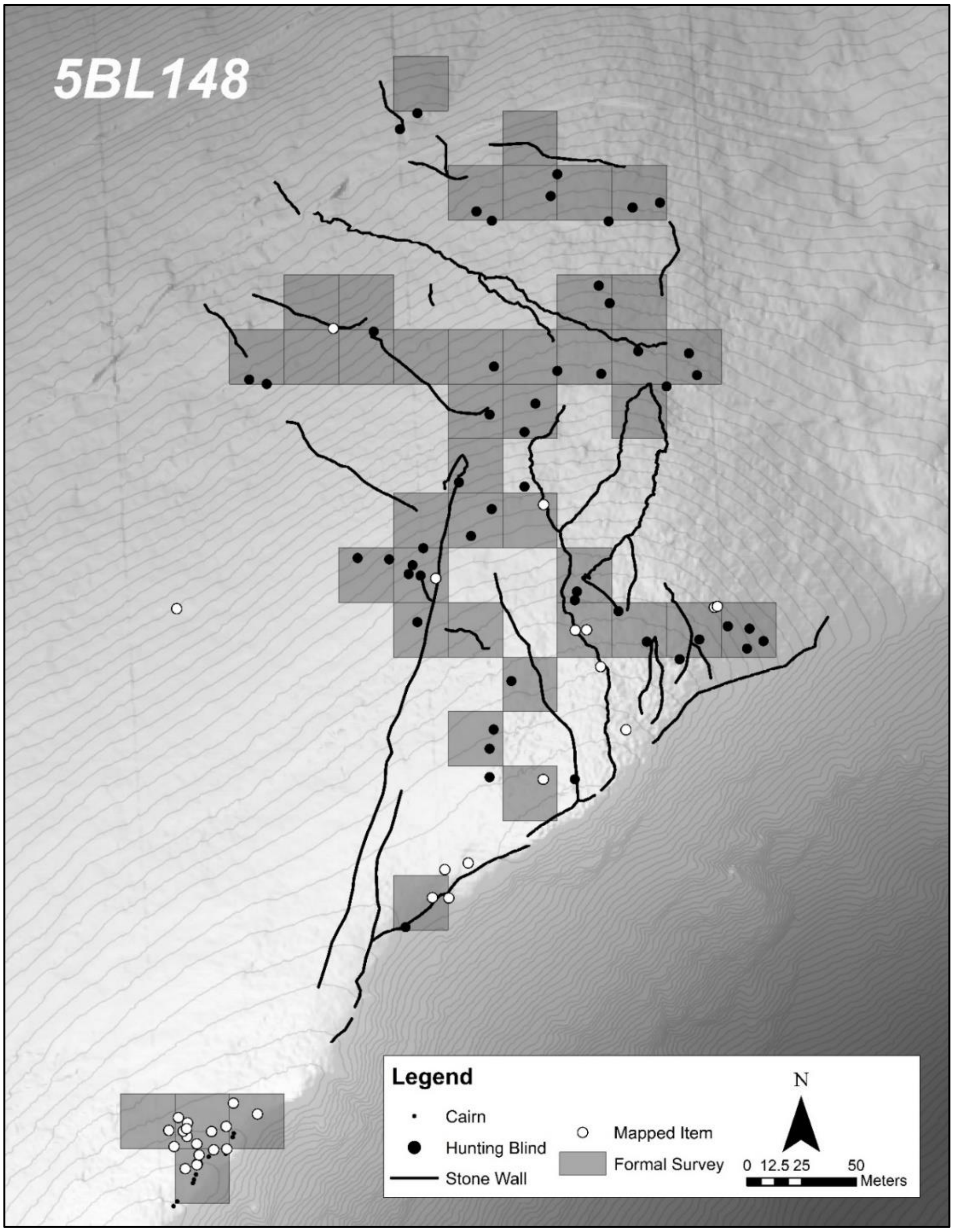

Figure 6. A Digital Elevation Model (DEM) with feature locations, mapped items, and formal survey blocks completed by the CMPA at the 5BL148 game drive, Rollins Pass, Colorado.

Summary and Conclusion

Rollins Pass is best characterized as an accumulated landscape of Prehistoric and Historic era sites/isolated finds (LaBelle and Pelton 2013; Pelton 2012), represented by significant time depth but also diversity in cultural material composition, environmental setting, and breadth of human activity. The game drives of Rollins Pass distinguish the area as a dense hunting complex used by hunter-gatherer groups, but numerous other campsites of various sizes and ages also exist in the immediacy of the pass and demonstrate the significance of the landscape for hunter-gatherer groups throughout time. It is important to note that this thesis considers just one aspect of a diverse prehistoric Native American representation at Rollins Pass.

Previous studies at alpine game drive sites demonstrate that no one game drive is constructed by the same exact means or at the same spatial scale as another. Some game drives are interpreted as "destination drives" that are repeatedly reused and modified by hunter-gatherer groups during annual subsistence-settlement regimes (Binford 1978b; LaBelle and Pelton 2013). Exceptionally large game drives that are characterized by numerous and complex arrangements of stone features fit the model for reoccupied game drive sites, in combination with absolute and relative dating methods applied to feature and artifact assemblages. Chronological measures are used in this thesis to determine the occupation span for 5BL148, to assess whether the frequencies and extent of features are characteristic of a reoccupied high-altitude hunting locale. Relative occupation span is explored with time-diagnostic artifacts collected during surface surveys and hunting blind excavations. A lichenometric analysis of four large stone wall features is used to determine the minimum age of feature construction events. Absolute chronologies are also reconstructed by radiocarbon dated bone and charcoal remains. Each of these methodologies create temporal information that are keyed to specific positions on the landscape at 5BL148, allowing for a spatial reconstruction of hunter-gatherer occupation episodes, site modification through time, and the presence/absence of accumulated palimpsest activities. The following chapters detail the results of a chronological reconstruction of 5BL148.

CHAPTER II – ARTIFACT ASSEMBLAGE

The purpose of this chapter is to 1) provide a descriptive assessment of the artifact assemblage from the 5BL148 game drive, and 2) use typological characteristics of the artifacts to derive a relative chronology and assess evidence for a one-time occupation versus evidence for multiple occupations at the site. Time-diagnostic artifacts from 5BL148 are used to infer past occupations by hunter-gatherers during broadly defined periods of prehistory or history, that reflect regionally bound age-ranges of an artifact morphology or type. Additional technological characteristics of non-diagnostic chipped stone artifacts are presented in this chapter to aid in a synthetic reconstruction of site activities and the use of space at 5BL148.

Theory in Typology and Relative Chronology

Occupation span is explored in this chapter with time-diagnostic artifacts collected during surface surveys at 5BL148, and from excavations conducted in the early 1970's (Olson and Benedict 1970). The lack of stratigraphic control at alpine game drive sites limits the ability of researchers to assign absolute temporal information to lithic and/or dry-laid feature assemblages, and the most commonly used method of estimating occupation span at any open-air lithic assemblage is typological cross-dating (Hildebrandt and King 2002; Holmer 1986; Smith et al. 2013; Thomas 1981). In typological cross-dating, artifacts with specific morphologies are treated as stylistic types that are indicative of a specific cultural or technological complex. Stylized artifacts identified at sites in deflated or sediment-devoid surface contexts are then compared to morphologically identical specimens from other sites with dated and/or stratified occupational horizons. It is inferred that a sample of dated components and non-dated components with identical artifact types are of the same approximate age.

There are limitations to typological cross dating. Typological cross-dating assumes that lithic artifacts (which cannot be directly dated) and datable materials (like charcoal from a hearth, bone samples, or perishable artifacts) that are found in close spatial/geological associations are in fact the same age (Schiffer 1987; Smith et al. 2013:582). Cultural and natural disturbances at sites can limit or skew the visibility of multiple occupation episodes. Further, specific artifact morphologies may develop or disappear at different times in prehistory or history, and across different geographic regions, which limits the use of the method across vast amounts of space and potentially across great time depth. However, typological cross-dating is a necessary method when applied in conservatively defined geographic regions that are limited to only a few stratified sites with dated cultural components.

In the CFR, and at alpine game drives specifically, few artifact types are treated as time-diagnostic indicators of past occupation episodes. Projectile points are the primary artifacts used in typological cross-dating, and points are the predominant lithic tools recovered from surface contexts at alpine game drives in the CFR. Several game drive sites exhibit multiple types of projectile points attributed to early and later prehistoric periods, providing an indication that hunter-gatherer groups reoccupied alpine sites over the course of prehistory. However, projectile points are only rarely identified in excavated contexts at game drive sites (Benedict 1975a, 1975b; Benedict and Olson 1978; LaBelle and Pelton 2013), and it is difficult to associate the use of game drive features with any specific prehistoric typological complex based only upon the presence of projectile points recovered from site surfaces and with little other provenience information in some cases. Spatial context is key to understanding the temporal and functional relationship of time-diagnostic artifacts recovered near or away from stone features at any game drive site. However, temporal markers such as projectile points are useful for determining the relative time span of prehistoric activities at sites in alpine environments, despite the presence, absence, or use of stone features at game drives. It is possible that the construction and use of stone features at game drives is temporally or functionally unrelated to the activities represented by discarded projectile points found within alpine site boundaries.

In this chapter, time-diagnostic projectile points are used to discuss occupation span at the 5BL148 game drive without consideration for the timing of stone feature construction or use. Table 3 reviews the relative span of prehistoric occupations at alpine game drives in Colorado based upon the presence of collected projectile point types, and Table 4 summarizes projectile point types that are commonly recognized at alpine game drives along with the associated calibrated age ranges of regionally excavated and dated cultural components. Paleoindian era (10,000 – 5,500 BCE) projectile point forms are found at game drives in the Front Range (Benedict 1987, 1996, 2000; Brunswig 2007; Morris 2014), but these exceptionally early forms are reported with low frequency per site and it is difficult to incorporate game drive technology cohesively into theories concerning Paleoindian subsistence-settlement systems. The use of stone features to control animal movements during the Paleoindian period is not thoroughly evidenced. The earliest consistently identified point type at alpine game drives are Early Archaic period (5500 – 3000 BCE) Mount Albion complex points (Benedict 1978, 1992, 2012; LaBelle and Pelton 2013:46). It is currently supported that Early Archaic occupation of the CFR coincided with Altithermal refugium, where drought on the Plains likely pressured groups to utilize high elevation watersheds and to concentrate on local resources (Benedict 1978, Pelton 2013). Late Prehistoric era Hogback Corner-notched points, affiliated with the Early Ceramic period (CE 150 – 1000), are found with the greatest frequency at game drives and in good association with stone features at sites (Benedict 1975a, 1987, 1992, 1996; Benedict and Cassells 2000; LaBelle and

Pelton 2013; Meyer 2018; Nelson 1971). The Early Ceramic period in Northern Colorado coincides with demographic expansion and rapid technological change (Gilmore 1999, 2008), and communal alpine game driving situates well within theories concerning Early Ceramic period subsistence-settlement systems (Benedict 1975a, 1975b, 1992). As previously addressed, it is difficult to determine how and why prehistoric groups occupied alpine game drive sites based on the presence of surface level artifacts alone. The author expected that multiple time-diagnostic artifacts from more than one broadly defined period in prehistory should be represented at 5BL148, based on the large size of the site and the fact that most other alpine game drives show evidence for reoccupation based on projectile point typologies.

Table 3. Relative chronological span of published alpine game drives in Colorado based on projectile point typologies.

Game Drive	Paleoind.[1]	Early Archaic[2]	Middle Archaic[3]	Late Archaic[4]	Late Prehist.[5]	Reference
Murray (5BL65)					X	Benedict 1975a
Hungry Whistler (5BL67)		X	X		X	Benedict and Olson 1978
5BL68		X			X	Benedict 1975b
Bob Lake (5BL127)				X	X	Benedict and Cassells 2000
Olson (5BL147)		X	X	X	X	LaBelle and Pelton 2013
Devils Thumb V. (5BL3440)	X	X			X	Benedict 2000
Waterdog Divide (5CF373)		X	X	X	X	Hutchinson 1990
5GA35,36,37		X	X	X	X	Whittenburg 2017
Sawtooth (5GA55)			X	X	X	Cassells 1995
Flattop Mountain (5LR6)	X	X	X	X	X	Benedict 1996
Trail Ridge (5LR15)	X				X	Benedict 1996
Mount Ida (5LR1089)	X		X	X	X	Benedict 1987

[1] Paleoindian era (10000 - 5550 BCE), Chenault (1999:Table 3)
[2] Early Archaic period (5550 - 3000 BCE), Chenault (1999:Table 3)
[3] Middle Archaic period (3000 - 1000 BCE), Chenault (1999:Table 3)
[4] Late Archaic period (1000 BCE – CE 150), Chenault (1999:Table 3)
[5] Late Prehistoric era (CE 150 – 1540), Chenault (1999:Table 3)

Table 4. Projectile point types recognized at one or more alpine game drives in the CFR, and corresponding regional age-ranges from excavated contexts in the CFR.

Point Type	Era/Period	Form	Regional Age (BCE, CE)	Reference
James Allen	Paleoindian	Spear/dart	6460-4960[1] BCE	Benedict 1981, 1985; Pitblado 2000
Mount Albion	E. Archaic	Dart	4650-4220 BCE	Benedict 2012; Benedict and Olson 1978
Oxbow	E. Archaic	Dart	4000-3220 BCE	LaBelle and Pelton 2013; Todd et al. 2001
Duncan/Hanna	M. Archaic	Dart	3400-1000 BCE	Benedict 1981, 1990; Cassells 1995
Yonkee	M. Archaic	Dart	1370-950 BCE	LaBelle and Pelton 2013; Todd et al. 2001
Elko Corner-notched	M. Archaic	Dart	1265-1070 BCE	Benedict 1996; Benedict 1979; Frison 1991
Pelican Lake	L. Archaic	Dart	1250 BCE - CE 230	LaBelle and Pelton 2013; Todd et al. 2001
Hogback Corner-notched	L. Prehist.	Arrow	CE 600 -1000	Benedict 1975a, 1975b; Nelson 1971
Plains Side-notched	L. Prehist.	Arrow	CE 1100 - 1800	Gilmore 1999; Whittenburg 2017
Plains Tri-notched	L. Prehist.	Arrow	CE 1600 - 1800	LaBelle and Pelton 2013; Frison 1967

[1] The more recent date for the James Allen point type is from the Fourth of July Valley site (5BL120), a possible multi-component Allen/McKean locale (Benedict 1981), and is considered an interregional outlier.

The 5BL148 Artifact Assemblage

The artifact assemblage from 5BL148 is comprised of cultural materials collected during the CMPA's pedestrian surveys from 2012-2013 and 2017, and from excavations conducted by Byron Olson and James Benedict in the early 1970's (Olson and Benedict 1970, Olson 1971). Olson and Benedict excavated two hunting blinds at 5BL148 that contained cultural artifacts: Pit 190 and Pit 280. The spatial provenance of the excavated pits is unknown. Materials recovered from Pit 190 and Pit 280 include unmodified debitage (n=132), two edge-modified flake tools, a single projectile point tip, and a white glass seed bead of Euro-American origin, for a total of 136 artifacts. The surface artifact assemblage collected and recorded by the CMPA is comprised of edge-modified flake tools (n=7), unmodified lithic debris (n=6), several projectile points and point fragments (n=7), generalized bifacial tools (n=3), a single bifacial drill, and one end scraper, for a total of 25 surface collected artifacts. The CMPA recovered one unmodified flake during subsurface soil-core probe tests in feature number 5BL148.11, a hunting blind pit. In the sections following, artifacts are organized by type and are described by morphological and technological characteristics.

Projectile Points

Eight chipped stone projectile point fragments are discussed herein. None of the projectile tools in the assemblage are complete specimens, and several of the points exhibit identifiable impact fractures consistent with use as hunting weapon tips. Most points and point fragments in the collection are temporally non-diagnostic, meaning that there are little to no morphological attributes per point that ascribe a relationship to a known projectile style from a defined period in prehistory or history. Three projectile point fragments with relatively intact basal portions are used to discuss the relative occupation span of the 5BL148 game drive, and each of the points compare with stylized specimens from other game drives and excavated sites in the CFR. The Early Archaic (5500-3000 BCE), Middle Archaic (3000-1000 BCE), and Early Ceramic periods (CE 150-1000) are represented in the three projectile point specimens. Additional metric and descriptive attributes of all projectile tools are presented in Appendix A.

Diagnostic Projectile Points

2013.1 is a large, nearly complete corner-notched dart point made from a tan and red quartzite raw material (Figure 7). The point is incomplete due to a transverse snap-fracture that removed the distal end, a commonly recognized impact fracture type among broken points recovered from game drives and other types of hunting sites (LaBelle and Pelton 2013). 2013.1 is bifacially flaked and exhibits no remnants of a flake blank or cortical nodule surface. The base morphology is convex and ground, and the stem is upward expanding. The blade morphology is generally ovate and the blade shoulders are asymmetrical, with one shoulder being highly defined and the other being repaired and ground. Blade edges on 2013.1 are heavily rounded, suggesting further use of the point as a cutting and animal processing tool. The base morphology and blade shoulder characteristics are consistent with the Mount Albion type, an Early Archaic period form consistently documented at high-elevations throughout the CFR and at several significant alpine game drive sites in the region (Benedict 1978; Benedict and Olson 1978; LaBelle and Pelton 2013; Whittenburg 2017). Benedict (1978) first defined the Mount Albion type at the Hungry Whistler game drive (5BL67) and an adjacent processing campsite (5BL70) located in the CFR. Excavations at Hungry Whistler yielded 40 projectile point specimens of the Mount Albion type, demonstrating variable blade, notch, and blade shoulder morphologies but with a highly replicated point size and convex basal form. The Mount Albion projectile point type is regionally dated between 4650-4220 BCE (Benedict 2012; Benedict and Olson 1978; LaBelle and Pelton 2013), with examples of excavated and radiocarbon dated components at the Hungry Whistler and 5BL70 sites (Benedict and Olson 1978), and the Spotted Pony (5BL82) campsite (Benedict 2012).

2013.6 is a corner-notched dart point made from a yellow silicified wood raw material (Figure 7). The point is fractured along the lateral midline, with the distal tip portion snapped off. The base of the point is concave, and the stem expands upwards towards nearly symmetrical and highly defined blade shoulders. The blade outline morphology is straight to slightly ovate, and the lateral blade margins show some evidence for re-sharpening based on the presence of highly parallel but diminutive flake scars extending from the blade edges towards the midline of the tool. The Middle Archaic Duncan/Hanna point type provides an acceptable analogue for the 2013.6 specimen presented here. Examples of Duncan/Hanna projectile points are recognized from the Sawtooth Game Drive site (5GA55) in the Indian Peaks Wilderness (Cassells 1995, 2000:Figure 6.25), as well as the 5GA35 game drive site recently summarized by Whittenburg (2017:Figure 4.3). From regionally excavated contexts, Duncan/Hanna type points are documented at the Fourth of July Valley campsite (5BL120) in the Indian Peaks Wilderness and comparable forms are also recognized from the Coney Lake campsite (5BL94) (Benedict 1981, 1990). Other campsites with stemmed and concave-based projectile points and associated Middle Archaic-aged dates are known from the CFR, such as the Devil's Thumb Valley Hearth Site (5BL102), but the cultural/technological affiliations presented by the authors are more so indicative of hunter-gatherer groups from the Colorado Plateau and Great Basin as opposed to the Southern Rockies or eastern Plains (Kindig 2000).The Duncan/Hanna point type is regionally dated between 3400-1000 BCE (Benedict 1981; Cassells 1995, 2000; Larmore 2002; Whittenburg 2017). The completeness of 2013.6 is unlike most other specimens of similar typology found at high elevation game drives due to the mostly intact basal portion and blade edges (Benedict and Olson 1973:324; Cassells 2000: 207-210; Whittenburg 2017:50-51).

2017.7 is a proximal-midsection of a small corner-notched arrow point, made from a red and brown chert raw material (Figure 7). The point exhibits snap fractures at the extent of the base below the notching area, as well as the distal tip. The neck or stem of the point is very narrow and terminates at heavily arcing blade shoulders. The blade morphology of the point is generally straight, and the blade margins exhibit a mild to moderate serration, predominantly on one of the blade margins. The morphology of the 2017.7 projectile point is highly consistent with a nearly ubiquitous arrow point form found at CFR game drives, known as the Hogback Corner-notched point of the Early Ceramic period in the Late Prehistoric era (Benedict 1975a; LaBelle and Pelton 2013; Nelson 1971). In terms of frequency, Hogback Corner-notched projectile points dominate most projectile point assemblages from published game drives in the Southern Rockies (Meyer 2018). Nelson (1971) defined the type specimen at the Lindsay Ranch site, an Early Ceramic residential occupation in the foothills east of the CFR. High altitude excavations at the Murray Game Drive (5BL65) in the Indian Peaks recovered numerous Hogback Corner-notched points from a single hunting blind pit (Benedict 1975a), and the nearby Scratching Deer campsite also produced several comparable point specimens (Benedict 1975b). The Hogback-Corner notched point type is regionally dated between CE 150-1000 (Benedict 1975a, 1975b; Nelson 1971).

Table 5. Descriptive morphological attributes of diagnostic projectile points from the 5BL148 surface assemblage.

Specimen Number	Point Type	Form	Notch Type	Base Shape	Blade Shape	Cross-section
2013.3	Mt. Albion	Dart	Corner	Convex	Ovate	Bi-convex
2013.6	Duncan/Hanna	Dart	Corner	Indented	Straight	Bi-convex
2017.7	Hogback Corner-notched	Arrow	Corner	Straight	Straight	Plano-convex

Figure 7. Diagnostic projectile points in the surface collection from 5BL148. Scale in centimeters. Left to right: Early Archaic Mt. Albion projectile point, Middle Archaic Duncan/Hanna projectile point, Early Ceramic/Late Prehistoric Hogback Corner-notched projectile point.

Non-diagnostic Projectile Points

1970.5 is a distal portion of a projectile point made from a clear chalcedony raw material, with cloudy white inclusions (Figure 8). 1970.5 is the only formal chipped stone tool recovered from excavated contexts at 5BL148, during hunting blind excavations in Pit 280. The tip is indicative of a transverse snap fracture that initiated during use of the bifacial tool as a hunting weapon tip, but the deposition of the tip in the hunting blind pit could also suggest that tool shaping and maintenance processes are an equally possible cause for biface tip breakage and discard. Projectile point and tool resharpening events are documented in hunting blind pits at other game drives in the CFR (Benedict 1975a; Cassells 1995; LaBelle and Pelton 2013; Whittenburg 2017). Its longitudinal cross-section is plano-convex, and the outline shape of the blade margins is straight though largely incomplete. The tip is considered a portion of a projectile point, rather than a generalized biface or other specialized bifacial tool, on the presence of its narrow thickness and blade symmetry.

2013.3 is a near-complete corner-notched projectile point made from a white chert raw material (Figure 8). The distal tip and proximal extent of the base of the projectile point are missing, but the blade morphology and shoulders are intact. The blade outline shape is described here as triangular to slightly excurvate, and the shoulders are highly pronounced and contract sharply towards a narrow stem. The morphology of the point is consistent with other known styles recognized at high altitudes along the CFR, known only as Park points, but the typology is undated in the Colorado mountains and is thus non-diagnostic of time (Benedict 1981:30; Stewart 1970). Examples of Park points are in collections from hunter-gatherer campsites in the Fourth of July Valley in the Indian Peaks Wilderness (5BL166) (Benedict 1981:Figure 20), and the Devil’s Thumb Trail Site (5BL6904) (Kindig 1997; Tate 1999). Tate (1999:95) estimates that Park points are Middle Archaic in age, but there are no excavated or dated sites with intact components bearing Park points in Colorado. The LoDaisKa site (5JF142) assemblage contains one possible Park point (specimen 60-64), but radiocarbon dates of Middle Archaic layers (1885-868 cal BCE and 2200-1219 cal BCE) are complicated by multiple specimens including McKean point types (Irwin and Irwin 1959; Stewart 1970; Tate 1999).

2013.4 is a large midsection of a projectile point made of a white and tan chert raw material (Figure 8). Snap or bend-break fractures removed an ear from the proximal basal portion of the point, the very distal tip, as well as sections of both blade shoulders of 5BL.148.2013.4. Intact blade segments on the point demonstrate a straight to slightly excurvate blade shape for the point. A small portion of the base remains, which shows a convex outline form and it is unground. The narrow stem and blade shape are like Park points, previously described for 2013.3, but the demonstrated morphology and heavily fragmented characteristics of 2013.4 are non-diagnostic of time.

2013.7 and 2017.16 are small, non-diagnostic midsections of projectile points (Figure 8). Each of the midsections are considered fragments of projectile points, rather than other formal bifacial tools, based upon the diminutive width and thickness measurements, as well as symmetrical appearances. The 2013.7 point fragment is made from a tan and pink chert raw material, and shows what remains of a straight to slightly ovate blade outline shape, as well as a diagonally oriented flaking pattern. A single remnant portion of a notching area, on one side of the 2013.7 projectile point, is present. The 2017.16 projectile point is made from a red chert raw material and the blade shape of intact edge margins is ovate. The blade edges of 2017.16 are mildly serrated, and the longitudinal cross-section of the point is highly bi-convex or lenticular. No other morphological attributes of the 2017.16 projectile point are intact.

Table 6. Descriptive morphological attributes of non-diagnostic projectile points from the 5BL148 lithic assemblage.

Specimen Number	Point Type	Form	Notch Type	Base Shape	Blade Shape	Cross-section
1970.5	Non-diagnostic	?	?	?	Straight	Plano-convex
2013.3	“Park”; non-diagnostic	Dart	Corner	Straight	Excurvate	Bi-convex
2013.4	“Park”; non-diagnostic	Dart	Corner	Convex	Excurvate	Bi-convex
2013.7	Non-diagnostic	?	Corner	?	Straight	Bi-convex
2016.16	Non-diagnostic	?	?	?	Ovate	Bi-convex

Figure 8. Non-diagnostic projectile points from excavated and surface contexts at 5BL148. Scale in centimeters.

Hafted Bifacial Drill

The drill tool class described in this section is a specifically prepared bifacial tool with an intended function of drilling and or piercing/perforating items such as animal hide, wood, and/or perhaps jewelry. Only one artifact collected from the 5BL148 site is considered a formerly shaped drill tool. 2013.2 is a bifacial drill with a partially fractured expanding base and missing distal tip, made from a dark brown chert raw material (Figure 9). The shoulders of the expanding base are highly symmetrical, broad, and unground. The intact proximal portion of the bit or distal end of the drill exhibits a diamond shaped cross-section consistent with bifacial shaping reduction techniques. The narrow distal end of the drill is fractured and missing, potentially initiated from drilling or perforating processes, and the breakage observed is the likely reason for discard. Drill fragments are documented from other game drives in the CFR (Benedict 1975a), including an associated campsite (5GA48) in close proximity to the 5GA35, 5GA36, and 5GA37 game drive cluster at Rollins Pass (Whittenburg 2017:Figure 4.13). However, the drill form exhibited in 2013.2 is non-diagnostic of time. It is described here as prehistoric in age, and

Native American in cultural affiliation. Additional metric and descriptive attributes of the hafted bifacial drill are presented in Appendix A.

Table 7. Descriptive morphological attributes of the single drill specimen from the 5BL148 lithic assemblage.

Specimen Number	Drill Type	Reduction	Hafted?	Base Shape	Bit Shape	Cross-section
2013.2	Expanding base	Bifacial	Yes	Expanding	Straight	Diamond-shaped

Figure 9. Hafted bifacial drill recovered from surface contexts at 5BL148. Scale in centimeters.

Unhafted Bifacial Tools

The unhafted bifacial tool class described herein consists of generalized bifacial forms that are formally shaped but are not identified as being specifically prepared or reduced to serve a specialized function within a hafted element, or are too fragmentary to determine the presence or absence of hafting preparation (Figure 10). Unlike projectile points and drills, previously described, the tool category defined in this section consists of nondescript bifacially flaked artifacts that may have served multiple functions, such as cutting, sawing, and even scraping (Andrefsky 2005:180-181; Kelly 1988; Odell 1981). The fragmentary nature of the tools and their generalized forms do not retain any identifiable time diagnostic attributes, though they can be reasonably assumed as prehistoric in age and Native American in cultural affiliation. Additional metric and descriptive attributes of unhafted bifacial tools are presented in Appendix A.

2012.1 is the only chipped stone tool collected by the CMPA during the 2012 field season. It is a distal-midsection of a large bifacial tool manufactured from a fine-grained gray quartzite raw material. The specimen is finely flaked and exhibits a diagonally oriented flaking pattern, and the intact blade margin is acutely resharpened and ovate in outline from. A remnant portion of the dorsal surface of a large flake exists on one side of the biface, providing evidence that the original flintknapper manufactured the 2012.1 biface from a large quartzite flake blank. The plano-convex longitudinal cross-section of the tool further suggests its reduction from a large flake blank. The large size of the tool and its fine shaping characteristics supports that the implement likely served as a bifacial knife, used for animal processing and butchery. 2012.1 is a nearly-completely thinned biface, indicative of a finished tool in terms of reduction terminology (Andrefsky 2005:Table 7.7; Callahan 1974, 1979). The CMPA field crew identified 2012.1 inside wall stones in feature number 55A, a large stone wall alignment located in the central portion of the site.

2013.5 is a mid-stage and unbroken bifacial tool made from a tan chert raw material. The biface is determined to be mid-stage based upon the remaining cortex, square edges, and the minimal number of thinning flake scars that extend across the midline of the artifact. The biface roughly compares to Stage 2 and Stage 3 bifaces in terms of reduction terminology, as described by Andrefsky (2005:189) and Callahan (1974, 1979). The bi-convex or lenticular cross-section of the tool is consistent with bifacial reduction in mid-stages. Evidence for platform crushing, from hard-hammer percussion techniques, is pronounced on one of the blade margins suggesting that the quality of the tool stone type contributed to its fracture characteristics and discard.

2017.8 is an early stage bifacial tool made from a gray silicified wood raw material. The biface roughly compares to Stage 2 bifaces described by Andrefsky (2005) and shows some outline regularization and thinning, but it is mostly shaped by marginal flaking. The tool is incomplete, as demonstrated by proximal and distal snap fractures. The biface exhibits a lenticular or bi-convex longitudinal cross-section form, but no other morphological attributes of the tool are identifiable due to its fragmentary status.

Table 8. Descriptive morphological attributes of unhafted bifaces from the 5BL148 lithic assemblage.

Specimen Number	Biface Stage	Functional Type	Portion	Blade Shape	Cross-section
2012.1	Stage 5; finished	Knife	Midsection	Ovate	Plano-convex
2013.5	Stage 2-3; edged, some thinning	Unfinished	Corner	Ovate	Bi-convex
2017.8	Stage 2; edged	Unfinished	Corner	Ovate	Bi-convex

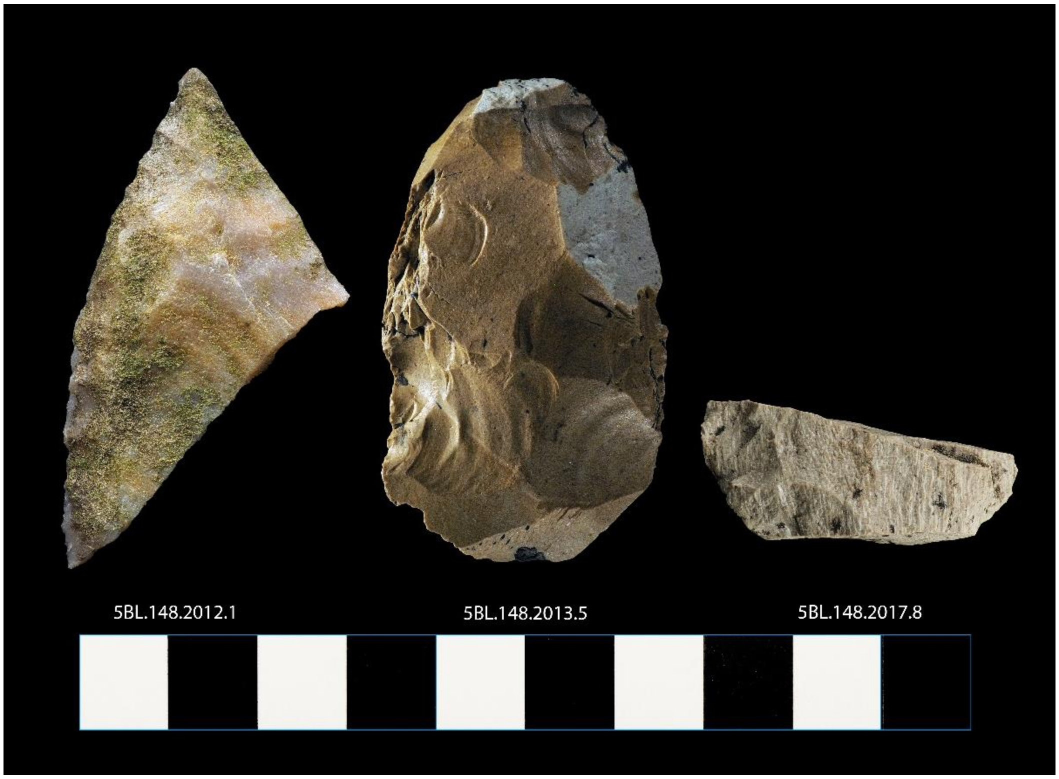

Figure 10. Unhafted bifaces recovered from surface contexts at 5BL148. Scale in centimeters.

Unhafted Flake Tools

Eight specimens in the 5BL148 lithic assemblage are unhafted flake tools. One specimen is a formally reduced end scraper tool manufactured from a thin flake blank, and seven informally modified and utilized debitage pieces are also present. Each of the specimens described herein show evidence for use in scraping or cutting functions, based upon the observation of edge-rounding and step fracturing on distal and lateral edge margins. Raw material types vary across all specimens, and the representative size classes of modified flakes and the presence of cortex on some specimens are indicative of early to late stage lithic reduction episodes. Additional metric and descriptive attributes of unhafted flake tools are presented in Appendix A.

End Scraper

The end scraper tool class described here is a formerly shaped flake tool with distally oriented edge margins that show evidence for unifacial and steep pressure flaking modifications on the dorsal surface, with a ventral flake surface that is largely unmodified. One artifact in the collection from 5BL148 is classified as an end scraper, specimen 2017.1, which is a nearly complete tool manufactured on a white to translucent chert raw material. The end scraper is not worked along the proximal or lateral portions, nor is it ground, suggesting that the tool is non-hafted. However, the proximal end of the flake is mildly fractured, as indicated by the absent bulb of percussion and the missing platform area. The distal portion of the scraper exhibits patterned edge working and steepened edge modifications, and cortex is present along the dorsal surface of the flake tool near its distal end suggesting that the flintknapper reduced the flake from a chert core relatively early in the nodule decortication process (Figure 11).

Table 9. Descriptive morphological attributes of the single end scraper from the 5BL148 lithic assemblage.

Specimen Number	Tool type	Flake Type	Portion	Modification	Cortex	Use-wear
2017.1	End scraper	Core reduction	Distal	Pressure flaking	Present	Edge rounding

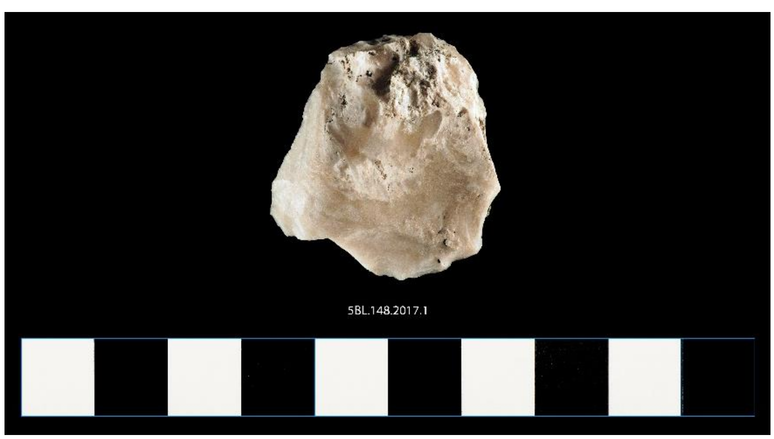

Figure 11. Unhafted end scraper recovered from surface contexts at 5BL148. Scale in centimeters.

Edge-modified and Utilized Debitage

Retouched and utilized flakes are the second most dominant tool class recognized in the 5BL148 site collection (Figure 12). Edge-utilized debitage are not formerly shaped or worked, but show some evidence for use in the form of edge rounding, step fracturing, and edge chipping. Edge-retouched specimens show evidence for formal lithic reduction episodes, a process used to resharpen edges for prepared functional use. Generally, the tools in this category fall under a unimarginal classification, in which only one surface of the tool (dorsal or ventral) show modifications regardless of the relative position of the worked or used area (Andrefsky 2005).

1970.1 is an edge-modified flake manufactured from a white chert raw material. Olson and Benedict (1971) recovered the flake tool during excavations in Pit 190, along with several other artifacts. The flake tool shows unimarginal retouch flake scars along the ventral flake surface, concentrated nearest the platform where the flake was terminated in initial core reduction, but some flake scars also extend from lateral edge margins towards the center of the flake. The distal end of the tool is missing due to a hinge fracture.

1970.6 is a proximal portion of an edge-modified flake tool manufactured from a translucent chalcedony raw material. The tool is broken due to a snap fracture initiated near the midline of the chalcedony flake. Small flake scars and chipping is visible on the dorsal surface of the flake, and the lateral edges are mildly rounded. Olson and Benedict (1971) recovered the tool during excavations in Pit 280, a blind of unknown provenience.

2017.4 is a bifacial thinning flake made from a yellow chert raw material. Multiple thin flake scars are visible on the dorsal surface, trending in a perpendicular orientation from the distal end of the flake. The thinning flake is considered a utilized flake tool based upon the edge-rounding of the distal end and minor edge chipping. The platform area of the flake tool is missing, due to a snap fracture.

2017.5 is an edge-utilized flake tool made from a fine-grained gray quartzite raw material. The tool is a midsection of a broken flake, where the distal and proximal portions are missing. The lateral margins of the flake tool are rounded and chipped, suggesting that both edges served for cutting and/or scraping functions.

2017.9 is an edge-modified flake tool made from a red and brown chert raw material. The tool is an incomplete flake fragment, with two transverse snap fractures at the proximal and distal ends. The ventral surface of the tool shows that one of the edge margins is acutely pressure flaked or retouched, with narrow and parallel flake scars extending along the unbroken edge portion. Some rounding is also present along the opposite edge of the tool.

2017.14 is a retouched fragment of angular debris, made from a translucent chalcedony raw material. The dorsal surface of the angular debris shows the remnant cortical surface of the raw material nodule, which is porous and white. Small step fractures occur along the worked edge of the tool, indicating use-wear.

2017.15 is a retouched midsection of a bifacial thinning flake, which is broken along its proximal and distal portions. The tool is made of a cloudy white chert raw material. The dorsal surface of the tool shows broadly spaced pressure flakes along one lateral margin, and edge-rounding accompanies the retouched area which may indicate use wear.

Table 10. Descriptive morphological attributes of edge-modified and utilized flakes from the 5BL148 lithic assemblage.

Specimen Number	Tool type	Flake Type	Portion	Modification	Cortex	Use-wear
1970.1	Modified flake	Core reduction	Distal	Pressure flaking	Absent	Edge rounding
1970.6	Modified flake	Core reduction	Proximal	Pressure flaking	Absent	Edge chipping
2017.4	Utilized flake	Bifacial thinning	Distal	None	Absent	Edge rounding
2017.5	Utilized flake	Core reduction	Midsection	None	Absent	Edge rounding
2017.9	Modified flake	Uncertain	Midsection	Pressure flaking	Absent	Edge rounding
2017.14	Modified flake	Core reduction	Complete	Pressure flaking	Present	Step fractures
2017.15	Modified flake	Bifacial thinning	Midsection	Pressure flaking	Absent	Edge rounding

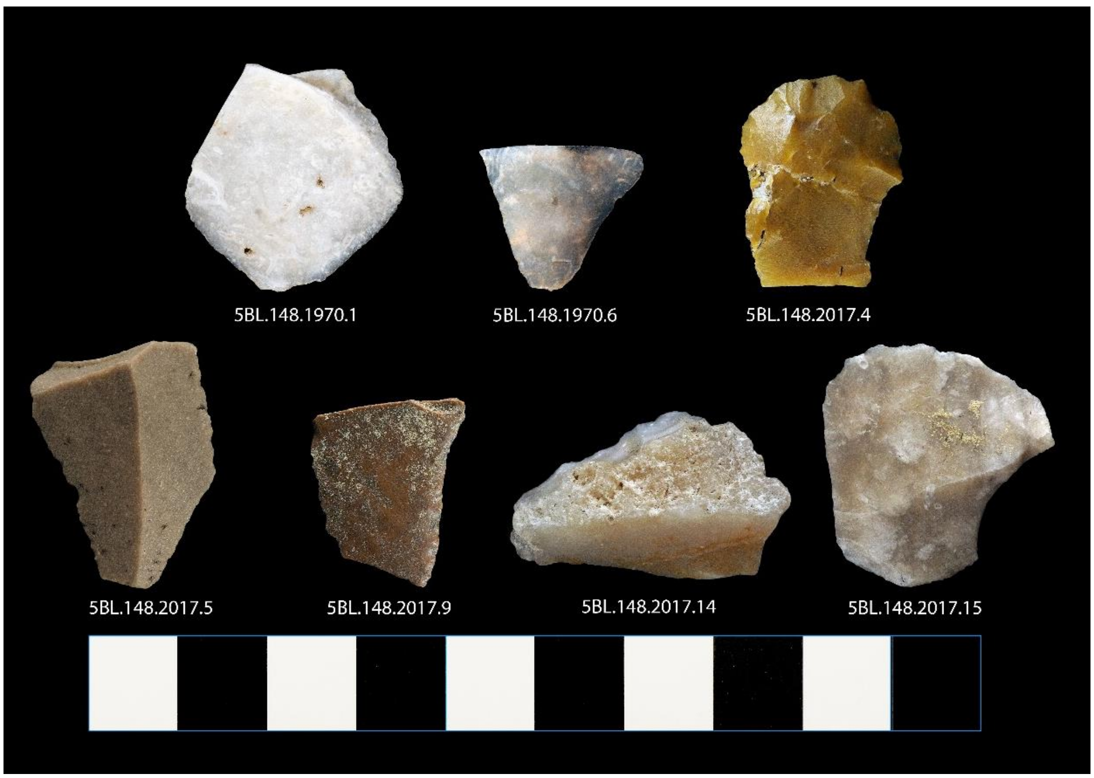

Figure 12. Edge-modified and utilized flakes recovered from excavated and surface contexts at 5BL148. Scale in centimeters.

Unmodified Debitage

The remainder of chipped stone artifacts collected from the 5BL148 game drive are classified as unmodified debitage, consisting of lithic reduction debris that is not visibly retouched or used. Flakes constitute the majority of the unmodified debitage (n=138), as identified by one or more morphological characteristics such as a platform, bulb of percussion, eraillure flake scar, or ripples along the ventral surface (Andrefsky 1994, 2005; Sullivan and Rozen 1985). An unmodified angular debris fragment is also recorded in the assemblage. None of the debitage exhibit cortex. The paucity of debitage with cortex suggests that early stage lithic reduction is underrepresented and did not serve as a primary function of the site.

Of the 138 flakes recorded in the assemblage, 129 of those flakes are collected from a hunting blind of unknown provenience (Pit 280). Olson and Benedict (1971) recovered flake specimens numbered 1970.8 through 1970.136 during partial excavation of Pit 280. The flakes are comprised of three varieties of raw material; a gray chert (n=31), a translucent chalcedony (n=96), and a white chert (n=2). A comparative collection of nodules from the Troublesome Formation in Middle Park, on file with the CMPA, shows that each of the color varieties in Troublesome Formation nodules are represented in the flake assemblage from Pit 280, indicating that each of the flakes could be derived from a single objective piece. The data show that the mean size class (maximum length or width) of flakes recovered from Pit 280 is between three and four millimeters. The size class of flakes suggests that tool resharpening events are the primary cause of flake discard in Pit 280. As stated earlier in this chapter, tool resharpening events are documented at other game drive sites in the CFR (Benedict 1975a; Cassells 1995; LaBelle and Pelton 2013; Whittenburg 2017).

Three unmodified flakes are recorded from Pit 190, another hunting blind location of unknown provenience. Flake specimens 1970.2-1970.4 consist of two raw material types, a white chert (n=2) and a red chert (n=1). The white chert raw material is visually and texturally comparable to nodules from the Troublesome Formation in Middle Park. The red chert material is not indicative of a specific source formation by comparison to raw material nodules in the

CMPA lithic library, but it is the expectation of the author that the toolstone likely represents an intermountain variety. A summary of the descriptive and metric attributes of the unmodified flakes from Pit 190 are available in Table 11.

Six unmodified flakes are of known provenience, mapped and collected by the CMPA during the 2017 field season at 5BL148. Five of the flakes are collected from the surface and are manufactured from a gray quartzite raw material. One of the flakes, 2017.17, is the byproduct of a tan quartzite raw material nodule. The author collected the 2017.17 flake during the waterscreening process of a sediment core sample conducted in a hunting blind, feature number 5BL148.11. Additional metric and descriptive attributes of all unmodified debitage specimens are presented in Appendix A.

Table 11. Summary of metric attributes of unmodified debitage from the 5BL148 lithic assemblage.

Context	Debitage Frequency	Average Length (mm)	Average Width (mm)	Average Thickness (mm)
Blind, Pit 190	3	12.7	15.9	2.1
Blind, Pit 280	129	3.9	3.2	0.5
Blind, 148.11	1	5.7	4.1	0.6
Surface	5	21.0	17.1	4.3

Figure 13. Unmodified debitage recovered from excavated contexts at 5BL148. Scale in centimeters.

Euro-American Bead

Olson and Benedict (1971) recovered a single Protohistoric or Historic period artifact during the partial excavation of Pit 280. The artifact is a small white glass seed bead, measuring less than 2 millimeters in length and thickness (Figure 14). The glass bead indicates a Protohistoric period occupation of the 5BL148 game drive, sometime after CE 1835 (LaBelle and Pelton 2013:57). A trade bead chronology conducted by Von Wedell (2011: Table 6.1) suggests that the seed bead may have been manufactured close to CE 1850. However, a cross-regional chronology of Protohistoric bead types presented by Newton (2016:Table 6) in reference to Northern Plains contact era sites shows that small white seed beads appear in radiocarbon dated assemblages between CE 1777 to 1885, with a mean age of CE 1835. Glass seed beads are the dominant type of bead traded to Native American groups following the onset of the North American fur trade in the 16th century (Von Wedell 2011), as smaller beads could be sold to Native American groups in high quantity bundles for cheaper prices than larger types of glass beads. White seed beads, such as 1970.7, are manufactured by a drawing process where long tubes of glass are broken into individual sections of desired length (Von Wedell 2011). Comparable examples of diminutive white seed bead styles are documented at the Lykins Valley site (5LR263) and the Weinmeister site (5LR12174) in Larimer County (Anderson 2012; Newton 2008, 2016; Von Wedell 2011:Figure 4.2). Euro-American groups established regional trading posts in the immediacy of the South Platte River drainage in the mid-1830's CE (Newton 2008).

Figure 14. Euro-American white seed bead recovered from Pit 280 at 5BL148. Scale in millimeters.

Chipped Stone Summary

Twenty chipped stone tools are documented from surface and subsurface contexts, but 95 percent of tools at 5BL148 are mapped and collected from surface contexts. Chipped stone tool types at 5BL148 include complete and fragmentary projectile points, a hafted drill, generalized bifacial implements, a single scraper tool, and several formal/informal flake tools (Figure 15). The most dominant tool class in the lithic assemblage is projectile points (n=8, 40% of all tools), followed closely by modified flake tools (n=7, 35% of all tools). Other classes of tools present in the assemblage that are underrepresented in terms of frequency are hafted bifacial drills (n=1), general bifaces (n=3), and formal scrapers (n=1).

The diverse representation of tools at 5BL148 suggests that multiple types of activities occurred. Broken projectile points are a commonly recognized discarded tool class at alpine hunting sites do to their use as hunting weapon tips (Benedict 1975a, 1987, 1992, 1996; Cassells 1995; Hutchinson 1990; LaBelle and Pelton 2013; Whittenburg 2017). Projectile points are also argued as primary butchering tools at some hunting sites do to the occurrence of edge-rounding and step-fracturing along blade edges (Benedict 1978; Olson and Benedict 1978).

Informal/formal flake tools and bifacial knives, which demonstrate similar use-wear characteristics in comparison to points at 5BL148, are documented as primary butchering implements at hunting sites in the CFR, though intensive animal processing likely occurred at secondary camp locations (Benedict 1992; LaBelle and Pelton 2013). Hafted bifacial drills and scrapers are affiliated with post-hunt animal processing activities, and while these two artifact classes are underrepresented in the assemblage, the occurrence of secondary processing tools suggests that hunter-gatherers performed some non-hunting specific tasks on-site at 5BL148. All tool types at 5BL148 share attributes in breakage patterns and macroscopic use-wear characteristics. Complete tools are underrepresented in comparison to broken portions (n=19, 95%), suggesting that the primary explanation of discard is breakage from either functional use or repair. In particular, the dominance of midsections over other portion classes supports that hunter-gatherer groups discarded exhausted tools that could no longer be maintained (n=11, 55%). There are many factors that support varying arguments for tool discard and curation within intermountain subsistence-settlement regimes (Bamforth 2006; Benedict 1992; Black 1991, 2000; Whittenburg 2017), such as distance to raw material source and effective hunter-gatherer group mobility range, but these factors are beyond the immediate scope of this thesis.

Unmodified debitage is also present onsite at 5BL148, and the majority of recorded debitage pieces are from excavated contexts in two blinds of unknown provenience (Pit 190 and Pit 280, n=132). Chipped stone flakes and angular debris mapped by the CMPA comprise less than 7 percent of the entire debitage assemblage at 5BL148 (n=6). Debitage of known provenience are collected primarily from the surface level of the site, but the CMPA did collect a flake during soil-core probe tests of blind feature number 5BL148.11 (Blind 11). There are two modes of lithic reduction that characterize flake debris at the 5BL148 game drive (Figure 16), based upon a size classification of the debitage assemblage. Thickness and length are appropriate variables to estimate flake size class (Andrefksy 2005:102). Proportionally, the assemblage consists primarily of tool resharpening waste flakes from Pit 280 (n=129, 93%), but a single resharpening flake from Pit 190 (n=1) and one from Blind 11 are also present. Flakes of a slightly larger size class (greater than 10 mm in length and 2 mm thickness) show evidence for tool production and shaping activities in contrast to tool maintenance tasks. Tool production/shaping flakes are primarily recorded from surface contexts at 5BL148, suggesting that the two modes of lithic reduction present at the site are functionally and contextually separated.

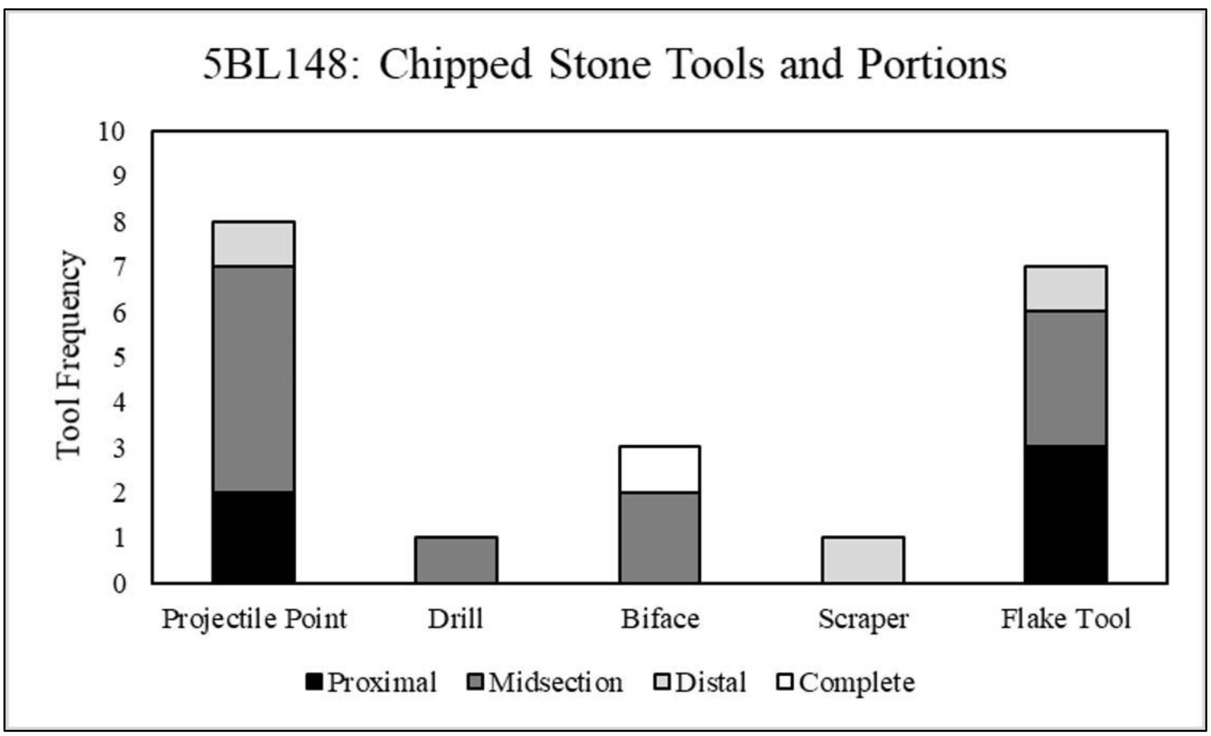

Figure 15. Summary bar chart depicting tool frequencies and tool types in the 5BL148 lithic assemblage.

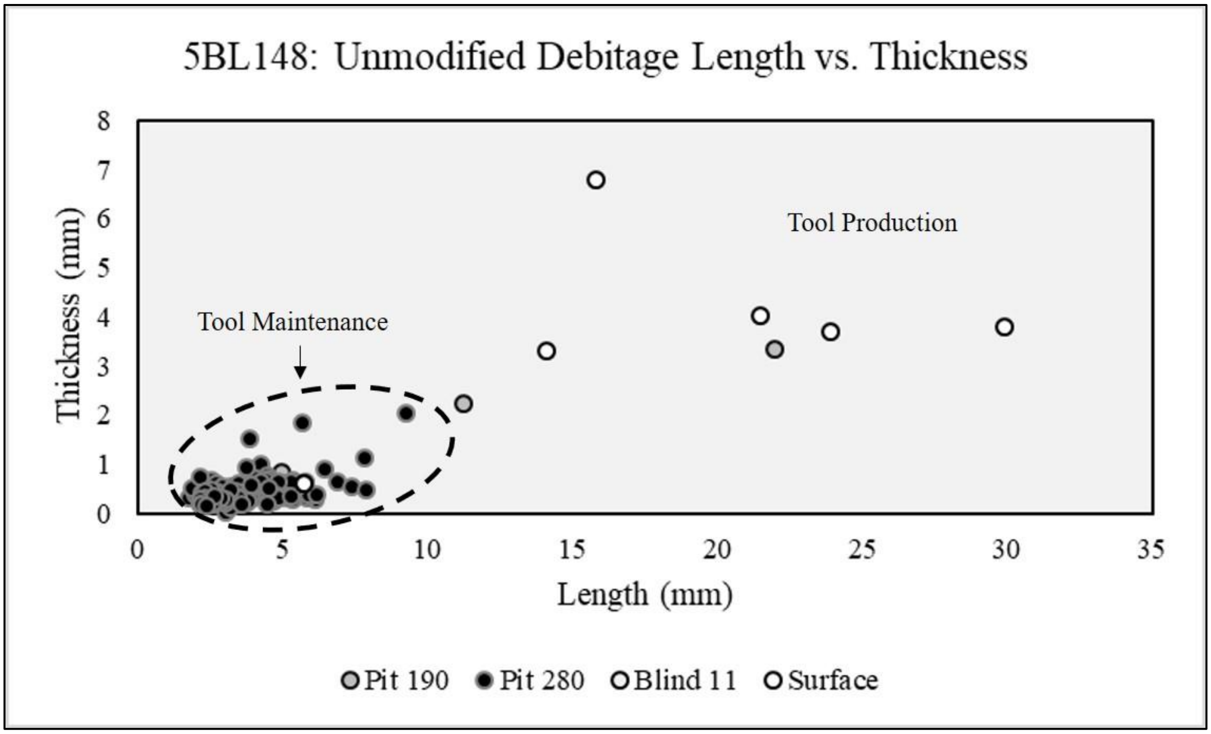

Figure 16. Summary scatterplot depicting the maximum length and thickness of lithic debitage from 5BL148.

Relative Dating Discussion and Conclusion

The artifact assemblage from 5BL148 contains a low frequency of surface materials, in comparison to other game drive sites surveyed by the CMPA at Rollins Pass (LaBelle and Pelton 2013; Whittenburg 2017). In addition to the spatial limitations of the CMPA's intensive survey coverage at 5BL148 during the 2017 field season, as well as factors limiting surface visibility such as patchy vegetation and sodding near features, there are other potential factors that could contribute to the observed paucity of surface level artifacts. 5BL148 is the located adjacent to the routes of a historic wagon road and railroad (LaBelle and Pelton 2013; Whittenburg 2017; Wright and Wright 2018), and it is the closest of the game drives to the Corona rail station and lodge at the Rollins Pass saddle. It is possible, but not proven, that historic artifact collecting during visits to Rollins Pass by historic period tourists and workers is a possible explanation for the lack of surface artifacts at 5BL148.

Time-diagnostic artifacts recovered from the 5BL148 game drive site include three chipped stone projectile points and a Euro-American trade bead. In terms of frequency, diagnostic artifacts in the assemblage comprise less than 3 percent of the complete artifact collection from the site (4 out of 162 total artifacts). Associated spatial data for artifacts are needed to address the presence or absence of spatially distinct occupation episodes at 5BL148 during any given time in prehistory or history, but the diagnostic artifacts do provide a means to discuss the temporal range of activities across broadly defined periods in the past regardless of site function or specific activity area use.

Diagnostic projectile point types in the lithic assemblage at 5BL148 demonstrate the use of two different technological traditions that are temporally bounded in North American prehistory, the atlatl and dart and the bow and arrow (Blitz 1988; Gilmore 2008; Shott 1997). In the CFR, atlatl and dart technologies are firmly affiliated with the Paleoindian and Archaic eras (5550 BCE – CE 150), whereas bow and arrow technologies emerge with the onset of the Early Ceramic period and continue throughout the Late Prehistoric era (CE 150 – 1540) (Gilmore 1999, 2008). Two of the diagnostic projectile points are Archaic era dart points, including an Early Archaic period Mount Albion type specimen (2013.1) and a Middle Archaic period Duncan/Hanna point (2013.6). The presence of bow and arrow technologies are exemplified by the Hogback Corner-notched arrow point (2017.7), indicative of an Early Ceramic period occupation (CE 150 – 1150) in the Late Prehistoric era. Typological cross-dating between diagnostic projectile points in the 5BL148 assemblage and stylistically identical specimens from dated components in the CFR suggests an occupation span for 5BL148 ranging from 4650 BCE – CE 1150. In addition to the projectile point assemblage, the presence of a Euro-American glass bead from excavated contexts in Pit 280 suggests a Protohistoric era occupation, which extends the younger range of occupation span to approximately CE 1835-1850.

In terms of frequency of diagnostic artifacts, four different periods of prehistory and history are equally represented at 5BL148. The typological artifact data equate to an occupation span of more than 6,000 years (4650 BCE – CE 1850), but only one representative artifact for the Early Archaic, Middle Archaic, Late Prehistoric, and Protohistoric periods are present in the assemblage. Other chipped stone artifacts in the assemblage (n=157) do not contribute temporal information beyond a general prehistoric Native American affiliation. Two fragmentary Park points are documented in the non-diagnostic assemblage of projectiles at 5BL148 (2013.3 and 2013.4), and while estimations for a Middle Archaic affiliation are discussed in the archaeological literature (Anderson 1989:164-165; Stewart 1970; Tate 1999), there are no data driven estimations for the antiquity of Park points that are based on a specifically defined morphological style with accompanying dated components and stratigraphic integrity.

Other projectile points in the assemblage are too fragmentary to attribute a diagnostic cultural/technological complex. Formal bifacial tools as well as modified and unmodified lithic debris at 5BL148 do not present temporal information either, but instead contribute functional characteristics for the assemblage which aid in a spatially informed temporal reconstruction of the site. On the basis of prehistoric projectile points and protohistoric bead chronologies, evidence suggests Native American hunter-gatherer groups reoccupied the 5BL148 game drive site over the course of millennia and that a one-time occupation is not represented in the artifact assemblage. The following chapters in this thesis are dedicated to additional methods for estimating occupation span at 5BL148.

CHAPTER III – SIZE-FREQUENCY LICHENOMETRY AND WALL CONSTRUCTION

In this chapter, a statistical measure of the growth rate for yellow-subgenus *Rhizocarpon rhizocarpon* lichens is used to address the minimum age of stone wall feature construction at the 5BL148 game drive site. Descriptive characteristics of stone wall features are presented herein to aid in a holistic reconstruction of hunter-gatherer site activities and feature construction methods. In this chapter, the results of the lichenometric analysis on stone walls are used to discuss evidence for a one-time occupation versus evidence for multiple occupations at the site. The results of the analysis also contribute to a broader discussion on the spatial signatures of reoccupation at 5BL148, in consideration with other methods of measuring chronology applied in this thesis.

Theory and Methods in Lichenometry

It is difficult to reconstruct the temporal scale of archaeological sites in alpine tundra environments, due to constraints on the preservation of datable materials, the lack of stratigraphic control, and the ephemeral nature of most hunter-gatherer occupations in alpine tundra environments. Previous chronological tests at game drive sites in the alpine of the CFR necessitated the use of experimental geological methods (Albino 1984; Benedict 1967, 1975a, 1985, 1996, 2009; Cassells 1995; Hutchinson 1990), which pioneered ways of differentiating the age of glacial and periglacial processes from cultural developments related to site formation and prehistoric stone feature construction at alpine game drives.

In lichenometry, geologists and archaeologists use naturally occurring populations of lichens to derive the exposure age (or age of modification) of rock substrata and subsequent lichen colonization events, and the method is applied most commonly in high altitudes and along coastal environments (Benedict 2009; Bradwell 2004; Broadbent and Bergqvist 1986; Innes 1985). Though several species of lichens are good candidates for numeric dating of rock substrates, yellow *Rhizocarpon* species are the most commonly used as they are widespread, long-lived, colonize rapidly, and grow at slow, predictable rates (Benedict 2009; Figure 17).

There are many variations of lichenometry that are used for numerical dating such as maximum-diameter lichenometry (measuring the single largest thallus), taking the average of the five largest thalli, and other ways of measuring exceptionally large specimens within a population. However, maximum-diameter methods should only be used on substrates assumingly devoid of lichen growth prior to deposition or stabilization, such as glacial moraines (Benedict 2009). Archaeological sites are not known to be formed from such environments at high altitude. Game drive sites in the CFR are comprised of numerous stone features such as walls, blinds, and cairns, and it is assumed by previous researchers and the present author that these features are manufactured of locally available stones and boulders which maintained actively growing lichen colonies prior to stone feature construction events (Benedict 1967, 1975a, 1985, 1996, 2009; Cassells 1995; Hutchinson 1990). In other words, measuring the largest lichen on a stone feature could reflect the age of a survivor thallus from a pre-construction colonization event, rather than the age of lichen colonization after anthropogenic feature construction or modification events.

Size-frequency lichenometry is a statistical approach used by geologists and archaeologists to differentiate the growth patterns of new colonists and surviving lichens on stone features, and to estimate the age of a lichen population that grows on features by comparing thalli measurement data to a regional calibration curve that models the age of a growth pattern. However, there are methodological limitations to applying size-frequency lichenometry at alpine game drive sites. The method requires upwards of one-thousand or more thalli measurements per stone feature to adequately represent a sample population of lichen colonies, and thus the method is commonly limited to the largest stone wall features at game drives in Colorado (Benedict 2009). Size-frequency lichenometry is generally not used to estimate the age of stone cairns or hunting blinds at game drives, due to the fact that these types of features contain a low statistical sample of thalli. Previous studies in the CFR and elsewhere along the Continental Divide used size-frequency lichenometry to discuss the minimum age of stone wall feature construction events at game drives characterized by numerous large walls (Table 12), but some stone walls are too short to be dated with lichenometry (Benedict 1975b). One exceptional case is a study provided for the drive walls at the Sawtooth Game Drive (5GA55/5BL123) in the Indian Peaks Wilderness Area, where Cassells (1995) used size-frequency analysis on numerous stone walls of moderate to minimal length (some fewer than 100 meters). Statistical procedures, challenges of lichenometry applications at game drives, and the use of regional calibration curves for dating are reviewed in the following sections of this chapter.

The majority of all lichenometric dates from stone walls in the CFR reflect Late Prehistoric era occupations by hunter-gatherer groups (Table 12), primarily within the Early Ceramic period which is argued to coincide with an increase in regional population size throughout Colorado (Gilmore 1999, 2008; Mitchell 2008; Perlmutter 2015; Zier and Kalasz 1999). Several alpine game drive studies present lichenometric wall ages that support arguments for recurring feature modification and construction events of walls over centuries within the Early Ceramic period in some cases (Table 12). Game drive sites in Colorado that yield competing/different lichenometric dates on stone walls suggest that hunter-gatherer reoccupation events occurred, but most lichenometric dates from game drives are temporally confined within the Late Prehistoric era due to effects of mass snow-kill of lichens (Benedict 1991, 1993). It is hypothesized in previous lichenometric studies that hunter-gatherer groups undertook recurring modification and construction events to fine-tune the functionality of some game drives for enhanced hunting efficiency (Benedict 2009; Cassells 1995).

In this chapter, the four largest stone alignments at the 5BL148 game drive are analyzed via size-frequency lichenometry and the data are compared to a reconstructed CFR calibration curve to determine age estimates for stone features in calibrated years before present (cal BP), which is then converted to common era years (cal CE). It is the expectation of the author that differences in the predicted age of each wall subjected to size-frequency lichenometric analysis indicates time progressive construction and modification events at 5BL148, a phenomenon documented or inferred at other game drive sites in the CFR such as the Arapaho Pass game drive (5BL114) and the Sawtooth game drive (5GA55) (Benedict 1985, 1996; Cassells 1995; Table 12). Conversely, contemporaneous lichenometric ages for wall alignments at 5BL148 could instead reflect a single occupation, construction, or wall modification event at the site.

Table 12. Reported lichenometric dates from alpine game drives in Colorado with feature descriptions. Wall lengths labeled "NR" depict lengths that are not reported in the literature.

Game Drive Site	Wall	Wall Length (m); Thalli Frequency	Reported Age (CE, BP, or calBP)	Reference
Murray (5BL65)	1	NR; 2000	970 ± 100 BP	Benedict 1975a
Devil's Thumb Valley (5BL103)	1	NR; 1010	880 BP; CE 1270	Albino 1984; Benedict 2009
Arapaho Pass (5BL114)	D	NR; 600	1050 BP	Benedict 1985
	E	NR; 1000	830 BP	
	G	NR; 1500	800 BP	
	H	NR; 1000	780 BP	
	I	NR; 1500	850 BP	
Bob Lake (5BL127)	B	109; 626	1560 calBP	Benedict and Cassells 2000
Olson (5BL147)	1	NR; 1000	CE 655	LaBelle and Pelton 2013
	2	NR; 1000	CE 1125	
Waterdog Divide (5CF373)	3	600; 617	CE 1645	Hutchinson 1990
Sawtooth (5GA55)	1	64; 1000	CE 320	Cassells 1995
	2	172; 700	CE 190	
	3	434; 1000	CE 695	
	3A	70; 1000	CE 205	
	3B	101; 600	CE 600	
	4	43; 800	CE 825	
	5	74; 1000	CE 890	
	6	38; 1000	CE 705	
	8	49; 1000	CE 1150	
	10	151; 1000	CE 575	
	10B	102; 1000	CE 335	
	10C	59; 1000	CE 705	
Flattop Mountain (5LR6)	D	NR; 1000	785 calBP	Benedict 1996

Figure 17. Example of *Rhizocarpon rhizocarpon* thallus measured and photographed by Jim Benedict at Ouzel Lake, Rocky Mountain National Park.

Stone Wall Features and Thallus Samples

The author and CMPA collected metric data on large stone wall alignments and performed an intensive *Rhizocarpon rhizocarpon* measurement sampling protocol at the 5BL148 game drive site during the summer of 2017. Linear measurement data of stone walls aided in the feature selection protocol and conditioned expectations for the subsequent lichenometric analysis. The author selected the four largest stone wall alignments for lichenometry analysis on the basis that 1) the largest stone alignments provided the greatest probability of containing a sufficient lichen population size required for size-frequency analysis, and 2) the alignments are spatially and perhaps functionally differentiated from one another, and could represent wall construction events of different ages. The data collected for the size-frequency analysis aid in a holistic interpretation of occupation span at the site, but also contribute towards a spatially informed reconstruction of past occupation episodes at the 5BL148 game drive site.

Stone Wall Features

Olson and Benedict (1970) and Olson (1971) first summarized the extent and characteristics of stone wall features at the 5BL148 game drive during inaugural investigations at Rollins Pass, where the investigators mapped approximately 2,085 linear meters of low-lying rock wall alignments with an intensive theodolite mapping protocol. The walls consist of long and linear arrangements constructed of naturally available gneissic stones, sourced from the boulder fields, sorted nets, and rock veins found throughout the site. Georeferencing the plan map constructed by Olson and Benedict shows that there are 30 discontinuous (spatially distinct) segments of stone walls at 5BL148, but the close spatial proximity of several wall segments at the site alludes to the complex nature of site formation processes and the possibility of recurring modification events over time. Feature numbers are assigned by the author to contiguous and linear arrangements of stone walls at the site, but several of the wall features show adjoining segments providing difficulty for assigning some individual features a singular designation. The walls range in size, with the smallest being only 10 meters long and the largest extending to more than 250 meters in overall length. There is an evident discrepancy in the length of stone wall features. Most walls at 5BL148 are less than 100 meters long (n=23), only a few walls are minimally greater than 100 meters in length (n=3), and the remainder approach 200 meters or greater in length (n=4).

The walls at 5BL148 are of dry-laid construction and are generally no more than one to two stone courses in height (Figure 18), but some of the larger stone walls exhibit a greater magnitude of stacking nearest wall convergences and clusters of hunting blind features. Other game drive sites in the CFR exhibit a similar pattern in wall height near feature junction areas that form nearly perpendicular, v-shaped, or sometimes u-shaped intersections (Benedict 1975a, 1979, 1985, 1992; Cassells 1995; LaBelle and Pelton 2013; Whittenburg 2017), an observation that supports funneling of game into restricted intercept spaces (Benedict 1975a, 1979, 1992; LaBelle and Pelton 2013; Whittenburg 2017). The observation of wall convergences at 5BL148 contributes to a broader understanding of site function over time and game drive intercept zones. Stones used in construction of wall features at the site vary in size and shape, ranging from large and thin tabular pieces to small cobbles. Gneissic stones are immediately available for use as raw material for feature construction on the site surface (Young 1991). Wall features are spatially associated with the onsite periglacial rock arrangements (like sorted nets, hummocks, stripes, and polygons), and many of the larger wall segments trend immediately alongside sediment devoid (rock covered) slopes. Several wall segments link together different periglacial rock deposits at the site, suggesting that game drive functionality played heavily off the location of naturally occurring boulders and stones, but also the natural boundaries such as the nearby cliff edge.

Stone features at game drive sites are sometimes organized into classification schemes of types, dependent on the observed variability in feature compositions but also local environmental variables. Hutchinson (1990) developed descriptive characterizations of stone wall types at the Waterdog Divide game drive system at Monarch Pass, which provides a useful methodology to organize spatially complicated hunting systems. Hutchinson (1990: 64-65) classified five different types of stone wall features at Waterdog Divide, including contour walls, crest walls, direct drive walls, connecting walls, and sewel walls. This thesis does not assume rigid definitions of wall types, but rather accepts that variations in feature form likely co-occurs with local environmental variables. However, several of the wall trajectories and shapes at 5BL148 are roughly comparable to the classifications presented in Hutchinson (1990). Contour and crest walls are the longest wall types, and appear in a sinuous pattern which connect onsite tundra rock outcrops. Direct drive walls tend to be shorter in length, and often terminate directly into hunting blind features. Connecting walls are also shorter than contour or crest walls, but are more often located at the lowest portions of a game drive site and are aligned in u-shapes which are similar in form to some interregional corral-type hunting sites (Frison 1987; Lubinski 1999; Wilke 2013). At the Waterdog Divide game drive, sewel walls are features that contain remnants of wooden branch post which likely served to provide both hunter concealment and visual impediments for game wall funneling lanes (Hutchinson 1990). No wood fragments are documented in wall features at 5BL148, or at other sites at Rollins Pass.

Rather than classifying each wall feature by its possible type at 5BL148, the author instead proposes a broad functional description for walls based upon the observed trajectories of walls and overall lengths of walls. The longest walls at the site, which connect onsite tundra rock outcrops, likely provided the greatest directional routing for animals navigating the game drive system. The shortest walls onsite are either 1) linear segments that are marginally separated by onsite rock fields, which functioned with natural topographic barriers, or 2) directional impediments that allowed hunters to kill or capture animals in the game drive system at an optimal orientation when using projectiles.

Figure 18. Stone wall feature number 5BL148.58 (Wall 58) at the 5BL148 game drive, representing a low-lying and linear arrangement of stones. Photo by the author.

Figure 19. Stone wall feature number 5BL148.55A (Wall 55A/Alignment C) at the 5BL148 game drive, representing a stacked and propped arrangement of stones near a wall feature convergence area. Photo by Michelle Dinkel.

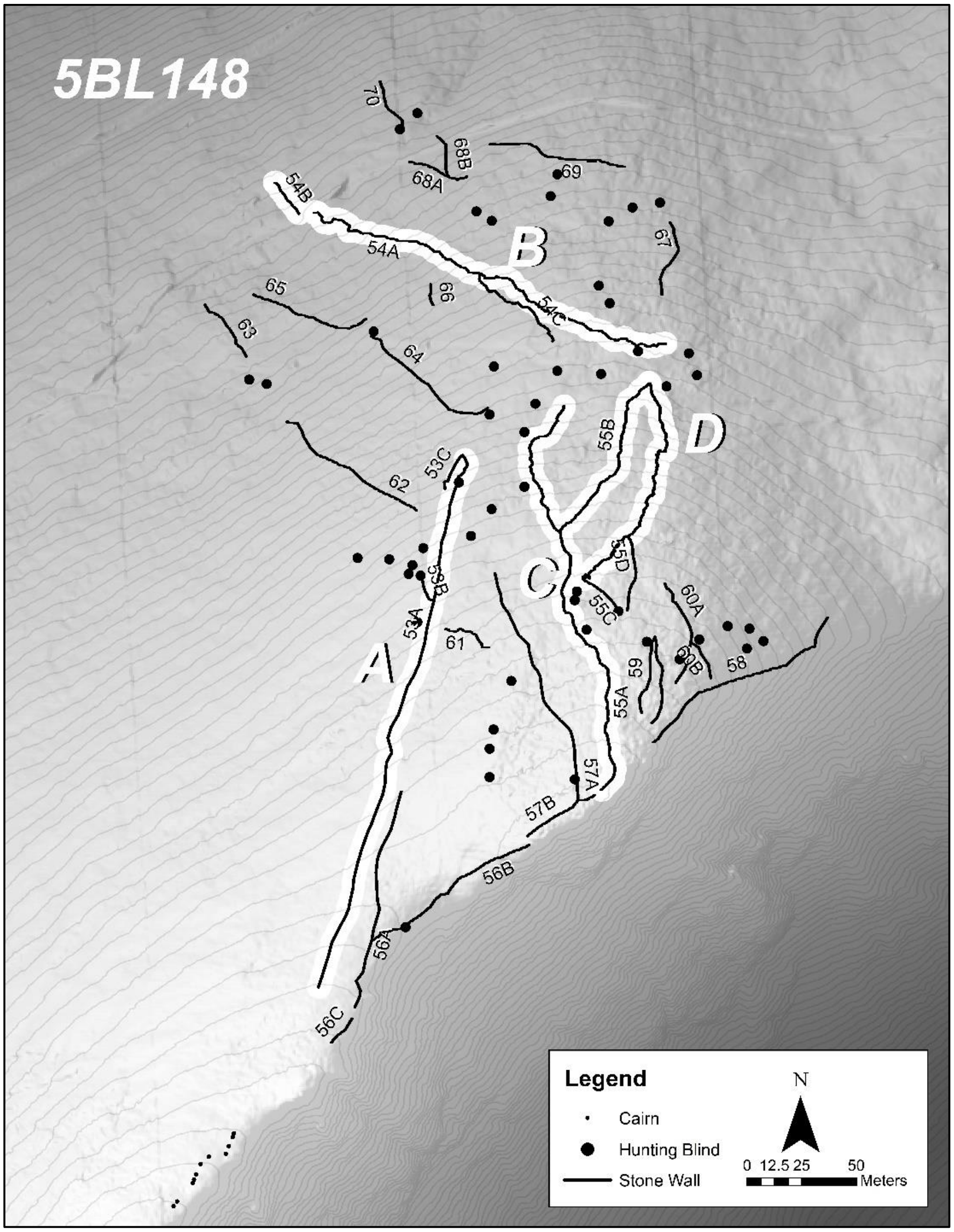

Figure 20. Map of the 5BL148 game drive depicting stone feature locations. Stone wall features are labeled with corresponding feature numbers.

Thallus Samples and Rhizocarpon Measurement Protocol

The lichenometric study presented in this thesis considers a size-frequency analysis of the four largest stone wall alignments, comprised of individual features numbered 53A, 54A, 54B, 55A, and 55B (Figure 20). The author selected the four wall alignments for lichenometric analysis during the fieldwork preparation phase of this thesis project, based upon the high probability that each wall alignment maintained a population of one-thousand or more *Rhizocarpon rhizocarpon* thalli required for the size-frequency method. The average length of walls published in lichenometric studies for alpine game drives in Colorado is approximately 150 meters (Table 12), and the wall alignments selected for lichenometry at 5BL148 provided a greater likelihood of maintaining an adequate number of thalli as determined by the georeferenced length of the longest walls (each greater than 200 m in length). For the purposes of simplification and description, the wall alignments used in the lichenometric analysis at 5BL148 are labeled as Alignment A, Alignment B, Alignment C, and Alignment D (Figure 20).

Published lichenometric studies of alpine game drives in Colorado sometimes underplay the sample selection methodology or wall sampling protocol that researchers used for field measurements of lichen thalli on stone walls, largely because only the lichen population measurement statistics are needed to derive numeric-age estimates for wall features. Descriptions of individual thallus measurement methods are presented in Benedict (1985, 1996, 2009), but exactly how researchers selected each of the one-thousand or more thalli on stone wall alignments is not detailed in many game drive studies. The methodology presented herein provides a highly replicable protocol in an effort to further the advancement of lichenometric studies at alpine game drives. The CMPA remapped Alignments A, B, C, and D with a Trimble Geo7x GPS system to an accuracy of 15 cm during the field sessions conducted in 2017. The author divided the length of remapped walls into smaller arbitrary segments of equal length to ensure that the lichenometry crew members measured at least one-thousand or more thalli on each complete wall alignment (Table 13). The smaller arbitrary wall segments allowed for field crew members to estimate the approximate number of thalli measurements required, per segment, to facilitate complete and even sampling of an entire wall alignment. Arbitrary wall segments on each wall alignment ranged from 10 to 12 m in length, depending on the overall length of the wall.

The author directly supervised a crew of two to three students during lichen diameter measurements to ensure that measurements were taken consistently between all crew members. Lichenometry crew members used digital calipers to measure each thallus to an accuracy of .01 millimeters and imported the measurements into a digital tablet for efficient data storage. Crew members followed the method of taking thallus measurements as described in Benedict (1975a, 1985, 1996, 2009) and Lock et al. (1979). The crew measured individual thalli by the largest inscribed circle (Figure 21), or the visually estimated circumference within hypothalli (prothalli), which equates to maximum diameter, and the crew made all efforts to avoid measuring thalli simply along the longest or shortest axis, though some lichenometric studies report success by mean or maximum dimension measurements (Albino 1984; Bradwell 2001, 2004). Crew members measured only the largest thallus per stone in an arbitrary wall segment, and the crew members took an average of 50 individual thallus measurement per arbitrary wall segment. Critically, crew members avoided thalli that visually displayed a length/width ratio greater than 2:1, as well as thalli that appeared to cluster and overlap one another (Benedict 1996; Innes 1986). The lichenometry crew did not measure thalli less than 10 mm in diameter as suggested by Lock et al. (1979), due to the potential for handheld caliper measurement errors. Though several alpine game drive studies in the CFR used measurement data from thalli with less than 10 mm diameters during size-frequency analysis (Benedict 1996; Cassells 1995, 2000), lichenometry for stone walls at the Olson game drive used a 10 mm cut-off and it is with consistent practice of lichenometric analysis at Rollins Pass game drives to use the 10 mm cutoff (Benedict 2009; LaBelle and Pelton 2013).

Table 13. Summary data for walls used in lichenometry analysis at 5BL148.

Feature No.	Alignment	Total Length (m)	Arbitrary Segments	Length of Segments (m)	Total Thalli Frequency	Measurements per Meter
53A	A	275	25	11	1000	~ 4
54A, B	B	238	20	11-12	1000	~ 4
55A	C	240	20	12	1000	~ 4
55B	D	212.4	21	10	1050	~ 5

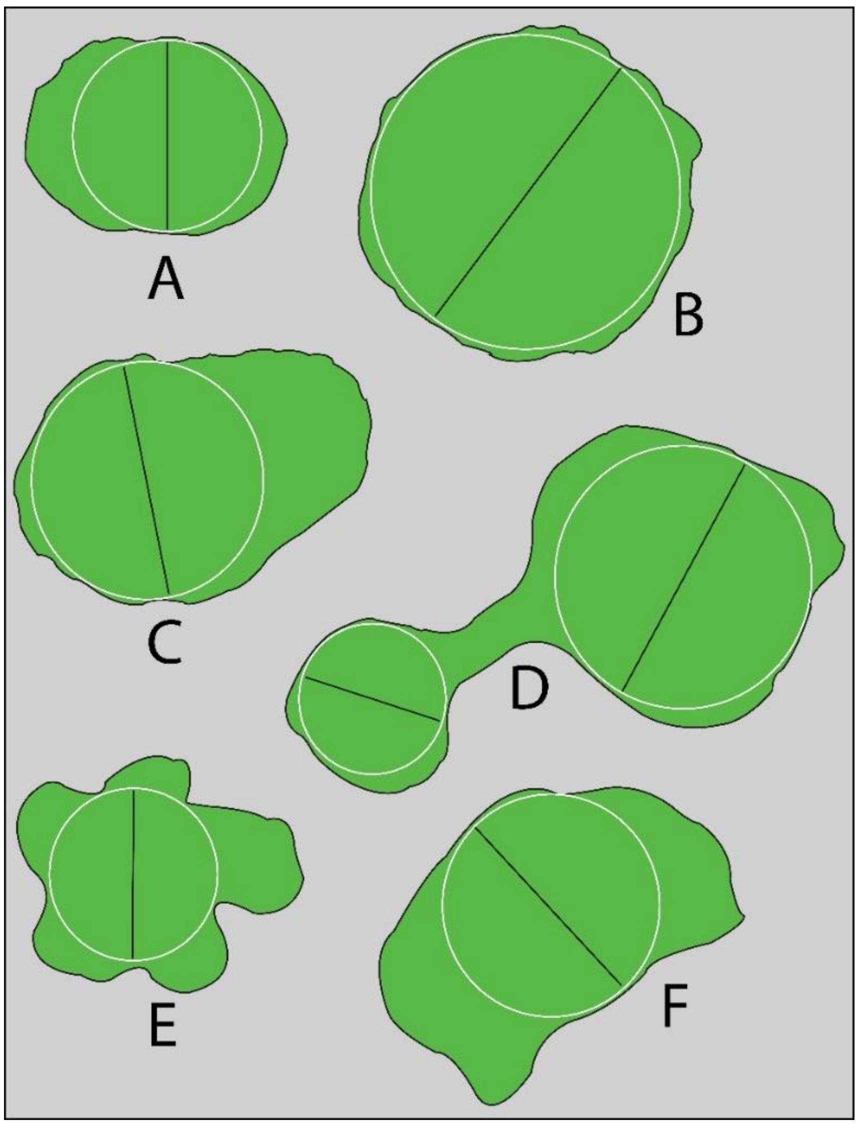

Figure 21. Illustration of thallus diameter measurements and the variable morphologies of lichen thalli, redrawn from Lock et al. (1979). Thalli circumferences (white line circles) are visually estimated per selected thallus, and calipers are used to measure the diameter between circumferences.

Methods - Size-Frequency Lichenometry

Basic statistical reporting of the mean, standard deviation, median, and mode of thallus measurements for wall alignments at 5BL148 show that each of the lichen populations are highly comparable to each other in terms of raw measurement data per wall (Figure 22, Table 14). The average thallus diameter measurement for all wall alignments at 5BL148 is 13 mm, and the average diameter for each individual wall ranges from 12 mm to 13 mm. Range and quartile plots of the data (Figure 22) illustrate the similarities in lichen diameter measurements from each stone wall alignment. However, basic statistical measures of the lichen population do not adequately support the efficacy and use of thalli measurements in a size-frequency analysis for dating purposes. All lichenometric studies of alpine game drive walls, which used 10 mm as the cut-off value for measuring thallus diameters, depict the highest frequency of measurements in the 10 mm and 15 mm thalli size subclasses over larger size subclasses (Benedict 1967, 1975a, 2009). Game drive walls at 5BL148 exhibit the same patterns recognized at all game drives, where the smallest diameter size subclass shows the greatest frequency of measurements. The data are heavily skewed towards the smallest diameters, as opposed to larger diameters (Figure 22).

Thalli measurements collected during field work at 5BL148 are used in the size-frequency analysis and subsequent age calibration with the CFR growth curve for *Rhizocarpon rhizocarpon* (Benedict 1985, 1996, 2009). Thalli measurement data from each wall are rounded to the nearest whole millimeter and summarized into 5 mm subclasses, beginning at the 10-15 mm subclass. The frequency percentages of each thallus size subclass are $\log_{10}$ transformed, as described in the size-frequency methodology (Benedict 1985, 1996, 2009; Cassells 1995; Locke et al 1979). Logarithmic frequency percentages are then plotted against respective thalli size subclasses, and a running correlation coefficient (Pearsons's coefficient, *r*) is calculated for each thallus size subclass (from the smallest size subclass through progressively larger size subclasses). Critically, thalli size subclass data points are drafted at the midpoint of each 5 mm subclass, an important protocol for the size-frequency method used in past lichenometry studies in the CFR, but one that is only detailed in Albino's (1984) thesis of the Devil's Thumb Valley and in mathematical notes provided in the archives of Jim Benedict, housed in the CMPA collections at CSU. The author constructed a regression line run through each successive data point with a running correlation coefficient value greater than 0.95, or roughly 95 percent confidence. Data points with low correlation coefficient values indicate an abrupt change in the growth trajectory of lichen populations, which are interpreted as signatures of survivor thalli from pre-construction events (Benedict 1975a, 2009), and thus data points with low correlation are not included in the regression lines for each wall alignment (Figure 23).

The $\log_{10}$ frequency percentage data for individual thalli size subclasses used in the size frequency analyses are summarized in Appendix C-F, and representative regression plots are shown in Figure 23. Correlation coefficients calculated for data points in each of the regression plots show a nominally high r-value and R^2 value, suggesting a highly correlated relationship and near negative log-linear trend for successive thallus diameter subclasses, but several of the walls also show signatures of survivor thalli that continued to grow after anthropogenic modifications to the lichen community on walls at 5BL148. For most of the wall alignments at 5BL148 (the exception being Alignment D), thalli with maximum diameters approaching 40 mm or more are considered construction survivors. The slopes of the best fit regression line for each wall alignment at 5BL148, run through the most highly correlated data points (r-values greater than 0.95), range from -0.084 to -0.127.

Table 14. Summary statistical data of lichen population measurements at 5BL148.

Feature No.	Alignment	Mean Thallus (mm)	Standard Deviation	Median Thallus (mm)	Mode Thallus (mm)	Largest Thallus (mm)	Sample Size
53A	A	12	2.74	11	10	47	1000
54A, B	B	13	3.55	12	10	42	1000
55A	C	13	4.11	12	11	71	1000
55B	D	13	3.58	12	11	45	1050

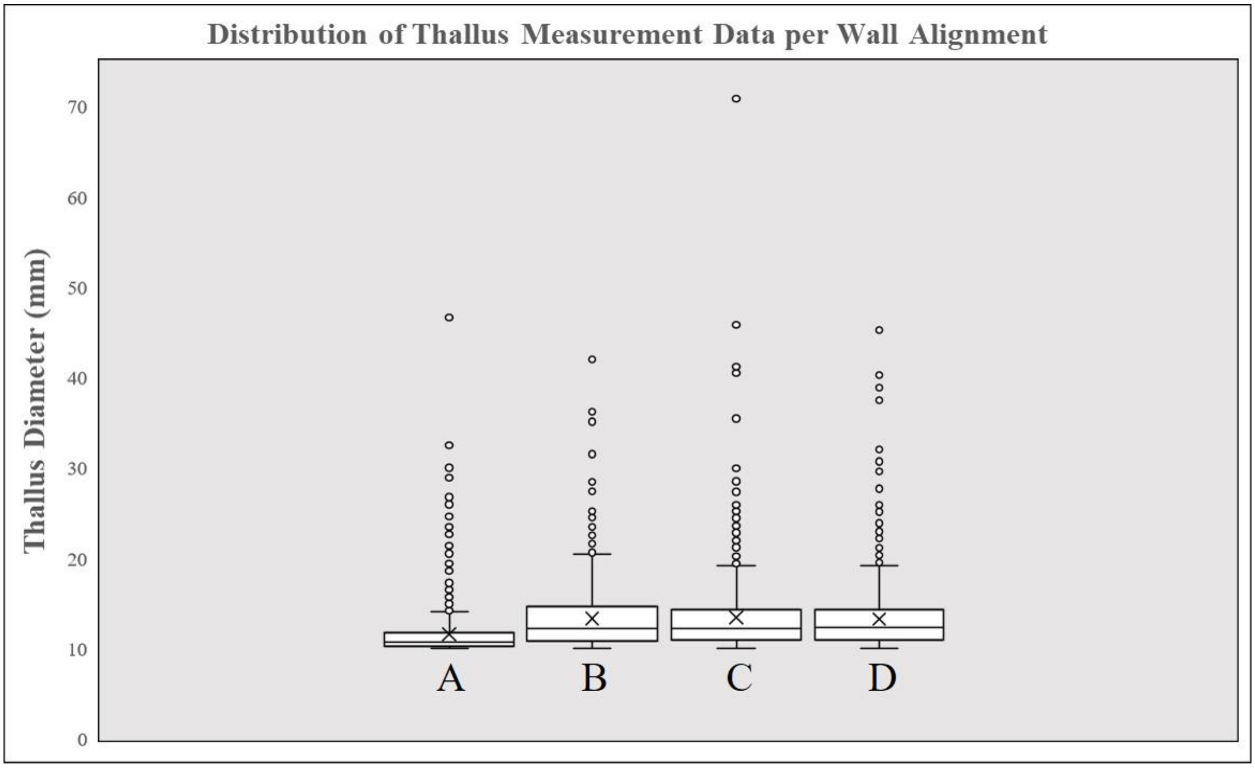

Figure 22. Range and quartile plots for raw thallus diameter measurement data from each of the four longest wall alignments at 5BL148.

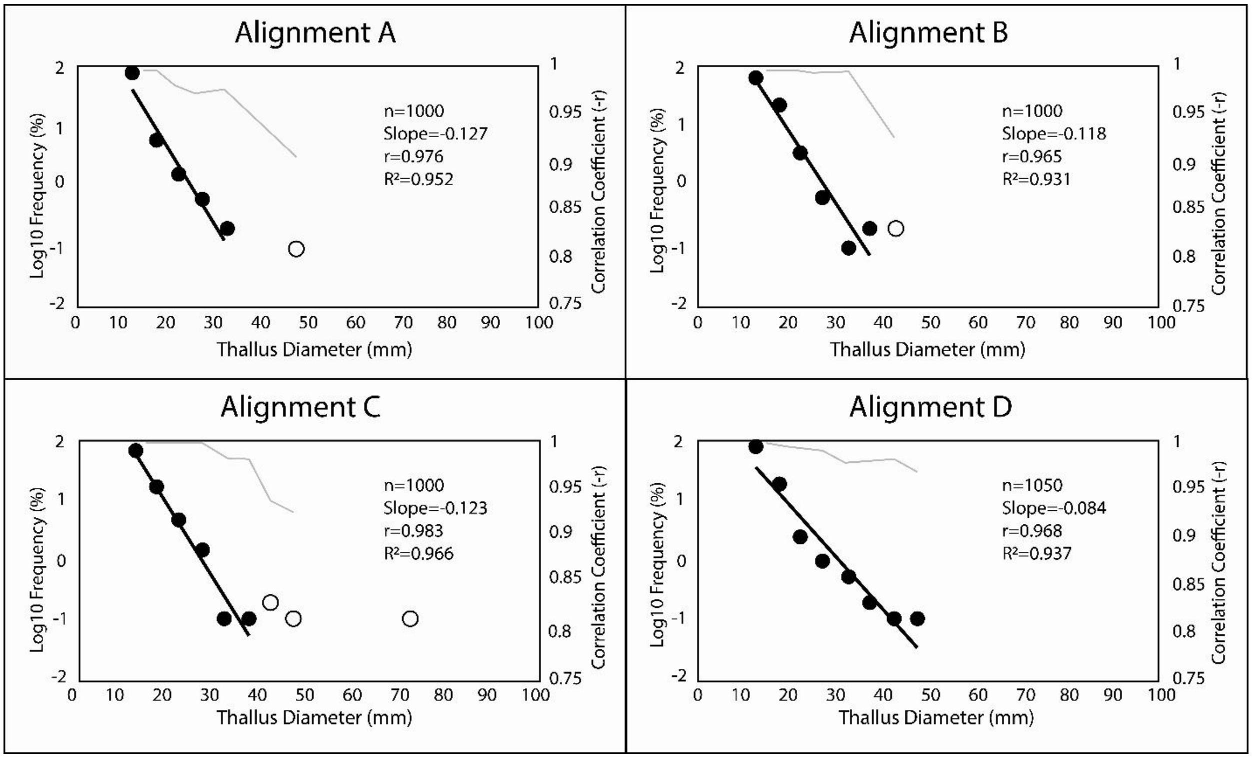

Figure 23. Regression plots of $\log_{10}$ transformed thalli measurements on the four largest stone wall alignments at 5BL148. Hollow circles represent survivor thalli from pre-construction events, that are not included in the regression analysis.

Results – Size-Frequency Lichenometry

Calibrated growth curves are required to relate measurements of a single lichen thallus or multiple thalli to growth patterns recognized in a regional population of thalli measurements. Direct measurements of a singular lichen thallus are sometimes used to construct a growth curve, but the process requires recurring measurements of the same lichen thallus over years (even decades) and it does not adequately take into account life-cycle variations in lichen growth, climatic and environmental differences between lichen populations, or measurement errors by geologists and archaeologists (Benedict 2008, 2009). An indirect approach to developing a lichen growth curve involves measuring numerous thalli on historically or radiometrically dated substrates within a region, which can account for differences in climate, environment, and minute variances in growth patterns at each substrate (Benedict 2009:152-153). The CFR calibration curve for *Rhizocarpon rhizocarpon* (*senso lato* for yellow sections of Rhizocarpons, *Superficiale* and *Rhizocarpon*), developed by Benedict (1967, 1975a. 1985, 1996, 2009), is derived from the size-frequency method and maintains an effective age-predicting range extending to roughly 5,000 years ago.

Each of the data points that Benedict (1985, 1996, 2009) used to construct the CFR growth curve are representative of the same size-frequency lichenometry process that is applied to walls under investigation in this thesis. Jim Benedict measured one-thousand or more thalli growing on six historically and radiometrically dated substrates in the CFR, and then used the slope of regression lines derived for thalli size subclasses from each of those substrates as a function of exposure age to construct the CFR growth curve (Benedict 1985, 1996, 2009). The growth curve transformed through several iterations over the past several decades (Benedict 1985, 1996, 2009; Benedict and Cassells 2000; Cassells 1995, 2012). The earliest CFR growth curve used conventional age estimates of dated substrate control areas, presented in radiocarbon years before present, to compare against regression line slopes (Benedict 1985). The subsequent iteration of the curve used calibrated years before present for substrate control areas (Benedict 1996, 2009; Cassells 1995, 2009). The slope of regression lines for each wall alignment at 5BL148, drafted by running best-fit lines through highly correlated thalli size-frequency data points for each wall, are used in the calibration procedure with the CFR *Rhizocarpon rhizocarpon* growth curve.

The author reconstructed the CFR growth curve with the mean age of calibrated radiocarbon dates for each control point in Benedict's CFR growth curve, plotted against the regression line slopes of each of the same control points used in the curve (Figure 24, Table 15). The mean ages of calibrated radiocarbon dates are on file in the notes of Jim Benedict, housed in the CMPA's collections. The author did not recalibrate Benedict's radiocarbon dates as a part of this analysis. In order to calibrate regression line slopes from walls at 5BL148, the author imported the mean ages of the CFR growth curve substrates and accompanying regression slopes into the statistics program Rstudio, and then used a second order polynomial function to reconstruct the curve, which closely mirrors the curve shown in Benedict (1996, 2009). Regression line slopes for each wall alignment measured at the 5BL148 site are compared against the CFR growth curve as reconstructed in Rstudio.

The regression line slopes indicate that the minimum age of feature construction events for the largest four wall alignments at 5BL148 range between 1451 cal CE to 1756 cal CE (calibrated common era years). The dates presented for wall alignments at 5BL148 are derived from a predictive function in Rstudio, where the regression line slopes are compared against an estimated age in calibrated years before present (Figure 25). Though the curve prediction reports ages in cal BP (calibrated years before present), the author converts cal BP dates to cal CE dates to keep consistency with other chronological methods applied in this thesis. Three of the four wall alignments (Alignments A, B, and C) present very similar lichenometric dates within the last few hundred years before present. Alignment A, B, and C are dated to 1756 cal CE, 1722 cal CE, and 1744 cal CE respectively. Interregional chronologies extending throughout the Great Plains use the term "Protohistoric" to describe Native American occupations that date to the time of Euroamerican contact following Spanish *entradas*, but Euroamerican contact in northern Colorado did not firmly exist until the mid-nineteenth century (Newton 2008, 2016; Von Wedell 2011). The lichenometric age of Alignments A, B, and C pre-date Euroamerican trading posts in northern Colorado (Newton 2008, 2016), and though the dates fall within the Protohistoric era broadly (1540+ CE), the author uses the Protohistoric term only as a temporal marker, as opposed to using the term to denote a particular group of people or a culturally specific tradition. One stone wall alignment, Alignment D, dates to a few hundred years earlier than Alignments A, B, and C, at 1451 cal CE. Alignment D situates within the Middle Ceramic period (1150 – 1540 CE), and like the walls that date to the Protohistoric era, the author uses the term Middle Ceramic only as a moniker for chronology.

Table 15. Uncalibrated and mean ages with size-frequency regression slopes of substrates used in Benedict's (1985, 1996, 2009) size-frequency calibration curve for Colorado Front Range *Rhizocarpon rhizocarpon*. Mean ages are on file with the CMPA collections at CSU.

Control Point No.	Description	Age (rcyBP)	Mean Age (cal BP)	Regression Slope
1	Arapaho Pass Historic Wagon Road	75 ± 2	75	-0.1836
2	Murray Site Game Drive Wall	970 ± 100	925	-0.0638
3	Debris-Flow Lobe, Caribou Lake Valley	1110 ± 90	983	-0.0615
4	Debris-Flow Levee, Upper Diamond Lake	1155 ± 85	1061	-0.0542
5	Rock Glacier, 4th of July Valley	3340 ± 65	3344	-0.0240
6	Rock Glacier, Caribou Lake	4190 ± 70	4383	-0.0185

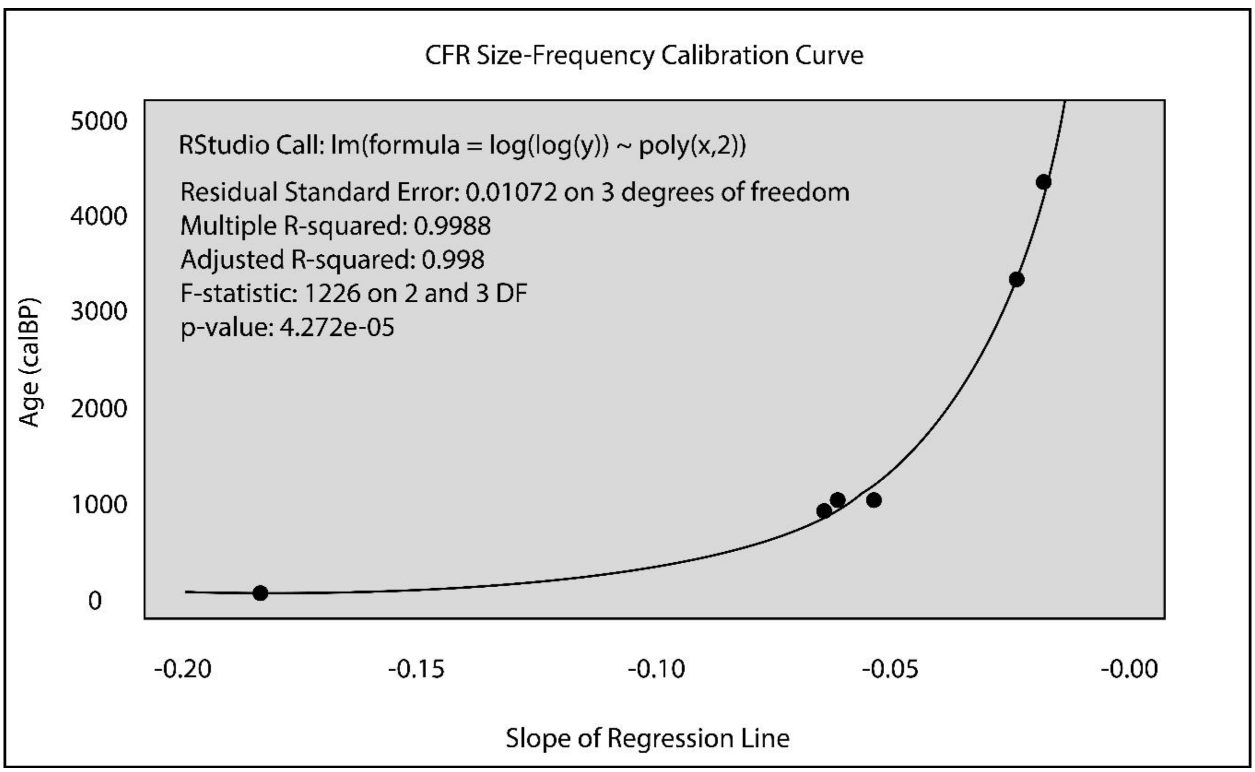

Figure 24. Reconstructed Colorado Front Range size-frequency growth curve used for lichenometry in this thesis project. Statistical results of curve reconstruction in *RStudio* are presented above.

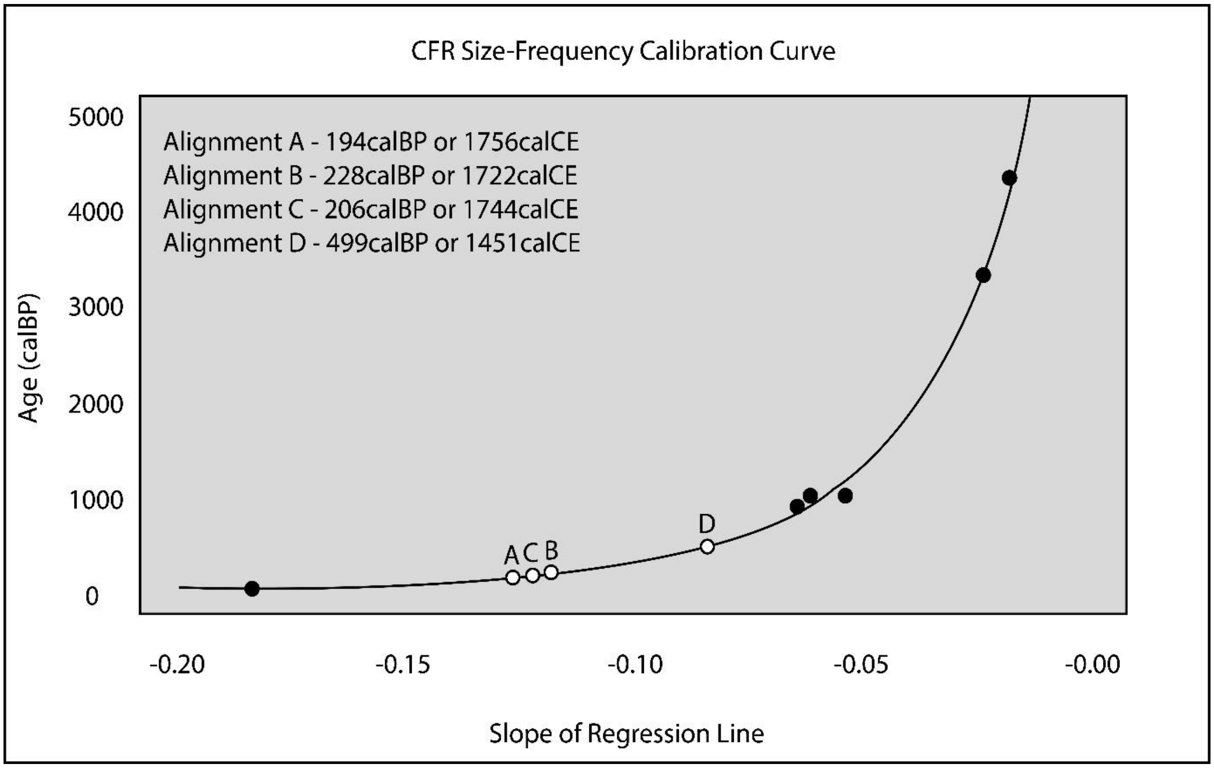

Figure 25. Reconstructed Colorado Front Range size-frequency calibration curve depicting calibrated walls from 5BL148 (white data points).

Methodological Concerns and Potential Sources of Error

The precision of lichenometric dating is somewhat unclear in the archaeological literature. Benedict (2009:Figure 17) presents data to suggest that biases from variable sample sizes of measured lichen populations on a single wall feature could affect the results of size-frequency analysis by as much as 600 years. Lichenometric dates from walls at 5BL148 are considered within Benedict's recommended sample size, but Benedict also presents data to show that lichenometric dates for several walls at the Arapaho Pass game drive, that are thought to be contemporaneous in age, can vary by as much as 100 years when considering size-frequency analysis of large sample sizes between 1000-1500 thalli (Benedict 2009:Figure 17). Lichenometrically dated stone walls at Arapaho Pass game drive are dated between CE 990 to 1390 when the maximum sample sizes are considered for size-frequency analysis (Benedict

1985, 2009), with two apparent wall construction episodes (one earlier, CE 990-1030; one later, CE 1360-1390). No other archaeological studies from the CFR address this potential error in the presentation of expected lichenometric age when recommended sample sizes are below, or above, one-thousand thalli, some of which used thalli sample sizes in the range of 700 or less (Benedict and Cassells 2000; Cassells 1995; Hutchinson 1990).

Environmental and biological variables are increasingly criticized as determinants of the effective use of lichenometry as an age-predicting method (Bradwell 2009; Innes 1986; McCarthy 1999; Rosenwinkel et al. 2015). Climatic variables are known to correlate with lichen species growth patterns in mountainous environments. Benedict (1993) documents mass snow-kill events of crustose lichen species in the CFR, including *Rhizocarpons*, during the Audubon interglacial period (400 BCE – CE 1050). Seasonal snow-cover is thought to have minimal effects on *Rhizocarpon rhizocarpon* (Benedict 1991), but late-lying snow on north facing slopes could condition lichen survival and recolonization events to more favorable climatic intervals. Some lichenometric studies suggest avoiding visibly snow-killed walls (Albino 1984; Benedict 1996), but the spatial extent of snow-kill events throughout time is difficult to quantify. The 5BL148 site is situated on a north-facing slope, but the walls dated furthest north are the oldest (discussed further in chapter 5), and thus snow-kill is not expected to be a factor limiting the accuracy of the dates presented here. Weathered rock surfaces are also known to condition the growth extent of individual thalli, which limits observable circularity and constrains the dimensional measurements of thalli (Benedict 1996; Innes 1986). More importantly, McCarthy (1999) argues that there is little biological basis to rely on a dimensional analysis of lichens as a means to examine absolute age of rock substrates or the simultaneous colonization of lichen cohorts (groups of thalli that establish synchronously), but supports that relative changes in lichen demographics over time are observed. Rosenwinkel et al. (2015) model that both climatic and biological controls on lichen population dynamics are difficult to reconstruct considering the differences in methodological applications by lichen researchers and sub-regional climate/demographic variances.

Challenges in estimating the precision of lichenometric dates are further influenced by cumulative error in the CFR *Rhizocarpon rhizocarpon* growth curve. The range of prediction for lichenometric age, when using the CFR growth curve, is limited to roughly 5,000 calibrated years ago, but observable error of the curve increases with age-depth so that more recent dates are more precise in comparison to older dates (Benedict 2009:167). The predicted lichenometric age of wall alignments at the 5BL148 should be considered highly precise, given their Protohistoric era and Late Prehistoric era affiliations, but factors related to sample size may complicate this reconstruction, perhaps by a factor of 100 years or more from the predicted age. Additionally, while the CFR growth curve is constructed with the mean radiocarbon age for each representative substrate control point, it is not discussed or illustrated if standard deviations of radiocarbon age estimates are taken into account, nor if cumulative probabilities of 1σ (1-sigma) and 2σ (2-sigma) calibrated age ranges are assumed in the estimation of the mean radiocarbon age of growth curve control points. Additional research is needed to further account for the precision of expected lichenometric age when using the CFR growth curve, but such work is beyond the immediate scope of this thesis. It is difficult to estimate age-error until the CFR growth curve is refined with consideration for control point age-resolution. With these statistical factors in mind, it may be best practice to avoid treating lichenometry as an absolute dating method, but rather as a means of addressing an observable difference in lichen growth of older and younger stone walls at game drives.

Discussion and Conclusion

The size-frequency lichenometry analysis presented in this thesis yielded results suggesting that some wall feature construction and/or modification events took place during the Late Prehistoric and Protohistoric eras at 5BL148. Alignments A, B, and C (comprised of features 53A, 54A, 54B, 55A, and 55B) date between 1722 cal CE and 1756 cal CE. A comparable lichenometric date on a stone wall is documented further south of Rollins Pass in the Sawatch Range at the Waterdog Divide game drive (Hutchinson 1990), dated to CE 1645, but there are no other lichenometric dates for game drive walls in Colorado that reflect construction/modification ages as recent as the eighteenth century.

Alignment D at 5BL148 (feature 55B) dates slightly older than the other wall alignments at the site, to approximately 1451 cal CE. The Alignment D wall is best described as part of a u-shaped corral-type structure, which appears to function by a somewhat different means than other linear alignments at the site. Two other game drives in the CFR present lichenometric dates at the onset of the Middle Ceramic period, including the Devil's Thumb Valley Game Drive (Albino 1984; Benedict 2000) and the Sawtooth Game Drive (Cassells 1995), but most other game drive sites in Colorado date to the Early Ceramic period which immediately precedes the Middle Ceramic (Cassells 2012:Table 1).

The presence of both Protohistoric and Late Prehistoric era wall alignments at 5BL148 provides evidence that hunter-gatherer groups reoccupied the site, and that hunter-gatherer groups constructed the four largest walls during a span of roughly 300 years, at minimum. It is difficult to associate the age of the stone walls at 5BL148 with a known cultural-technological complex or tradition, as the dates only reflect the reconstructed age of the lichen population, and the dates are not a direct measure of a specific occupation event by a known cultural group. In terms of frequency, the number of features that comprise the four wall alignments tested via the size-frequency lichenometry method in this thesis represent only 13 percent of the total frequency of walls at the site. There remains the possibility that other stone wall features from the site date to earlier in prehistory, as documented throughout the CFR (Benedict 2009; Cassells 2012).

CHAPTER IV – ABSOLUTE DATING OF FAUNAL AND CHARCOAL REMAINS

The purpose of this chapter is to examine the faunal and charcoal remains collected from the 5BL148 game drive, and to present the results of absolute dating methods on selected organic samples as a measure for evaluating evidence for a single occupation or multiple occupations at the site. Detailed descriptions of the faunal remains are provided herein, and justifications for the association of collected bones to prehistoric or historic period occupants at the site are discussed. Additionally, sediment samples collected during soil-probe tests of hunting blind features are described, as are the results of radiocarbon analyses on charcoal fragments from probe test sediment samples. Seven radiocarbon dates are analyzed via summed probability distributions, on four bones and three charcoal samples, which are used to assess the potential relationship of the absolutely dated materials to hunter-gatherer occupations at 5BL148.

Theory and Methods in Radiocarbon Dating

Archaeological sites found in alpine settings are complicated by a suite of geological and environmental issues that create a sparse record of organic material for researchers to use in absolute dating methods, such as radiocarbon dating. Radiocarbon dates reported in the literature of high altitude game drive sites in the CFR are derived mainly from excavated contexts, with samples selected from test units or noninvasive soil-core probe tests placed in the sodded floors of hunting blind features. A selected sample of 49 radiocarbon dates from published game drive sites in Colorado shows that 78 percent of the materials used in radiometric analyses are charcoal pieces collected from pit floors in hunting blind features (Table 16), many of which are thought to represent the remains of small thermal features. In some cases, alpine researchers used charred twigs and burned spruce needles recovered from hunting blind features at game drives for radiocarbon dating (Benedict 1996, 2000; Benedict and Cassells 2000). Bones are rarely documented at alpine game drives (Benedict 1975a; LaBelle and Pelton 2013), but a recent study at the Olson game drive (5BL147) presents radiocarbon dates on faunal remains from a blind in conjunction with radiocarbon dates on charcoal, to situate the timing of hunter-gatherer occupations at the site with absolute dating (LaBelle and Pelton 2013).

It is important that absolute dating methods are applied to chronological studies at alpine game drive sites, but it is imperative to consider that most game drives in the CFR are situated in vulnerable and deflated environmental settings that limit the preservation of sample types such as bone and charcoal. There is the potential for differential preservation of organic materials within and between game drive sites due to site-specific factors related to climate, the presence or absence of vegetation and sediment, as well as the antiquity, size, and species types of faunal or wood specimens present at sites. Prehistoric anthropogenic variables also permit or limit the preservation of organic material remains at alpine game drives, as the quantity of organic debris left by prehistoric occupants is related to the intensity of hunter-gatherer occupation episodes but also the spatial and geological context of hunting, butchering, or other activities which occur at hunting sites. Contextual issues need to be further addressed in order to adequately discuss the relationship of dated organic materials recovered from alpine game drives and past hunter-gatherer occupations. Specifically, and as noted in discussion of bone samples at the Olson game drive (LaBelle and Pelton 2013:54), there are questions about the circumstances in which datable materials are deposited in archaeological contexts at high altitudes. It remains to be demonstrated that bones found at some published game drive sites are discarded as the result of past cultural activities (such as hunting and animal butchering). No faunal remains from published game drive sites in the CFR are recovered from surface contexts within hunting intercept areas, though burned bones and non-attributable bone fragments are recorded in hunting blind features within some game drives (Benedict 1975a; LaBelle and Pelton 2013).

The context for the deposition of charcoal at alpine game drives is also of critical concern. Benedict (2002) presented the occurrence of eolian deposited forest fire charcoal, transported from low elevation settings to higher altitudes sites in the CFR, allowing for the possibility that several (possibly many) accelerator mass spectrometry (AMS) radiocarbon dates on charcoal pieces recovered from features at game drive sites are representative of the age of non-cultural fires from subalpine mountain valleys. Benedict (2002) developed a size-based classification of forest-fire charcoal to help differentiate non-cultural charcoal pieces from those thought to be derived from intermittent warming fires conducted by prehistoric hunter-gatherers in blind features (Benedict 2002:35-36). Charcoal grains with mean diameters larger than 3.1 mm, and/or sediment samples containing 20 or more charcoal particles per 100 cm^3 of sediment accumulation, are considered anthropogenic with good certainty (Benedict 2002). Unfortunately, the majority of radiocarbon dates published in the game drive literature do not present information of charcoal grain size and are generally argued to reflect a cultural occupation episode despite the possibility of eolian fire debris accumulation. The temporal resolution of radiocarbon dates from wood charcoal grain samples from high altitudes is considered to be relatively high, since culturally transportable elements of trees include branches and twigs which minimize the old-wood effect (Benedict 1996, 2002; Troyer 2014).

In this thesis, AMS radiocarbon dates on charcoal grains are presented with consideration for Benedict’s size-classifications of cultural and non-cultural charcoal at high altitudes (Benedict 2002). It is possible that both anthropogenic and natural factors contributed to the presence of charcoal documented in the samples collected from 5BL148. It is also possible that bone specimens collected from surface contexts at 5BL148 are derived from natural depositional processes. Samples of charcoal and bones from 5BL148 are discussed in this chapter by specimen type, and estimations for the cause of sample visibility/occurrence at the site are elaborated. It is the expectation of the author that radiocarbon dates from 5BL148 will reflect multiple occupation episodes with a higher representation of Late Prehistoric and Protohistoric period dates, based on published dates of organic materials from game drives in the CFR and elsewhere in Colorado (Figure 26, Table 16). The majority of all radiocarbon dates presented for alpine game drive sites show that dates from earlier periods in prehistory are rare (Paleoindian and Archaic periods), perhaps conditioned by the lack of preservation of older materials but also the infrequent or non-use of game drives by exceptionally ancient hunter-gatherer groups (Figure 26, Table 16).

Table 16. Conventional radiocarbon dates from published alpine game drive sites in Colorado arrayed by feature context type (FEA) and sample type.

Game Drive Site	Material Type	FEA Type	Age (rcyBP)	Lab Number	Reference
Murray (5BL65)	Charcoal	Blind	670 ± 150	SI-301	Benedict 1975a
	Charcoal	Blind	970 ± 100	M-1542	
Olson (5BL147)	Bone	Blind	80 ± 25	UGa-11,670	LaBelle and Pelton 2013
	Bone	Blind	140 ± 25	UGa-11,671	
	Charcoal	Blind	360 ± 170	I-11,133	
	Charcoal	Blind	2785 ± 90	I-5709	
	Charcoal	Blind	3275 ± 120	I-3856	
Waterdog Divide (5CF373)	Wood	Blind	350 ± 60	Beta-24183	Hutchinson 1990
	Charcoal	Blind	720 ± 60	Beta-24184	
	Charcoal	Blind	1060 ± 60	Beta-24185	
Flattop Mountain (5LR6)	Charcoal	Blind	220 ± 60	Beta-79749	Benedict 1996
	Charred Twig	Blind	240 ± 60	Beta-79745	
	Charred Twig	Blind	880 ± 60	Beta-79742	
	Charcoal	Blind	940 ± 60	Beta-79750	
	Charred Twig	Blind	1190 ± 60	Beta-79748	
	Charcoal	Blind	1210 ± 60	Beta-79738	
	Charcoal	Blind	1240 ± 60	Beta-79743	
	Charcoal	Blind	1290 ± 60	Beta-79741	
	Charcoal	Blind	1550 ± 60	Beta-79740	
	Charcoal	Blind	1550 ± 60	Beta-79747	
	Charcoal	Blind	1570 ± 60	Beta-79736	
	Charcoal	Blind	1600 ± 60	Beta-79737	
	Charcoal	Blind	1740 ± 60	Beta-79739	
	Charcoal	Blind	2620 ± 60	Beta-79744	
	Charcoal	Blind	4310 ± 80	Beta-79746	
	Organic (?)	Blind	1740 ± 50	Beta-161358	Brunswig 2005
Trail Ridge (5LR15)	Charcoal	Blind	2610 ± 60	Beta-75998	Benedict 1996
	Charcoal	Blind	4590 ± 60	Beta-85363	
	Organic (?)	Hearth	260 ± 40	Beta-133230	Brunswig 2005
Bob Lake (5BL127)	Charcoal	Blind	280 ± 60	Beta-101398	Benedict and Cassells 2000
	Pine Needle	Blind	310 ± 70	Beta-96542	
	Charcoal	Blind	1210 ± 50	Beta-96544	
	Charcoal	Blind	1230 ± 50	Beta-96543	
	Charcoal	Blind	1650 ± 50	Beta-96545	
Sawtooth (5GA55)	Charcoal	Blind	255 ± 60	Beta-39157	Cassells 1995
	Charcoal	Blind	430 ± 60	Beta-39158	
	Charcoal	Blind	915 ± 60	Beta-39154	
	Charcoal	Blind	1180 ± 55	Beta-50909	
	Pine Needle	Blind	1265 ± 60	Beta-39155	
	Charcoal	Blind	1325 ± 60	Beta-39156	
	Charcoal	Blind	1365 ± 65	Beta-50908	
Devil’s Thumb Valley (5BL3440)	Charred Twig	Blind	765 ± 55	Beta-54909	Benedict 2000
	Pine Needle	Blind	765 ± 55	Beta-68389	
	Charcoal	Blind	950 ± 40	Beta-67705	
	Charcoal	Blind	1850 ± 50	Beta-96541	
	Charcoal	Blind	2155 ± 55	Beta-57992	
5BL68	Charcoal	Blind	1230 ± 360	SI-302	Benedict 1975b
	Charcoal	Blind	1360 ± 180	I-2423	
5GA35	Charcoal	Blind	3090 ± 250	I-11,132	Whittenburg 2017

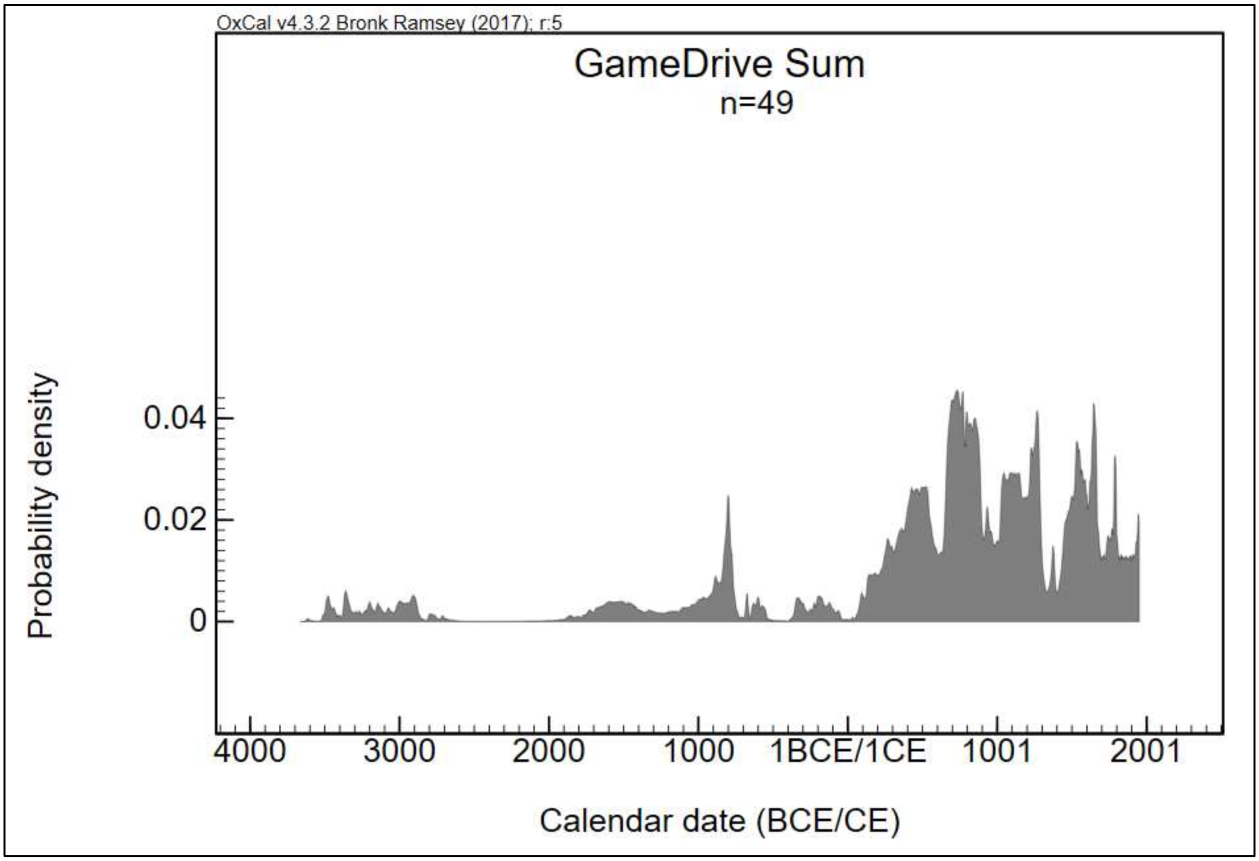

Figure 26. Summed probability distribution of 49 calibrated radiocarbon dates from game drive features presented in Table 16 (IntCal13 Atmospheric Curve, Reimer et al. 2013).

The Faunal Assemblage

The faunal assemblage at 5BL148 is comprised mainly of fragmentary bones of medium sized ungulates (Figure 27). Surface surveys conducted by the CMPA in 2012, and as part of the archaeological field school in 2017, identified ten individual specimens at the site and a collection of clustered bones. The CMPA did not collect any bone samples from the bone cluster, which included numerous elements of an unknown animal species. Several bone elements are represented in the total faunal assemblage from 5BL148, including portions of the appendicular and axial skeletons of mule deer (*Odocoileus sp*.) and bighorn sheep (*Ovis canadensis*). Seven of the ten bones are identified to the species level (France 2011; Gilbert 1973). Specimen 2017.18 and 2017.19 are representative portions of a thoracic vertebrae and spinous process, likely of bighorn sheep, potentially of the same animal and of a singular element, though CMPA crew members collected the two specimens roughly 2 meters from one another. Specimen 2017.20 is a large fragment of an innominate, likely from mule deer, and 2017.23 is a slightly smaller innominate fragment that is likely of bighorn sheep. Specimen 2017.22 is a highly degraded proximal tibia of bighorn sheep, and two complete phalanges (2017.25 and 2017.26), found in the immediacy of one another, are also of bighorn sheep. Three bone elements from 5BL148 are not identifiable to the species level, due to their highly fragmentary condition. Specimen 2012.2 is a midsection fragment of a rib bone, 2017.21 is a midshaft fragment, possibly of a long bone, and 2017.24 is a midshaft of what appears to be a radius (potentially of bighorn sheep), but this is uncertain.

There are no unequivocal attributes of the bones and bone fragments collected from 5BL148 that suggest direct associations with hunting and butchering events from past hunter-gatherer occupations at the site. Only one of the bones (2017.21) exhibits what could be considered a spiral fracture initiated from differential torsion forces (Binford 1978b, 1981; Karr et al. 2010; Pickering and Egeland 2006; Todd and Rapson 1988), while the majority of other breakage types on the other bone specimens appear to have resulted from oblique displacement that could have originated from post-depositional processes, thus making an account for human modification difficult. Several of the bones are hollow, exhibit low densities and mass, and show cortical surfaces that are highly weathered. However, the mapped locations of many of the bones may provide some evidence for a possible relationship to primary butchering events of hunted animals at the site, and aid in age-estimates of stone features at the site. It is hypothesized in previous game drive studies that small bone fragments identified at game drives could represent the remains of low quantity meal packages used by hunter-gatherers onsite (LaBelle and Pelton

2013), or instead detritus from initial butchery processes subsequent to hunting episodes (Benedict 1996). It is difficult to link the presence of bone materials at game drive sites with any specific hunter-gatherer activity types due to poor geological contexts. Game cameras set up in view of 5BL147 and 5BL148 at Rollins Pass, and at a game drive complex near Cone Mountain, show that modern mule deer and elk populations walk along stone wall features, leading into primary intercept areas (LaBelle, personal communication). This situational evidence provides some justification that modern animal groups continue to travel along walls and could potentially expire in proximity to stone walls due to natural causes, long after human abandonment of stone features.

Table 17. Descriptive and metric attributes of faunal specimens collected during surface surveys at 5BL148.

Specimen Number	Element	Portion	Max Length (mm)	Mass (g)	Animal Size Class	Species
2012.2	Rib	Fragment	127.74	10.9	2-3	NA
2017.18	Thoracic Vertebrae	Fragment	23.57	1.9	3	*O. canadensis*
2017.19	TV/Spinous Process	Fragment	36.21	1.1	3	*O. canadensis*
2017.20	Innominate	Fragment	184	57.8	3	*Odocoileus sp.*
2017.21	NA	Fragment	55.03	4.5	2-3	NA
2017.22	NA	Fragment	173	24.6	3	NA
2017.23	Innominate	Fragment	117.78	16.5	3	*O. canadensis*
2017.24	Radius	Fragment	146.74	28.9	3	*O. canadensis?*
2017.25	1st Phalanx	Compete	56.99	21.4	3	*O. canadensis*
2017.26	1st Phalanx	Complete	53.84	19.2	3	*O. canadensis*

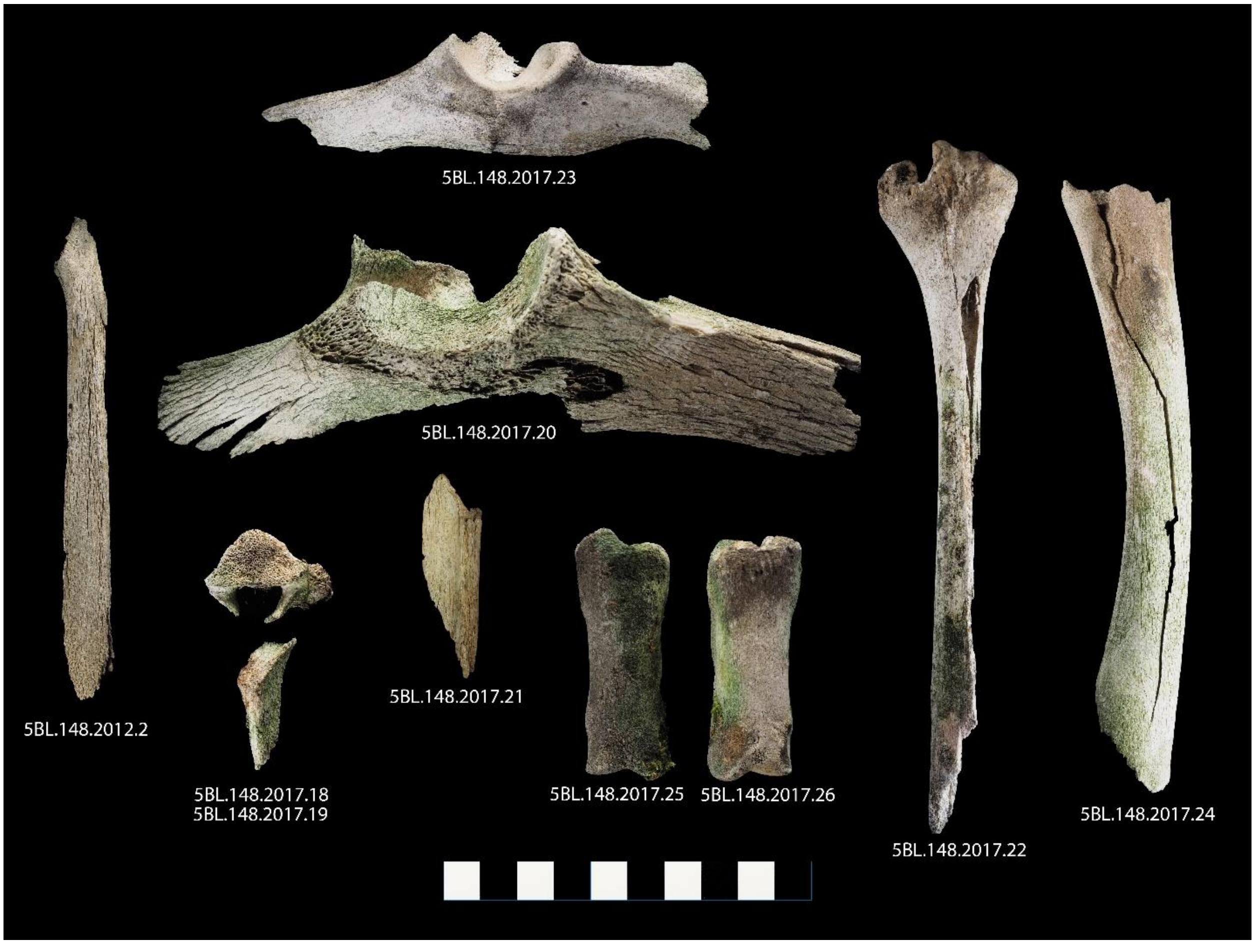

Figure 27. Collected faunal assemblage from 5BL148.

Hunting Blind Feature Descriptions, Soil Probes, and Charcoal Samples

In the summer of 2017, the CMPA collected charcoal samples during an intensive soil-core study of 19 hunting blind feature pit floors at the 5BL148 game drive site. Previous soil-core probe tests in blinds at several alpine game drive sites in the CFR yielded small samples of charcoal used for absolute dating (Benedict 1996; Benedict and Cassells 2000; Cassells 1995). Undergraduate and graduate student crew members provided documentations of hunting blinds as part of the 2017 archaeological field school recording procedures, and the author used the crew-recorded feature attributes in the selection process for the soil-core probe methodology.

The following descriptions address the metric and descriptive attributes of hunting blind features, as well as the sample protocol for soil-core probing at 5BL148.

Hunting Blind Features

There are numerous functional characteristics interpreted for hunting blind features at game drives in the CFR. Rock blinds provide wind cover and permit space for chipped stone tool maintenance and/or tool production tasks during pre-hunt and post-hunt feature occupation episodes, in addition to concealment for one or multiple hunter-gatherer occupants during primary hunting events. Lithic reduction episodes are documented in hunting blind features elsewhere in the CFR (Benedict 1975a, 1996, 2000), at Rollins Pass (LaBelle and Pelton 2013; Olson and Benedict 1970; Whittenburg 2017), and most importantly for this thesis, at the 5BL148 game drive. Critically, there is documented evidence from previous hunting blind excavations at Rollins Pass and elsewhere in the CFR which denote the presence of small fire pits in the interior of blinds, and these secondary features are commonly interpreted as small warming fires (Benedict 1996, 2000; Cassells 1995; Olson and Benedict 1970).

The primary function of hunting blinds is for hunter concealment and to provide a station for shooting projectiles. Hunter-gatherer groups armed with either bow and arrow or atlatl darts situated themselves in hunting blinds in wait for animal groups navigating the spatial structure of game drive systems. Over the course of use and disuse episodes over centuries (or millenia), hunting blinds accumulate eolian deposits and colluvial fill along with the lithic and charcoal debris from hunter-gatherer groups. It is also reasonable to assume that hunting blinds accumulate materials deposited during reoccupation events, considering the confined spatial limits of blinds and their stationary nature. In previous chronological studies at game drives in the CFR, hunting blind pits are treated as a window into the occupation span of hunter-gatherer groups who may have occupied, modified, and practiced various preparatory and active hunting tasks over the course of time (LaBelle and Pelton 2013).

There are 52 recorded hunting blinds at 5BL148, each constructed of locally occurring granitic boulders and stones with dry-laid masonry techniques. Hunting blinds at 5BL148 are typically circular or oval in shape, with some features appearing in a semi-circular arc or even rectangular shape in outline (Table 18). Generally ovoid blind outlines are documented at most alpine game drive sites in the CFR (Benedict 1975a, 1975b, 1985, 1992, 1996, 2000; Benedict and Cassells 2000; Cassells 1995; LaBelle and Pelton 2013; Whittenburg 2017). The mean interior diameter of hunting blinds at 5BL148 measures to 1.82 meters, while exterior diameters average 2.82 meters. The greatest metric variation of the blinds occurs with the estimated wall height, where the lowest estimated height measures only 31 centimeters and the maximum height exceeds 1.5 meters. On average, blinds at 5BL148 measure 78 centimeters in height, as taken from the bottom of the floor to the top-course of the sidewall. Though the majority of hunting blinds are two to three stone courses high, the representation of stacked stones in pit sidewalls is highly variable. Blind pit wall size is likely dependent on 1) the immediate availability of local stones as raw material for blind construction, 2) the anticipated concealment needs of hunters, and 3) the degree of feature degradation over time. The removal of rocks from the interior of blind features to create suitable depth for concealment and occupiable space is also a characteristic of blind morphologies documented at other game drive sites in the CFR (Benedict 1996; Cassells 1995; Whittenburg 2017), and several of the hunting blinds pits at 5BL148, particularly for blinds within periglacial rock arrangements, show evidence for interior rock removal.

Traditional excavation techniques pose potential detriments to the integrity of hunting blind features at game drives, and researchers necessarily make decisions about the potential costs to preservation when undertaking subsurface investigations at sites. The author selected to do non-invasive recording and sampling techniques in hunting blinds at 5BL148 in order to best preserve the condition of the site, and to adhere to the United States Forest Service recommendations for limited testing. Soil-core probing yielded evidence for hunter-gatherer fire use in hunting blinds at other game drives in the CFR (Benedict 1996; Benedict and Cassells 2000; Cassells 1995), and the soil-core probe protocol used in this thesis is described in the following sections.

Table 18. Summary data for hunting blind features at the 5BL148 game drive, Rollins Pass, CO.

Hunting Blind Shape	Frequency	Mean Height (cm from floor to sidewall top)	Mean Pit Length (cm)	Mean Pit Width (cm)
Circular	21	72	289	169
Ovoid	20	89	290	190
Rectangular	1	56	194	157
Semi-circle	10	66	254	191

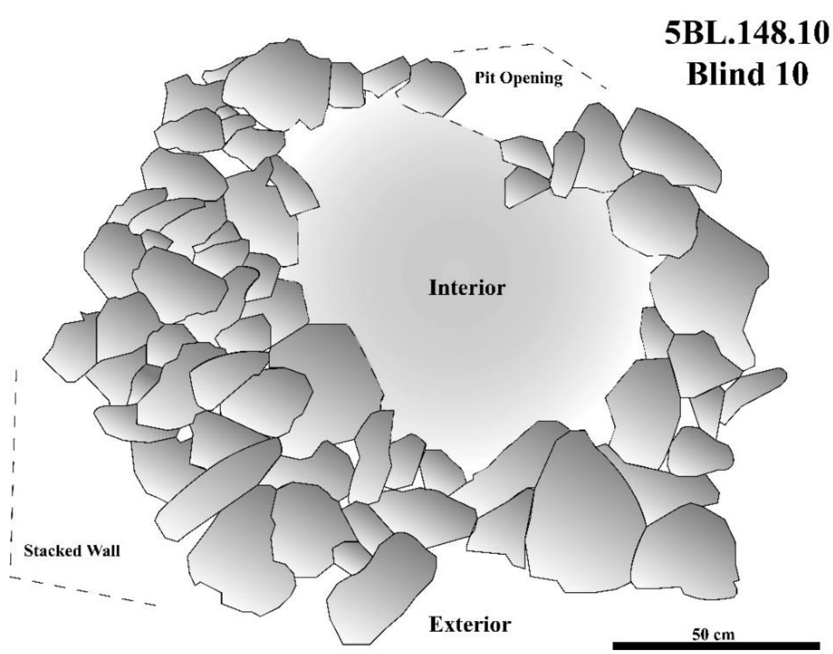

Figure 28. Digitized plan view outline of feature 5BL.148.10 (Blind 10) at 5BL148.

Figure 29. The author recording UTM positions via Trimble GNSS in feature 5BL148.8 (Blind 8).

Figure 30. CMPA graduate student Michelle Dinkel performing pole photography of feature 5BL148.13 (Blind 13).

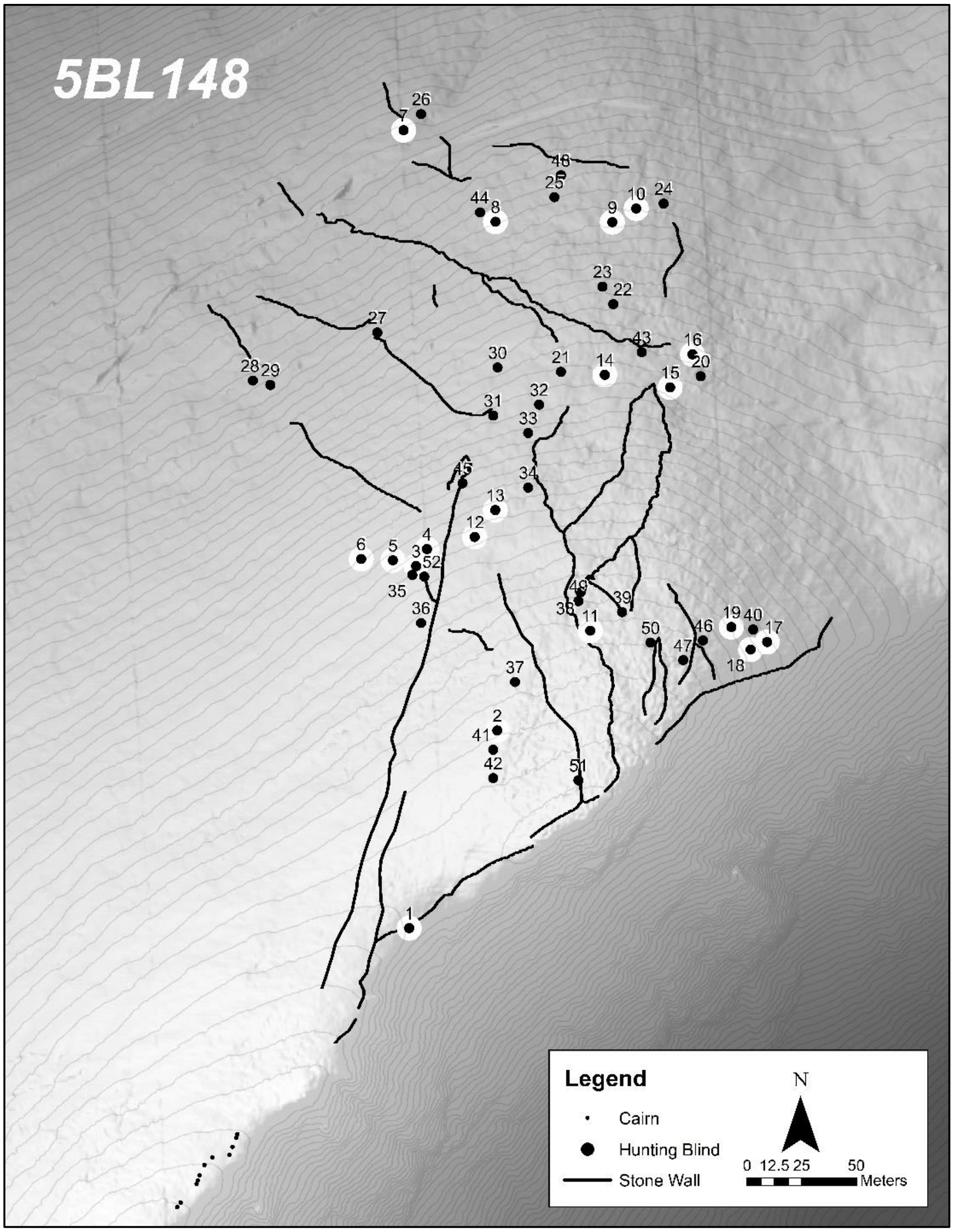

Figure 31. Map of the 5BL148 game drive depicting stone feature locations. Hunting blind features are labeled with corresponding feature numbers. Blinds tested with a soil-probe are outlined.

Soil-Core Probes and Sediment Processing

Benedict (1996, 2000) and Benedict and Cassells (2000) conducted soil-probe tests in hunting blinds at several game drive sites in the CFR, including the Flattop Mountain game drive in Rocky Mountain National Park, and the Bob Lake game drive near Rollins Pass. The soil-probe tests used in blinds at alpine game drives only minimally impacts feature integrity and does not damage or modify the structure of stones comprising the features. It is important to note here that thermal feature identification from soil-probe tests at other game drives in the CFR are not fully discussed in the present literature, and it is often assumed that charcoal or other organic material collected from soil-probe sediment cores are the product of hunter-gatherer occupations, though thermal features are not always fully unidentified. More recent research acknowledges the potential of forest fire charcoal deposition at high altitudes (Benedict 2002), and without definitive proof of the cause of organic material deposition in hunting blinds it is inadequate to assume that charcoal and burned pine needles collected by soil-probes equates directly to past hunter-gatherer occupation episodes.

CMPA field crews denoted the high or low potential for successful application of slotted-tube soil probe tests in blind pit floors during field recording procedures. Nineteen of the blinds exhibited a moderate to high potential for soil-probe tests, as indicated by an arbitrarily observed degree of sedimentation and floor sodding, but the majority of hunting blinds show little to no deposition of sediment in pit floors. The author and a graduate student crew member soil-probed each of the 19 hunting blinds with moderate to high probability of containing viable sediment for thermal feature preservation and subsurface artifact deposits (Figure 31). The CMPA tested the center of each of the 19 selected hunting blinds with a slotted-tube soil probe, with a core diameter of 2.5 cm. The field crew tested to the extent of maximum depth, or to the point where rocks limited further sampling. A summary of the sampling volume and maximum depth of each soil-probe test is presented in Appendix H, and illustrated in Figure 32.

The author subjected soil-probe sediment samples from 5BL148 to a series of analytical procedures in the CMPA laboratory at CSU. The author estimated soil texture for each soil probe sediment sample at intervals of five-cm below surface, as well as the Munsell color-hue characteristics of each 5 cm interval subsample. Soil texture from blinds at 5BL148 consistently presented as sandy loam, and dark sediment colors indicated dense organic activity associated with near surface alpine vegetation. Most probe tests ranged from 10 – 15 cm in maximum depth, and no probe test extended beyond 20 cm below surface (Figure 32). Each five-cm subsample produced approximately 40 cm^3 of sediment.

The author submitted sediment samples into a water-screening procedure with fine mesh to search for datable organic materials and artifacts. Two mesh sizes used in the water-screening process captured sediment, one mesh as a heavy fraction sieve with a screen size of 3.35 mm, and the other mesh as a light fraction sieve with a screen size of 850 micrometers (µm). The author searched the processed sediment samples for charcoal flecks, or other culturally deposited organic specimens, for use in AMS radiocarbon. Several of the sediment samples (from Blinds 9, 14, and 15) contained the necessary quantities of charcoal for AMS radiocarbon dating. The author did not identify any faunal specimens during the coring procedure. However, one soil-core probe test in 5BL.148.11 (Blind 11) produced a single chipped stone flake, a diminutive unmodified piece of debitage which most likely represents the debris of a stone tool resharpening event. It is difficult to estimate the intensity of occupation in Blind 11 based upon the single artifact recovered from the blind, given the narrow sampling window provided by the 2.5 cm diameter soil-probe. In sum of the soil-probe testing and sediment processing, most blinds at 5BL148 contained a shallow sediment depth (20 cm or less) and only three of the 19 blinds (16%) contained sufficient material for AMS radiocarbon dating. Quantities of organic and cultural material from each water-screened sample and mesh size are presented in Appendix I.

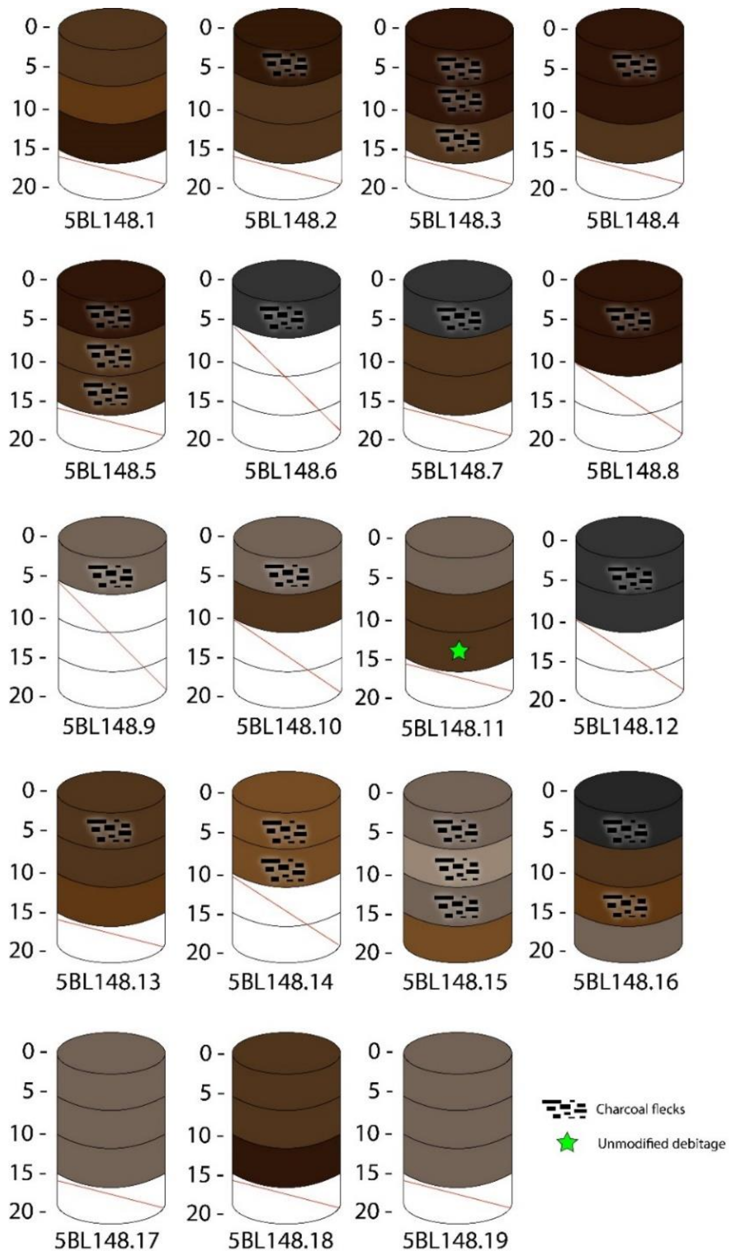

Figure 32. Graphical representation of soil-core probe tests conducted in blind features numbered 5BL148.1 through 5BL148.19 (Blind 1-19). Corresponding Munsell color-hue characteristics are depicted per 5 cm interval. Presence and absence of charcoal and chipped stone items are also shown. Scale in centimeters below surface.

Methods - Radiocarbon Dating of Bone and Charcoal Samples

Absolute dating of the 5BL148 site considers AMS radiocarbon dates of four bone samples from surface contexts and three charcoal samples from subsurface contexts in hunting blind features. The selection criteria for bone sample submission required that the horizontal provenience of bone samples be within at least ten linear meters of a stone feature at the site, including both wall and blind features, and that the maximum specimen thickness and mass ratio (thickness/mass) be low enough to indicate sufficient preservation of bone collagen. The author used a mechanical drill press to extract bone samples from individual bone specimens and submitted samples to Beta Analytic Inc. for AMS radiocarbon dating as well as stable isotope analysis (13C and 13N, C:N ratio). Bone specimens selected for radiocarbon analysis include two innominate fragments (2017.20 and 2017.23), a single phalanx (2017.26), and one midshaft fragment of an unknown species (2017.21). Bone sample specimen details are listed in Appendix K. The author chose charcoal samples from 5BL148 based upon a selection criterion of 1) effective sample mass to be used in AMS radiocarbon dating, 2) the size-classification of charcoal grains collected during the water-screen protocol, and 3) the spatial provenance of charcoal samples within observed hunting blind clusters. The metric attributes of charcoal samples from 5BL148 are important due to the size/mass-based requirements of the AMS protocol, but it is also important to consider the provenience of charcoal samples given that numerous hunting blinds are spread across an extensive area at 5BL148. The author selected charcoal samples from feature 5BL148.9, 5BL148.14, and 5BL148.15 (Blind 9, 14, and 15 respectively). Additional metric and descriptive data of submitted radiocarbon samples are listed in Appendix J-K.

This thesis uses radiocarbon dates to address evidence for either single occupation or multiple occupation episodes at 5BL148, and thus radiocarbon dates derived from samples are analyzed according to theoretical assumptions implemented in this thesis. Radiocarbon dates with statistically contemporaneous ages are strongly considered to represent single occupation episodes, while radiocarbon dates with ages extending beyond statistical contemporaneity are instead inferred as separate occupation periods. In order to test the statistical contemporaneity of radiocarbon dates from 5BL148, the author first considers the differing contextual agreements between samples submitted for analysis. All dated bones samples are derived from surface contexts at the site, whereas charcoal is exclusively from subsurface contexts in blind features. The reported age ranges of bone and charcoal are compared separately by sample type in the following results section. Using calibrated age ranges of samples, the author then used the R_Combine function in OxCal v.4.3 for analyzing statistically similar sample ages and to better isolate the calibrated age range of occupation episodes. Similar methods of comparing analogous age-ranges from within-component samples are used in Johnston (2015) for analysis of the Robert's Ranch Buffalo Jump (5LR100). Samples with dissimilar age ranges, that are not used in the R_Combine function, are discussed separately from statistically contemporaneous samples.

Results - Radiocarbon Dating of Bone

The four bone samples submitted to Beta Analytic for AMS radiocarbon analysis provided sufficient amount of bone collagen for dating. Three of the uncalibrated dates cluster within the last 200 years (specimens 2017.21, 2017.23 and 2017.26), affiliated temporally with the Protohistoric era in northern Colorado. An analysis of the three Protohistoric era radiocarbon dates in Oxcal v.4.3 demonstrates that the three most recent bone dates are highly consistent, supporting evidence for a hunter-gatherer occupation episode or nearly simultaneous natural death events of animals during this time. The chi-square test function of the R_Combine analysis shows that the three dates are statistically contemporaneous, with a weighted mean conventional age of 183 ± 13 rcyBP (Figure 33). Though the three Protohistoric era bone dates are statistically contemporaneous, it is difficult to firmly situate the accuracy of the calibrated age ranges due to the observed plateaus for seventeenth through eighteenth century dates in the radiocarbon calibration curve. The combined probability distributions for the calibrated ages of the three Protohistoric era bones show peaks of probability in the calibration curve between 1665 to 1684 cal CE and 1734 to 1786 cal CE at a 2σ range. A fourth radiocarbon bone date proved much earlier than the three Protohistoric era radiocarbon dates. The bone sample submitted for specimen 2017.20 provided an uncalibrated radiocarbon age of 1360 ± 30 rcyBP, consistent with an Early Ceramic period temporal affiliation in the Late Prehistoric era. At the highest probability peaks of the 2σ range, the Late Prehistoric era bone date most likely is reflective of a hunter-gatherer occupation or natural death event of an animal sometime between 615 and 694 cal CE (Figure 34).

Table 19. Radiocarbon results of four bone samples from the 5BL148 game drive, Rollins Pass, Colorado. IntCal13 atmospheric curve used in calibration of radiocarbon dates (Reimer et al. 2013). OxCal v4.3.2 used for calibration dataset processing (Bronk Ramsey 2017).

Laboratory Number	Specimen Number	Element	Uncalibrated Age (rcyBP)	R_Combined Date (rcyBP)	2σ Calibrated Date Range (calCE)
Beta-488945	2017.21	Fragment	180 ± 30	183 ± 13 rcyBP	1652 - 1696 (19.7%); 1726 - 1814 (53.6%)
Beta-504030	2017.23	Innominate	200 ± 30		1646 - 1690 (24.9%); 1729 - 1810 (51.2%)
Beta-504031	2017.26	1st Phalanx	170 ± 30		1659 - 1699 (17.3%); 1721 - 1818 (50.5%)
Beta-504029	2017.20	Innominate	1360 ± 30	Not available	615 - 694 (92.2%); 747 - 763 (3.2%)

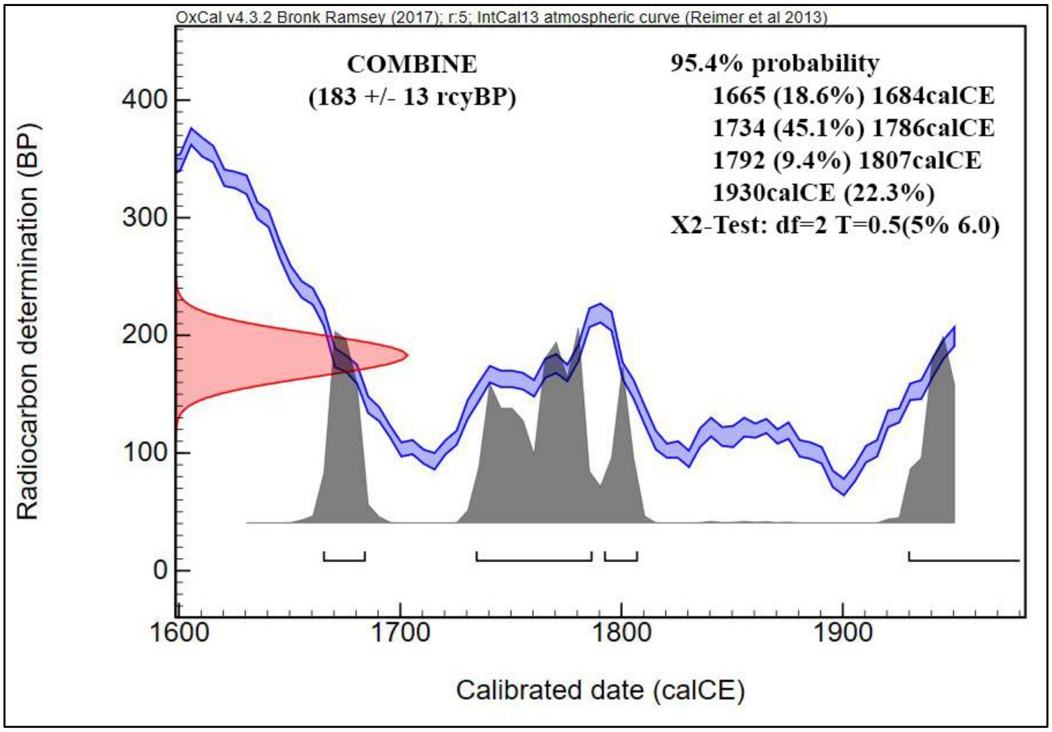

Figure 33. Two-sigma calibrated distribution of three combined bone dates from 5BL148, using R_Combine function in OxCal v4.3.2. The statistically contemporaneous bone dates are affiliated with the Protohistoric period.

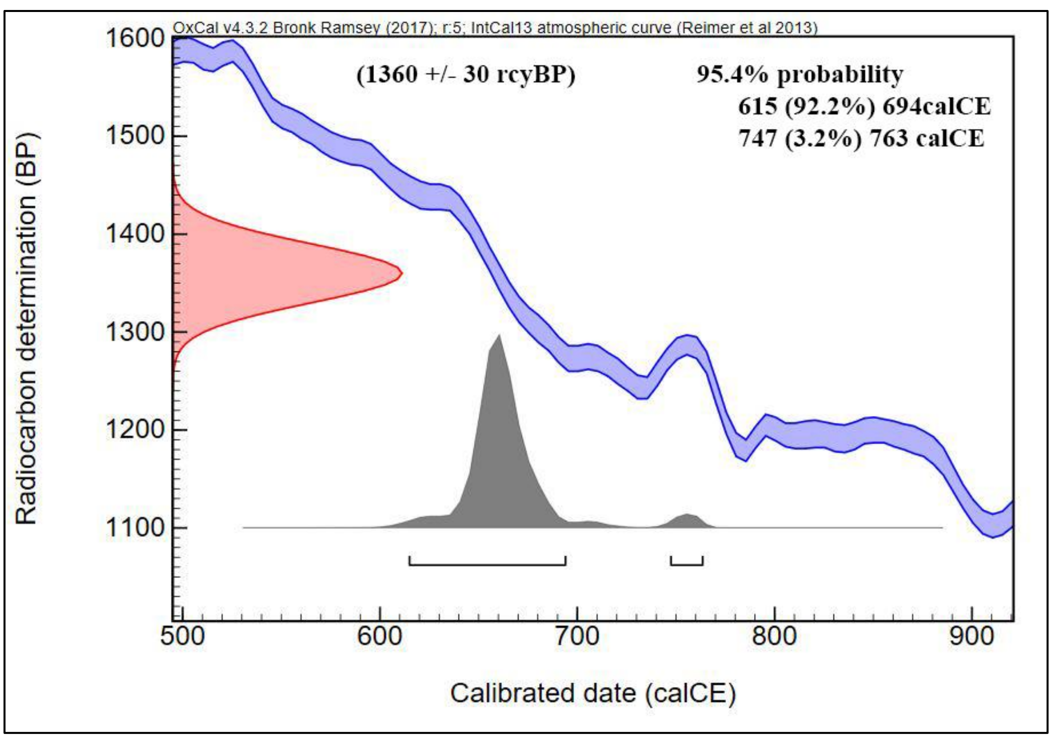

Figure 34. Two-sigma calibrated bone date from 5BL148 from the Late Prehistoric period.

Results – Radiocarbon Dating of Charcoal

The three charcoal samples submitted to Beta Analytic for AMS radiocarbon analysis provided a sufficient amount of material for dating. The author's directions to the Beta Analytic lab required that the single largest charcoal grain sample be submitted for analysis. The charcoal samples did not provide sufficient size for both fuel wood analysis and radiocarbon dating, so the wood species types of submitted samples are not addressed in this thesis. Further, the results of the radiocarbon analysis on charcoal samples indicate that some of the samples are likely not of fuel wood, but instead they are either non-cultural carbonates or fossilized materials. The Denver, Northwest, and Pacific railway trestle runs parallel to the site, less than 20 meters from the site boundary, and it is possible that railroad coal fragments are deposited on the site. Two of the three uncalibrated radiocarbon dates meet the measurable limit of AMS radiocarbon dating method, one in excess of 43,500 rcyBP (Blind 9), and the other dating to 40,890 ± 480 rcyBP (Blind 14). It is highly unlikely that hunter-gatherer groups constructed features at the 5BL148 game drive or occupied the site as early as 40,000 years ago. One other charcoal date provides a more plausible estimation of a past hunter-gatherer occupation episode, with a conventional radiocarbon age of 5100 ± 30 rcyBP (Blind 15), which situates within the Early Archaic period in the CFR. There are two prominent probability peaks and a slight plateau in the calibrated 2σ range for the Early Archaic period age-estimate for the charcoal sample from Blind 15 (Figure 35), indicating that the occupation period most likely occurred between 3968 to 3896 cal BCE or 3881 to 3800 cal BCE. It is problematic to attempt to define the age of the potential occupation event of Early Archaic hunter-gatherer groups at 5BL148 with high resolution, due to the plateau in the calibration curve, but the median age provided by the 2σ range is 3884 cal BCE.

Table 20. Radiocarbon results of three charcoal samples from the 5BL148 game drive, Rollins Pass, Colorado. IntCal13 atmospheric curve used in calibration of radiocarbon dates (Reimer et al. 2013). OxCal v4.3.2 used for calibration dataset processing (Bronk Ramsey 2017).

Laboratory Number	Feature Number	Material	No. of Particles/ Cumulative Mass (g)	Largest Grain Diameter (mm)	Uncalibrated Age (rcyBP)	2σ Calibrated Date Range (calBCE)
Beta-488942	5BL148.9	Charcoal?	8 / 0.057	9	> 43500	Not calculated
Beta-488943	5BL148.14	Charcoal?	10 / 0.011	4	40890 ± 480	Not calculated
Beta-488944	5BL148.15	Charcoal	14 / 0.011	3	5100 ± 30	3968 - 3896 (37.2%); 3881 - 3800 (58.2%)

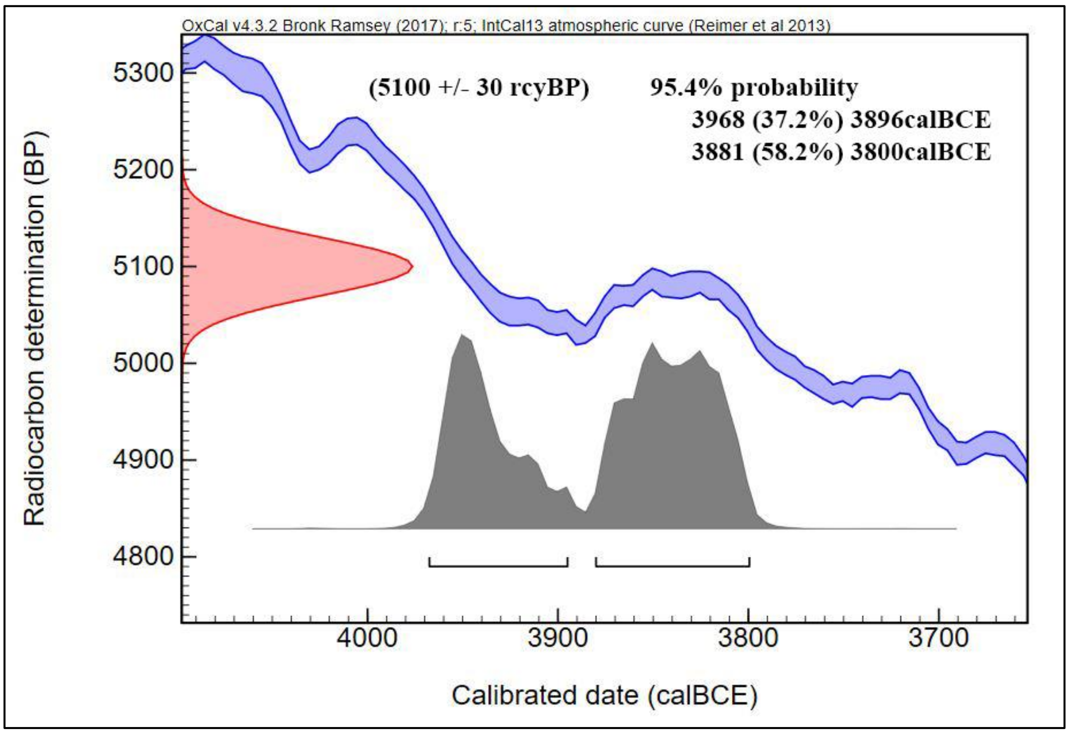

Figure 35. Two-sigma calibrated charcoal date from 5BL148 from the Early Archaic period.

Discussion and Conclusion

Absolute dating of bone and charcoal samples from the 5BL148 game drive site suggest that hunter-gatherer groups could have occupied the site during the Early Archaic, Early Ceramic, and Protohistoric periods. However, none of the samples submitted for dating are unequivocally derived from cultural processes at the site. Surface mapped and sampled bone fragments from 5BL148 are located in close association to stone walls, but there are lacking physical attributes such as cutmarks to suggest a direct association with hunter-gatherer butchery activities. One of the dated bones, specimen 2017.21, shows evidence for spiral fracturing from differential torsion, but it is uncertain whether human modification alone created the observed fracture. It is also difficult to estimate whether the prevalence of certain bone elements, primarily low utility lower limb elements (Binford 1978b, 1981), are indicative of segmental transport from cultural processes or instead the complications of preservation in harsh environments such as the alpine tundra.

The lack of cultural context is also of major concern for radiocarbon dates on charcoal samples. The author and CMPA graduate student crew members did not identify any additional evidence for thermal features (ash stained sediment, fire-cracked/altered stones, abrupt differences in soil-texture), during the soil-core probing or post-sediment processing of samples from hunting blinds at 5BL148. The narrow diameter of the sediment probe (2.5 cm) could provide an explanation for the paucity of materials recovered in tested blinds. However, the density of charcoal accumulation for submitted samples, and the largest observed grain diameters, are mostly consistent with the expectations for anthropogenic charcoal accumulation in CFR alpine tundra environments as discussed by Benedict (2002). The Early Archaic period charcoal sample from Blind 15 meets the 3 mm grain diameter cutoff for anthropogenic deposition of charcoal. Larger charcoal grain diameters are documented for the exceptionally ancient radiocarbon dates from Blinds 9 and 14, but those particular samples could represent pyrolized wood charcoal, diagenetic vitrinite from ancient root remains, or more likely railroad coal. The aforementioned carbonaceous sample types yield highly comparable conventional ages of directly dated and weathered granitic rock surfaces and non-cultural carbonates (Beck et al. 1998; Crook 2015), that are similar to the oldest charcoal dates presented in this thesis.

CHAPTER V – SPATIAL ANALYSIS AND PALIMPSESTS

The previous chapters in this thesis described the various types of material and temporal information collected at the 5BL148 game drive, as well as the results of independent methods of chronological reconstruction. This chapter uses a spatial approach to address the temporal data (projectile points, lichenometric dates, and radiocarbon dates), in order to understand whether the geographical positions of artifacts, bones, and features are representative of a discrete occupation episode or instead spatially overlapping accumulations of material at the site (palimpsests). A visual and spatial statistics-based approach is undertaken to address the presence or absence of palimpsest deposits of artifacts, bones, and features which comprise onsite activity areas. The spatial and statistical methods used in the following analyses sections are supported by archaeological theories concerning the spatial signatures of single occupation episodes and multiple occupation episodes in the prehistoric record.

Theory in Spatial Analysis

Game drives at Rollins Pass and elsewhere in the CFR are best considered as an accumulated record of the various behavioral and cultural practices of hunter-gatherer groups (Binford 1981b, 1982; LaBelle and Pelton 2013:61; Rossignol and Wandsnider; Stiger 2001). One method of organizing the diversity of sites and the functional characteristics associated within and between them is to order archaeological phenomena on the basis of time-scales (Lucas 2008). As this thesis addressed in the previous chapters, varying forms of material evidence left at hunter-gatherer sites retain differential resolution of chronological information. As an example, some forms of material culture are temporally bounded to coarsely defined periods in prehistory or history at the scale of centuries or millennia, whereas the detritus of human-made fire or bone fragments deposited during an occupation episode can provide a higher resolution age-estimation for an occupation event.

Archaeologists are limited in their ability to reconstruct hunter-gatherer occupation chronologies in challenging geological contexts, such as deflated alpine environments, especially when materials at sites are characterized by different age-resolutions. Archaeological phenomena that are temporally distinct are subsumed into spatial equifinality in deflated surface contexts at alpine sites. In other words, materials of different ages that are dated by archaeologists with a variety of methods are often entered into a single, deflated geological context as a result of taphonomic processes. This challenge is particularly relevant for alpine game drive research. Game drives provide evidence of a physical signature of a unique hunting strategy, but in order to identify when hunter-gatherers constructed and used game drives there must be congruence between the spatial and functional context of temporal data, as well as the resolution of temporal data. The deposition of archaeological materials over the course of time, at any given location within a site or site locus, may or may not result from the continuity or deviation from a particular set of behaviors. It is possible that game drive sites were not used exclusively as areas for hunting animals at all times in the past, and it is important to determine how the temporal data reflect specific or general behaviors of hunter-gatherer groups. There are spatial justifications needed to relate the temporal data from game drives sites to the behavioral and structural characteristics which typify game drives as hunting sites, specifically.

The occupational history of a site consists of its intended function or use during a particular time or period, as well as the changes or consistency in site use during reoccupation events (Camilli 1983). The challenge of distinguishing distinct occupations at sites is partially dependent on the structure of cultural site formation processes. In order to confront issues in the identification of discrete (or relative) occupation episodes at open-air surface sites, an analysis of assemblage structure and the spatial context of material culture is necessary (Binford 1981b; Camilli 1983; Camilli and Ebert 1992; Stiger 2001). Special purpose sites or loci within sites, such as hunting and animal processing areas, exhibit an internal consistency in the types of accumulated cultural material as related to the function of the site or locus (Camilli 1983:68-69), and reoccupation episodes of the same function create a patterned redundancy in the cultural material composition (artifact and feature assemblages) at a specified site or locus. In this sense, game drive site reoccupation at the temporal scale of days, weeks, years, centuries, or millennia, creates a material record of generally consistent artifact types and feature forms if the nature of reoccupation episodes is constant with the primary site structure of game drives: use for hunting preparation, active hunting, and post-hunt animal processing.

A single occupation episode at a game drive site could result in multiple artifact discard events from several spatially distinct clusters of activity related to feature construction/use, animal hunting and processing, but also pre-hunt preparatory tasks such as chipped stone tool production and/or maintenance (Benedict 1992; LaBelle and Pelton 2013). The hypothesized communal nature of alpine game drives in the CFR further suggests that numerous spatially distinct clusters of activity could occur during a single occupation episode, as related to the potential divisions of group labor (Binford 1978a, 1978b). Subsequent occupation episodes by the same hunter-gatherer group at a game drive may skew the visibility of the occupation intensity from a previous occupation episode, if the deposition of material culture (including both features and artifacts) followed the same behavioral and spatial site structure as the previous occupation. Recurring occupations at a single game drive site, by differing cultural groups over the course of centuries or millennia, could produce a multitude of both overlapping and spatially distinct activity areas, rendering the record of time-dependent events at an alpine game drive archaeologically indistinguishable.

There are multiple types of palimpsest deposits that occur in the archaeological record at the locus, site, or landscape spatial scales. Bailey (2007:203-208) defines five different modes of palimpsest deposits, each characterized by cultural, temporal, and spatial variables that are not necessarily mutually exclusive of one another. Only four palimpsest types are discussed herein. True palimpsests are archaeological deposits that represent the most recent occupation episode, exclusive to any evidence for previous occupations, regardless of any potential behavioral differences in the accumulation of material. At alpine game drives in the CFR, one possible example of a true palimpsest is the erasure of previous wall construction events due to rock-robbing for a subsequent wall construction or wall modification event. Cumulative palimpsests, instead, represent deposits from successive occupation episodes with some preserved evidence for the accumulation of material culture from each deposition event, but the individual events are difficult to distinguish on the basis of time due to mixing and reworking of materials. An example of a cumulative palimpsest at a game drive site includes the use of a single intercept area by hunter-gatherer groups for centuries and millennia, where broken or lost projectile points from different occupation periods are spatially clustered together. Similar to cumulative palimpsests are spatial palimpsests, but for spatial palimpsests the evidence for reoccupation episodes are distributed unequally across the specified scale of observation (landscape level, site level, or even locus level) as well as in the resolution of the temporal data. Spatial palimpsests are particularly relevant for discussions of the accumulation of material across space at open-air assemblages in alpine environments. Temporal palimpsests represent aggregations of material during a single occupation event, but the aggregated material types are of different ages, even though the deposition event is of a single age. At a game drive site, hunter-gatherer recovery, use, and discard of tools from previous occupation episodes provides one possible example of a temporal palimpsest.

In order to identify the presence or absence of palimpsest deposits at the 5BL148 game drive, the author uses a visual and spatial-statistics based approach to 1) statistically classify significant artifact and feature clusters and discuss the potential functions of those activity areas, and 2) address the spatial positions of the relatively and absolutely dated assemblage with consideration for activity area types. Previous studies at alpine game drive in the CFR argue that that multiple hunter-gatherer activity area types are represented at game drives, including game intercept areas, tool workshops, and animal processing locales (Benedict 1992; LaBelle and Pelton 2013; Whittenburg 2017). Characteristics of the assemblage, described in-depth in the previous chapters in this thesis, aid in the functional reconstructions of site activity areas and assemblage clusters at 5BL148. Further, the results from the following spatial analyses contribute to a broader understanding of the changes in the use of space at 5BL148 over the course of time, which allows for a holistic reconstruction of site function, site structure, reoccupation, and the challenges of alpine chronology reconstruction.

Methods – Spatial Analysis of the Artifact and Faunal Assemblage

The author used a complimentary set of spatial analysis tools in the ESRI program ArcGIS v.10.6.1 to display and query spatial data collected as part of the CMPA's recent site investigations, including the mapped positions of artifacts and bones. The assemblage from 5BL148 (excluding items of unknown provenience) is used in a spatial clustering study with three distinct but supportive tools in the Spatial Analyst toolset of ArcGIS: The Average Nearest

Neighbor tool, the Multi-Distance Spatial Cluster Analysis tool (Ripley's K-function), and the Kernel Density tool.

The Average Nearest Neighbor (ANN) tool is used to determine whether the distributions of mapped artifacts and bones are the product of random chance, if the distributions are significantly dispersed, or if the distributions are significantly clustered (Figure 36). The ANN tool measures the distance between each data position to the other nearest position for all incidences in the sample, and then the average of all neighboring distances is calculated. If the average calculated distance for incident data types in the ANN is less than a hypothetical average distance for a modeled random distribution of data, then the distribution for that incident data type is significantly clustered. Conversely, an average distance that is greater than a modeled random distribution in the ANN indicates that the data distribution is significantly dispersed. The hypothetical random distribution modeled in the ANN tool is dependent on the frequency of incident data positions, but also the spatial scale of the study area, and thus the results of the ANN are highly sensitive to potential observer biases such as pedestrian survey coverage or natural areas constraints such as cliffsides and vegetation cover. The ANN is used in this thesis to consider the presence or absence of statistically significant clusters at the site-scale level, which encompasses an area of more than 6.5 hectares considering the size of the minimum enclosing rectangle around features and artifacts at 5BL148.

It is also necessary to understand at what spatial scale of analysis a cluster is determined to be statistically significant or insignificant. The spatial scale of cluster significance is used to provide a means to address whether the distribution of materials is divisible by variable cluster sizes that may or may not represent distinct activity areas. The Multi-Distance Spatial Cluster Analysis tool (MDSCA) is used to measure the statistical significance of clusters over a range of distances. MDSCA is based upon the Ripley's K-function, which is useful to illustrate how the spatial clustering or dispersion of incident data positions changes at increasing intervals of neighborhood size. MDSCA works by computing the average frequency of neighboring incident data that are associated with each individual data position at a specified distance interval (in this thesis one-meter intervals are used for neighborhood sizes). The MDSCA compares the observed average frequency of neighboring data points with an expected average frequency of the data, derived from a random distribution at the same spatial scale. The MDSCA populates a neighborhood with a random distribution of points based on a user-defined permutation level, which creates the confidence level used to determine statistical significance. In this thesis, the author used a permutation level of 99, meaning that the MDCSA tool randomly distributed points in the study area 99 times over each scalar iteration, equating to a 99 percent confidence level. The output of the MDSCA are K values, which are used to determine significance of clusters at each scalar interval. When observed K values are larger than expected K values, and also higher than the expected confidence envelope values for a specified distance, then the data distributions are significantly clustered at that specified distance interval (Figure 37). In sum, the MDSCA tool allows the user to determine the approximate scalar values that data clusters are statistically significant.

The MDSCA is used to further assist in a visual approach to designating site clusters at 5BL148. The Kernel Density tool is used to provide a predictive visual contour overlay of high-density and low-density incident data clusters, such as clusters of artifacts or bones. The Kernel Density tool calculates the density of data in a circular neighborhood surrounding each incident position, dependent on a user specified bandwidth (in this thesis 0.5-meter bandwidths are used for neighborhood sizes). The results of the MDSCA are used to interpret the Kernel Density values and to show at which density values the clusters of incident data are statistically significant. Following the application of the density contours produced by the Kernel Density tool, the author designated quantitatively and qualitatively defined clusters of hunter-gatherer activity at 5BL148.

The author then classified various activity area types dependent upon the different material compositions of cluster areas. The results of the activity area designations are individually summarized in the following sections by assemblage type (artifacts and bones). The author used the functional interpretations of artifact types and the observed artifact use-wear characteristics (breakage type, edge-wear) to classify hunter-gatherer activities that are represented in artifact clusters at 5BL148. Temporally diagnostic chipped stone tools (projectile points) and other chipped stone tools are plotted within artifact clusters to aid in interpretations of palimpsest activity and the spatial signatures of discrete or overlapping occupation episodes. Clusters of bone are explored in terms of their relationship with stone feature locations to aid in interpretations of hunter-gatherer activities, or instead lacking evidence for hunter-gatherer association, to determine the presence or absence of hunter-gatherer primary butchery areas at 5BL148. Radiocarbon dated bone specimens from 5BL148 are plotted in the summarized distributions to aid in the interpretations of cultural site structure, or instead natural taphonomy issues.

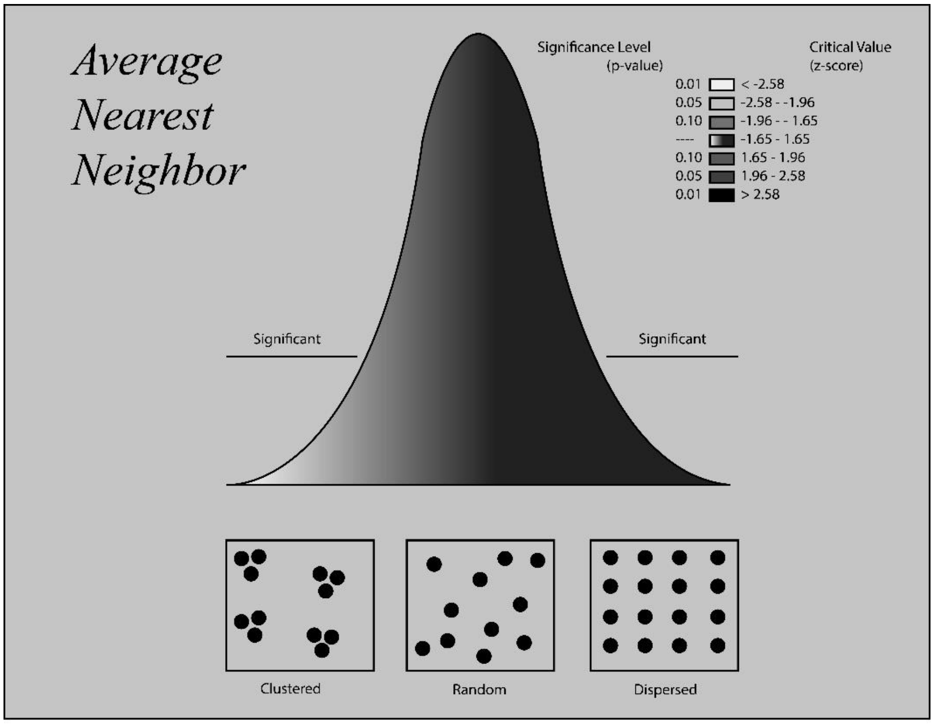

Figure 36. Conceptual diagram of Average Nearest Neighbor tool statistical output with distribution of significance levels (p-value) and critical value (z-score).

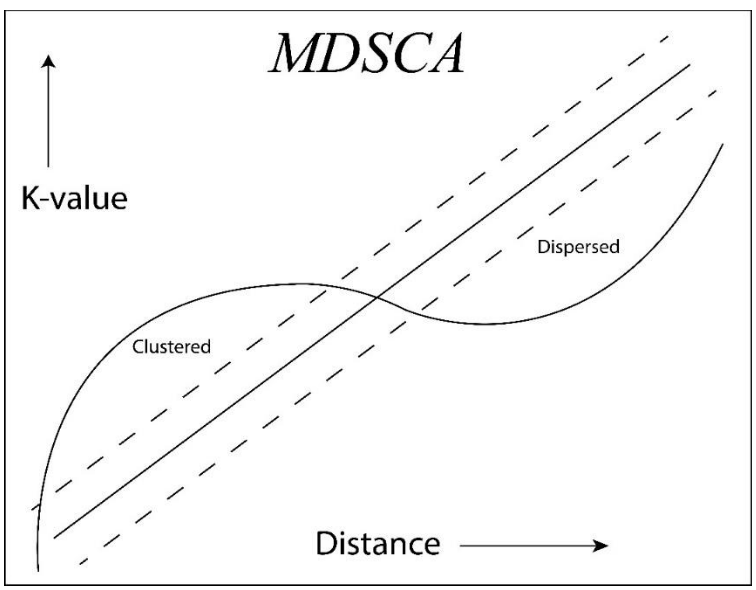

Figure 37. Conceptual diagram of Multi-Distance Spatial Cluster Analysis tool statistical output, with high and low confidence envelopes (dashed lines), expected distribution (straight line), and hypothetical observed distribution (sigmoidal line).

Results – Spatial Analysis of the Artifact and Faunal Assemblage

A spatial analysis of artifacts and bones highlighted several statistically significant clusters at the 5BL148 game drive site. Further, the plotted distribution of temporal data indicates that the 5BL148 game drive represents a spatial palimpsest (Bailey 2007), comprised of both overlapping and discrete activity areas but with differential temporal resolution. Individual activity areas at 5BL148 most likely reflect several forms of palimpsest deposits within the overarching spatial palimpsest of 5BL148, including cumulative palimpsests, and a potential temporal palimpsest. Incident data clusters are reviewed by assemblage type and assessments for potential hunter-gatherer activity areas are discussed.

Artifact Clusters and Activity Areas

The methods applied via the spatial analyst toolset in ArcGIS yielded results that allow for both visual and statistical observations of chipped stone artifact activity area distributions at 5BL148. The ANN tool demonstrated that the observed distribution of chipped stone materials, mapped from both surface and subsurface contexts at the site, exhibits statistically significant clustering with consideration for the entire site area. The observed mean distance of nearest neighbors in the chipped stone artifact distribution is 9.6 meters, whereas the mean distance of the expected random distribution computed by the ANN tool is 13.8 meters for nearest neighbors. A z-score of -2.9 and a p-value of 0.003 suggests that there is less than a one-percent chance that the clustered artifact pattern observed with the ANN tool is the product of random chance, and the null hypothesis is rejected (Table 21).

The MDSCA tool showed that artifact clusters at 5BL148 are significant up to 48 meters beyond the computed centroid of clusters, with a 99 percent confidence level. The observed K-values of the artifact distribution rise sharply between the 1-meter and 20-meter neighborhood levels, and then plateau between 20-meter and 40-meter neighborhood levels. Critically, the high and low confidence envelope values plateau sharply beyond the 48-meter neighborhood interval, suggesting that the small sample size of mapped artifacts size limit the use of MDCSA tool for statistical computing (Figure 38). The use of the MDSCA tool for other archaeological studies report significant deviations for high and low confidence envelopes due to low sample sizes (Casarotto et al. 2016; Fisher et al. 2016; Rice 2015:85; Sayer and Weinhold 2013). Yet, the results of the MDSCA are useful for showing spatial patterning over various distances in samples with low frequency distributions. Artifact clusters with high densities at the scale of 2304 square meters (48m x 48m) or less are considered significant for activity area designations.

The Kernel Density tool confirms that there are two spatially distinct artifact clusters which meet the size-based criteria for activity area designations at 5BL148 (Figure 39). Cluster 1 is the largest and densest artifact cluster at the site, and it consists of 17 artifacts in an area comprising 690 square meters. Cluster 2 is located 164 meters to the northeast of Cluster 1, and it consists of four artifacts within an area of 121 square meters. Figure 39 depicts the predictive density contour overlays produced by the Kernel Density tool. Two other artifacts are not distributed into clusters at 5BL148, a broken bifacial knife fragment (2013.1) and chipped stone flake (2017.17) recovered from a hunting blind.

Table 21. Summary data for results of Average Nearest Neighbor tool and artifact distributions at 5BL148.

Observed Mean Distance (m)	Expected Mean Distance (m)	Nearest Neighbor Ratio	z-score	p-value
9.6	13.8	0.7	-2.889	.004

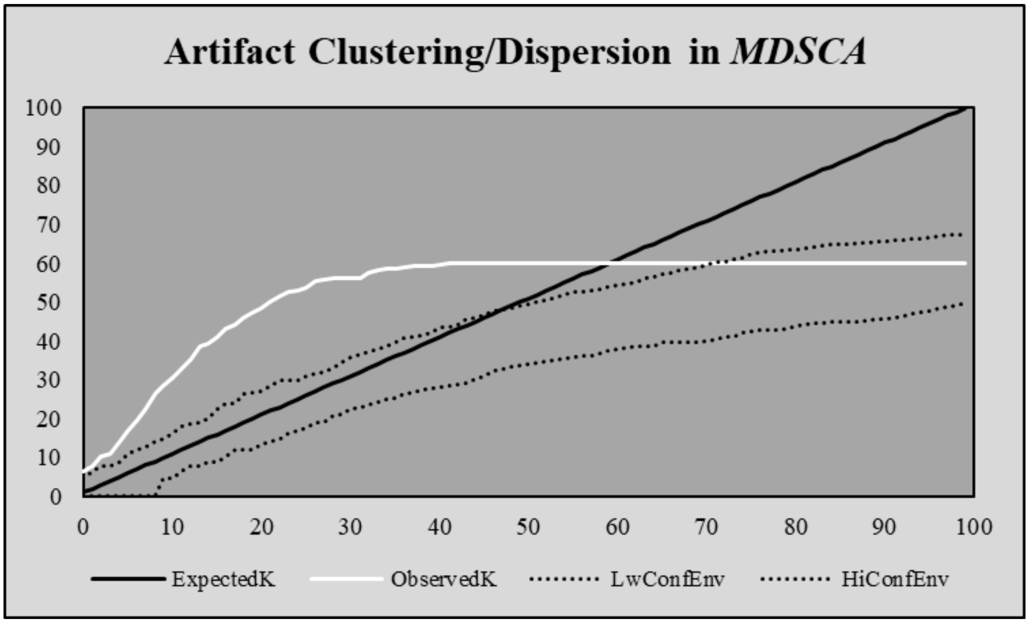

Figure 38. Graphical representation of Multi-Distance Spatial Cluster Analysis tool applied to artifact distributions at 5BL148.

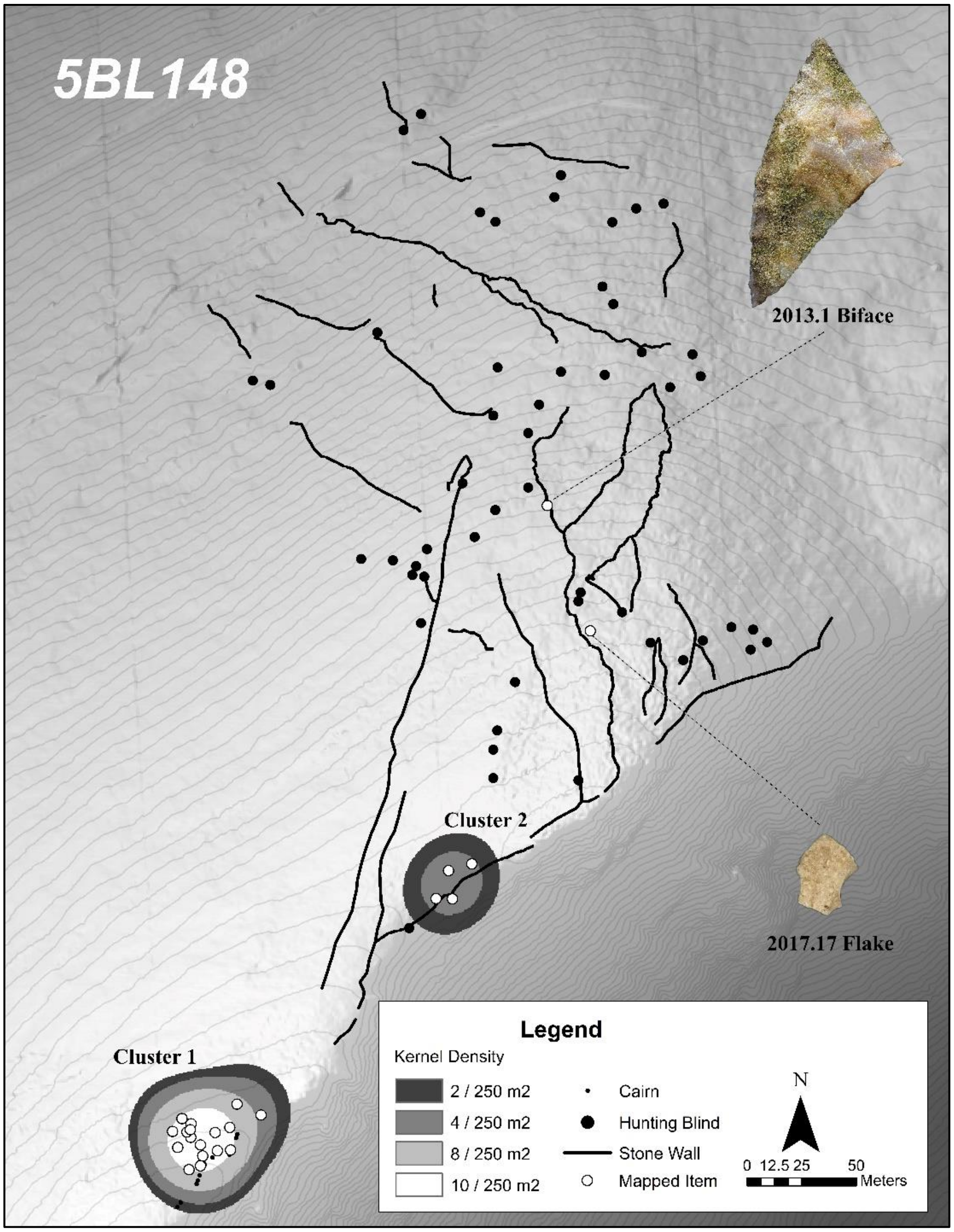

Figure 39. Map of the 5BL148 game drive depicting features, artifact locations, and artifact cluster areas.

Cluster 1

Cluster 1 is characterized by a diversity of formal and non-formal chipped stone tools and unmodified lithic debris (Table 22). In-depth summaries of artifact types and use attributes were presented earlier in this thesis. Projectile points are the most dominant tool class represented in Cluster 1 (n=6), followed by unmodified lithic debris (n=5), edge-modified flake tools (n=3), bifaces (n=2), a single scraper, and a single drill. In terms of frequency of mapped specimens, Cluster 1 includes 78 percent of all surface mapped chipped stone artifacts. Projectile points in Cluster 1 include a near complete specimen (n=1), multiple proximal fragments (n=3), and midsections (n=2). No distal fragments of projectile points are documented in Cluster 1. Bifaces from Cluster 1 include a complete early-stage edged/thinned biface and one early-stage edged biface midsection. Neither of the generalized bifaces represent finished tool forms. A hafted bifacial drill specimen is documented in Cluster 1, but it is an incomplete midsection. Edge-modified flake tools in Cluster 1 each show evidence for use in cutting and scraping actions, as denoted by rounded edges and small step fractures.

The author argues that several activities occurred in the area comprising Cluster 1. The presence of multiple, early stage bifaces and larger size classes of unmodified lithic reduction debris in Cluster 1 suggests that tool production took place during the pre-hunt or post-hunt stages of site occupation. Projectile point specimens in Cluster 1 are primarily represented by proximal fragments that hunter-gatherer groups likely transported and discarded following exhaustion from use at a kill locale. Formal and informal scraping and cutting tools are documented in Cluster 1 as well, indicating that post-hunt, early stage animal processing activities likely occurred (Whittenburg 2017). Each line of evidence suggests that Cluster 1 does not represent a kill locale, but that pre-hunt and post-hunt activities took place, including tool production and discard, animal processing, and potentially other forms of domestic tasks such as hide-working, as indicated by the hafted drill specimen which may have been used for hide working. The single cairn line identified at the site (feature 71) is located adjacent to Cluster 1, but the function of the cairn line and its potential relationship to the distribution of artifacts is unclear (Figure 40).

All of the time-diagnostic projectile point specimens from the site are also located in Cluster 1, which complicates the temporal resolution of the activity area. There are no sub-concentrations of material within Cluster 1 to permit an association of any of the non-diagnostic lithic materials with time-diagnostic projectile point specimens. The Early Archaic, Middle Archaic, and Late Prehistoric era tools are distributed in an area encompassing 120 square meters, within the overall 690 square meters of Cluster 1 (Figure 40). There are two potential palimpsest activity types that help to explain the distribution of materials in Cluster 1. The distribution in Cluster 1 could represent a cumulative palimpsest, where hunter-gatherer groups reoccupied and deposited materials relating to the pre-hunt and post-hunt activity phases of game drive use, within a space confined to 690 square meters. Cluster 1 is found at the flattest portion of the site and it contains an immense viewshed of the lower-elevation u-shaped valleys beneath the Continental Divide, and though this is not quantitatively proven in this thesis, it is expected that hunter-gatherers would have reoccupied the most comfortable spaces (flat areas) as opposed to the steep and rugged terrain located elsewhere at the drive when performing pre-hunt and post-hunt activities. Another possible explanation for the distribution of materials is that a more recent hunter-gatherer group scavenged time-diagnostic points of earlier periods and discarded them in Cluster 1, indicating a temporal palimpsest event.

Table 22. Cluster 1 summary data for cluster size and artifact frequency by type at 5BL148.

Cluster Size (m^2)	Artifact Frequency	Projectile Points	Bifaces	Drills	Scrapers	Modified Flakes	Debitage
690	18	6	2	1	1	3	5

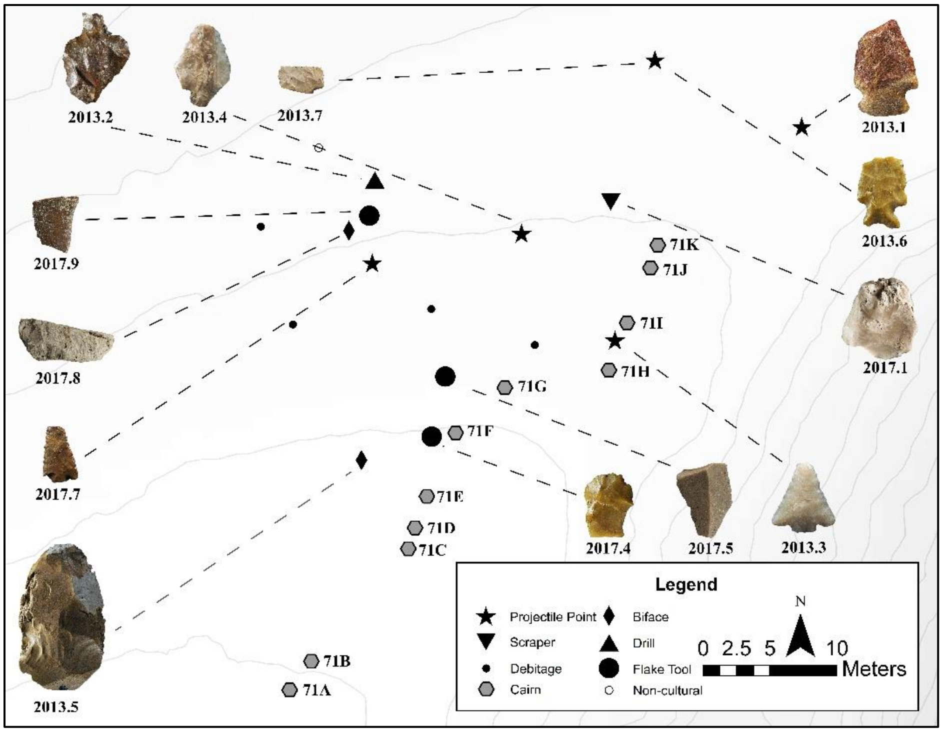

Figure 40. Map of the Cluster 1 artifact concentration and activity area at 5BL148.

Cluster 2

Cluster 2 is best described as a low frequency but moderate density cluster of chipped stone tools and debitage (Figure 41). A single projectile point midsection is represented, as are two modified flake tools and one piece of unmodified lithic debris (Table 23). Cluster 2 is comparable with artifacts represented in Cluster 1, but to a lesser degree in terms of overall size, frequency of artifacts, and artifact diversity. The only formal tool in Cluster 2 is a broken projectile point midsection. Modified flake tools in Cluster 2 each show evidence for scraping/cutting use, and the single piece of lithic of debris represented in Cluster 2 is exceptionally large which indicates, most likely, lithic core reduction or tool production tasks rather than tool maintenance. The low frequency of specimens in Cluster 2 may indicate that the cluster is representative of a single occupation episode, but as there are no time-diagnostic materials from Cluster 2, it is not possible to ascertain a relative or absolute age-estimation for the activity area. The blade outline trajectory of the broken projectile point represented in Cluster 2, as well as the thickness of the tool, provide some indication that the point is manufactured as a dart point rather than a spear or arrow point, but this is not certain. However, the similarities in potential activities represented between Cluster 2 and Cluster 1, and the distance between the clusters, suggests that each of the clusters likely represents a temporally unrelated occupation or multiple occupation events characterized by similar activity types. The evidence for spatially distinct clusters of similar activity types supports that separate occupation episodes occurred, and each of the clusters contain unequal representations of temporal information, indicating a spatial palimpsest effect (Bailey 2007).

Table 23. Cluster 2 summary data for cluster size and artifact frequency by type at 5BL148.

Cluster Size (m^2)	Artifact Frequency	Projectile Points	Bifaces	Drills	Scrapers	Modified Flakes	Debitage
121	4	1	0	0	0	2	1

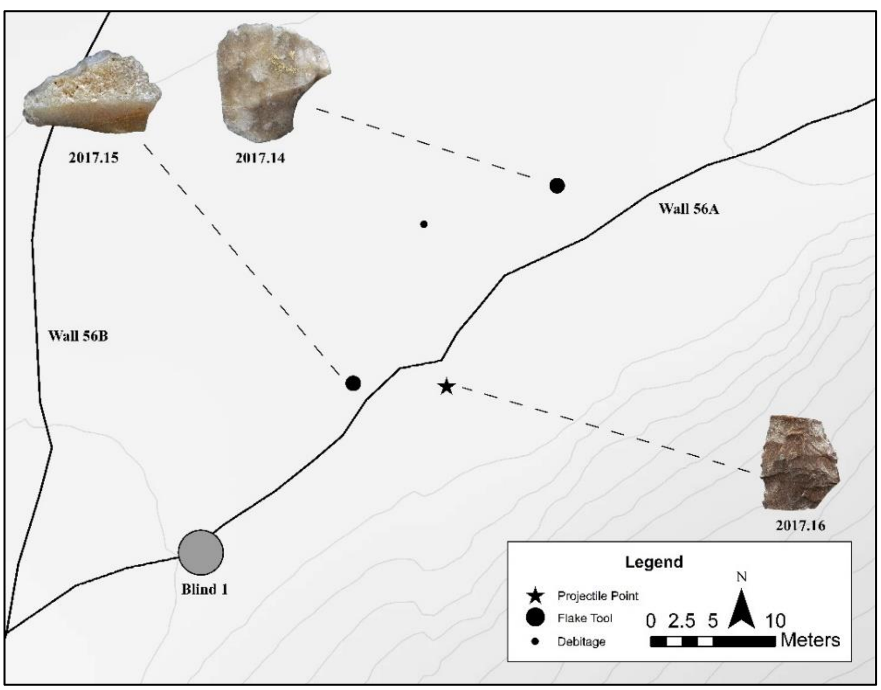

Figure 41. Map of the Cluster 2 artifact concentration and activity area at 5BL148.

Mapped Bones and Wall Features

The Spatial Analyst toolset in ArcGIS did not yield statistically significant results for bone clustering at the 5BL148 site. Rather, the ANN tool demonstrated that the distribution of mapped faunal specimens exhibited a statistically significant dispersed pattern. The observed mean distance between nearest neighbors in the bone distribution is 47.8 meters, while the mean distance of the expected random distribution computed by the ANN tool is 29.7 meters. In the case of faunal specimens at 5BL148, a z-score of 3.5 and a p-value of 0.0006 indicate that there is a less than one-percent likelihood that the dispersed pattern of bones is the product of random chance (Table 24). It is important to consider here that observer bias plays a critical role in the use of the *ANN* tool during analysis with 1) exceptionally low frequency sample sizes, and 2) incompletely surveyed study areas. The author did not explore additional spatial clustering analyses for faunal remains at 5BL148, following the results of the ANN tool application. In sum, the distribution of bones at 5BL148 should not be argued to reflect a clustered refuse area of discarded bone fragments from animal processing activities during a single occupation or multiple occupation episodes.

The occurrence of faunal specimens at alpine game drive sites in the CFR are rarely considered as definitive archaeological evidence of prehistoric hunter-gatherer activity (Benedict 1975a; LaBelle and Pelton 2013). This is especially true for surface mapped faunal specimens at game drives, presently unreported at any other game drive site in Colorado. Bones from subsurface contexts in hunting blind features are documented at several other game drives in the CFR, and bones from the interior of blind features are better attributed to hunter-gatherer refuse than any specimens mapped on the surface of sites. At 5BL148, the lack of anthropogenic bone modification further limits the use of the bones as indicators of past hunter-gatherer behaviors.

However, the author considers several of the bone specimens from 5BL148 as archaeologically informative. Nearly all faunal specimens are mapped within, immediately adjacent to, or very close to stone wall features at the site (within 15 m of walls). Photo documentation of several game drive sites shows that modern animal populations, such as herds of mule deer, elk, and bighorn sheep continue to travel along stone walls despite the considerable time since their abandonment years ago (LaBelle personnel communication). Natural and/or culturally induced animal deaths, evidence by bone distributions, could have occurred at a time when the stone features existed on the landscape. It is difficult to prove the association between degraded bone remains and wall features at 5BL148 based on spatial distributions alone, given that the extent and breadth of wall features at the site covers most occupiable/navigable space on the landscape, but the distributions that are present show that animals did perish in very close proximity to walls in most cases.

The author used the absolute age of dated bone specimens at 5BL148 as another means to provide a minimum age for the presence of stone features on the landscape at 5BL148, despite the possibility (or probability) that those faunal specimens reflect non-cultural or natural death events of migratory animals (Table 25). The author recovered specimen number 2017.21 (dated to 1726-1814 cal CE) from between wall stones in feature number 53A. CMPA field crew members recorded specimens 2017.20 and 2017.26 (dated to 615-694 cal CE and 1721-1818 cal CE, respectively) immediately adjacent to feature number 55A. Importantly, the bone specimens are mapped and collected from wall features with accompanying lichenometric dates. Alignment A (wall 53A) shows a lichenometric age of 1756 cal CE, and the conventional age of specimen 2017.21 recovered from that wall is nearly identical. The maximum age of Alignment A cannot be further estimated, but the complimentary lichenometric and bone dates suggest that

Alignment A is at least Protohistoric in age and could represent a one-time construction event and/or wall use event in the eighteenth century. The positions of specimens 2017.20 and 2017.26 along feature 55A (Alignment C) are more problematic for minimum age estimation of the wall, but are still important for understanding the potential for time-averaging of lichenometric dates. The lichenometric age of Alignment C is 1744 cal CE, and while the conventional age of specimen 2017.26 is close to lichenometric age of Alignment C, the conventional age of specimen 2017.20 is considerably older. If it is assumed that an animal death event occurred along Alignment C sometime around 615-694 cal CE as the date of specimen 2017.20 suggests, then the late lichenometric age of Alignment C and bone date of specimen 2017.26 could indicate an erasure of older lichen profiles by a more recent hunter-gatherer groups during wall modification events, perhaps at the termini (spatial ends) of the wall alignment. Figure 42 illustrates mapped faunal specimens and absolutely dated remains.

Table 24. Summary data for results of Average Nearest Neighbor tool and bone distributions at 5BL148.

Observed Mean Distance (m)	Expected Mean Distance (m)	Nearest Neighbor Ratio	z-score	p-value
47.8	29.7	1.6	3.5	.0004

Table 25. Summary data for the distribution of dated bones and spatial proximity to stone wall features at 5BL148. The highest probability dates of the 2σ calibrated range are presented for each bone.

Laboratory Number	Specimen Number	Element	Calibrated Age (calCE)	Proximity to Wall (m)	Stone Wall Alignment	Lichenometric Wall Age (calCE)
Beta-488945	2017.21	Fragment	1726-1814	0	A	1756
Beta-504029	2017.20	Innominate	615-694	1.8	C	1744
Beta-504030	2017.23	Innominate	1729-1810	13.9	50A	Not available
Beta-504031	2017.26	1st Phalanx	1721-1818	0.3	C	1744

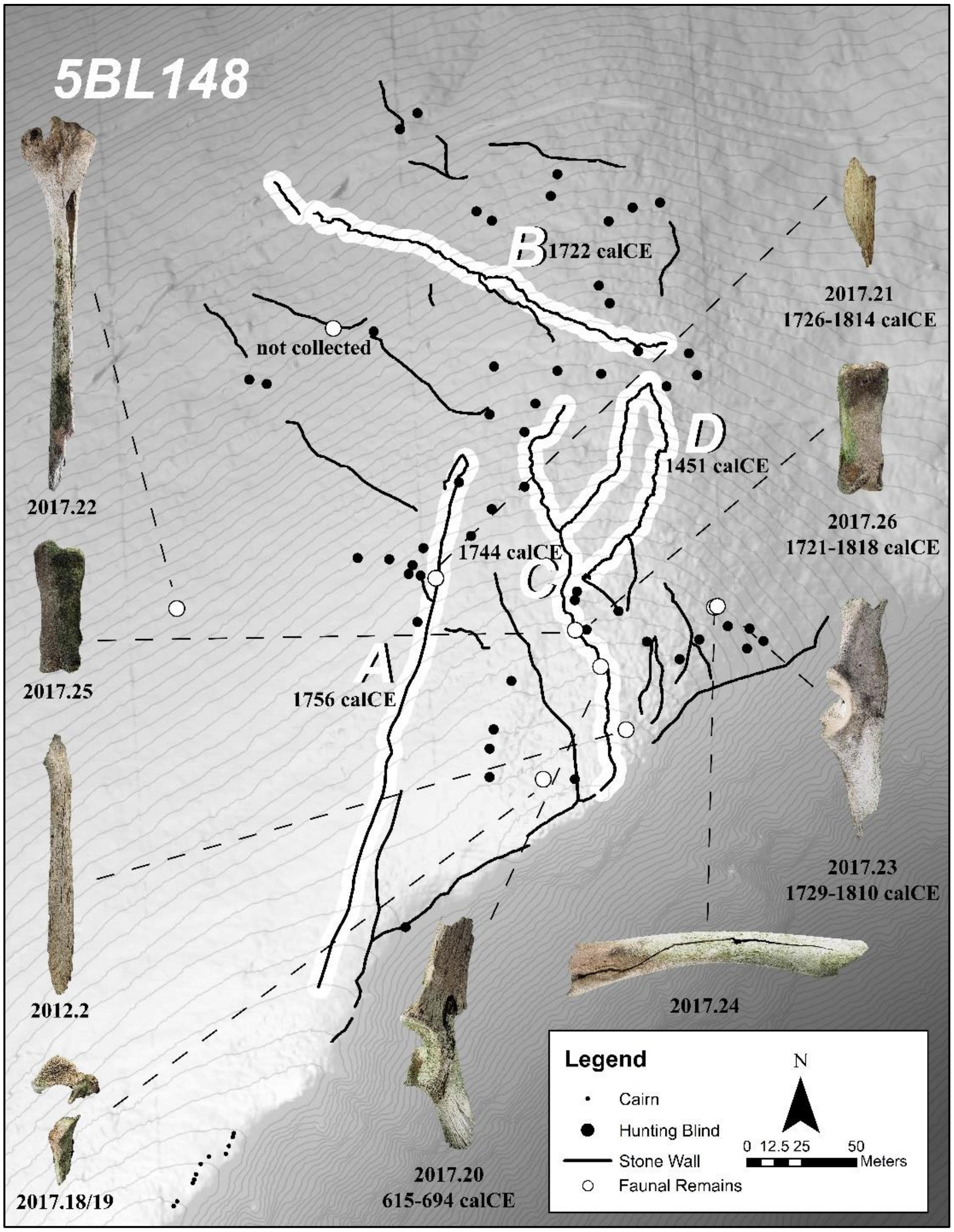

Figure 42. Map of the of 5BL148 game drive depicting features, faunal specimens, and lichenometry alignments.

Methods – Spatial Analysis of Game Drive Intercept Areas

The author used an additional suite of geospatial methods that support functional and theoretical concepts of intercept hunting to independently classify the presence or absence of a single intercept area or multiple intercept areas at 5BL148. Previous research at intercept hunting sites with characteristic features such as stone driving line walls or cairns and associated hunting blinds, demonstrated that hunting blind clusters in close proximity to v-shaped or u-shaped stone wall alignments are primary game intercept areas (Benedict 1992; Brink 2005; LaBelle and Pelton 2013; Whittenburg 2017). Further, larger size classes of hunting blinds closely correlate to game drive intercept areas, and are inferred to represent multi-person shooter pits to maximize the potential return for hunting (LaBelle and Pelton 2013; Whittenburg 2017). Natural topographic barriers probably served to funnel game into intercept locales at game drive sites as well (Benedict 1992), but natural site characteristics are not considered for this functional and temporal analysis.

The ANN, MDSCA, and Kernel Density tools are used to determine statistically significant clusters of hunting blinds at the 5BL148 site, but an additional toolset and further geometric computations allow for an independent methodology of game drive intercept area classification. The author used the Near tool in the Spatial Analyst toolset in ArcGIS to independently select the nearest stone wall features to individual blinds within statistically significant blind clusters. The author then used a Python script in ArcGIS to query the azimuthal orientation (degrees) of stone wall alignments at 5BL148, a process which designated a straight-line angle from the two termini of each wall feature.

Clusters of blinds and the azimuths of the two nearest stone wall alignments to blind clusters comprise the dataset for the intercept angle classification method (Figure 43). The author first calculated the interior angle formed by the intersection of the two nearest stone wall alignments to significant blind clusters at 5BL148, and then calculated the azimuth of the interior angle bisector for the two intersected walls used in the analysis. The intersect angle bisector azimuths (IBA), calculated for converging walls near blind clusters at 5BL148, equate to the opposing azimuth orientations of a straight-line approach into intercept wall convergences. The author does not argue that migratory animals approached game drive intercept areas at a straight-line orientation, rather alongside walls that comprise driving lines, but the bisected azimuth of converging walls represents a single variable unique to an intercept locale that can be tested for variation across a sample of intercept zones. The spatial distribution of intercept areas is discussed with respect for IBAs, to aid in interpretations of site function but also to discuss overlapping intercept area construction events and the presence or absence of palimpsests.

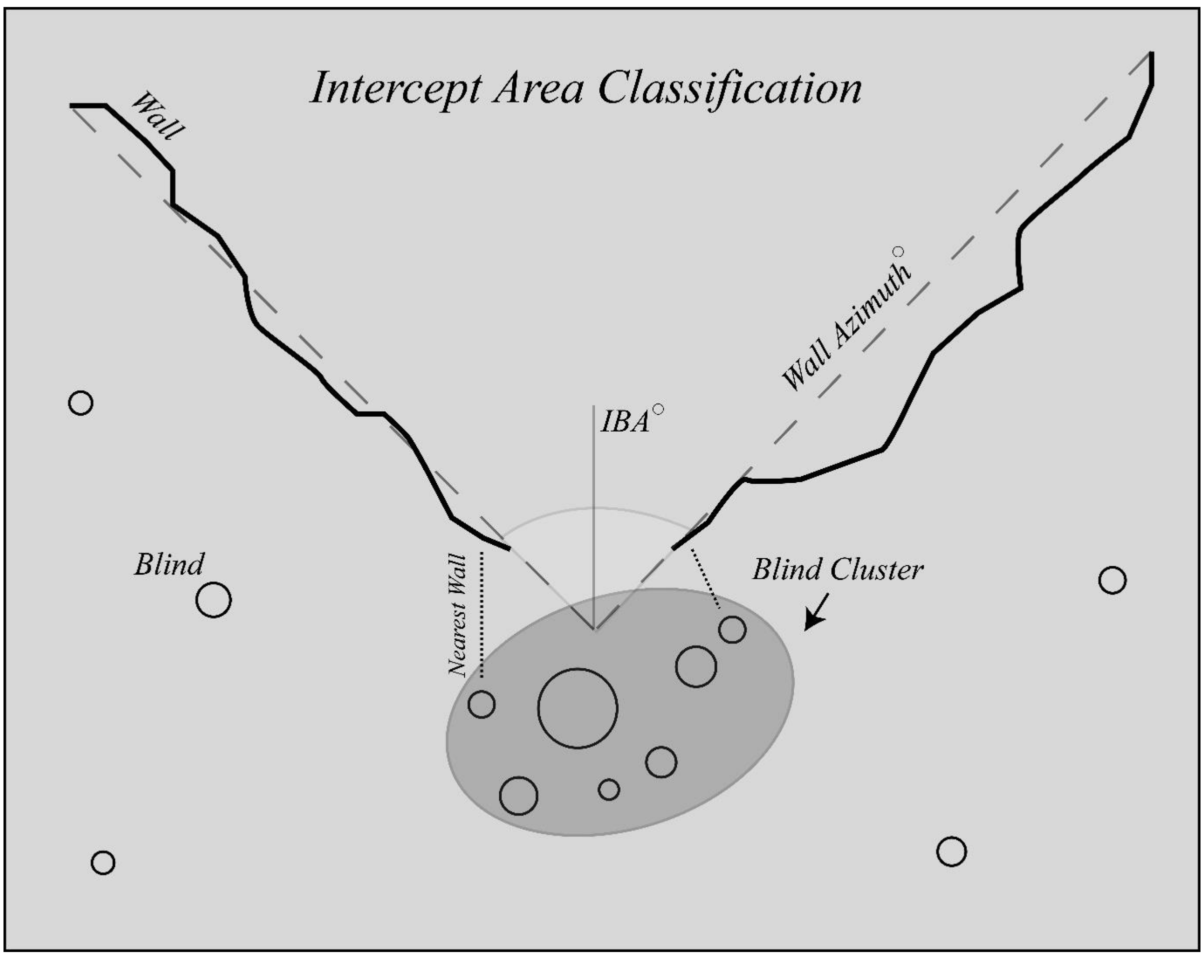

Figure 43. Conceptual diagram of the game drive intercept area classification method applied in the spatial analysis. Blind clusters are defined by ANN and MDSCA. Walls are independently selected and tied to individual blinds in clusters using the Near tool in ArcGIS, and wall azimuths are recorded. Interior angle of intersecting wall alignments is calculated, and the angle bisector is the resulting variable.

Results – Spatial Analysis of Game Drive Intercept Areas

Intercept area reconstructions at 5BL148 are produced from quantitative and qualitative evidence derived from 1) statistically significant clusters of blinds, 2) clustered blinds and adjacent wall segments, and 3) the orientation of the interior angles calculated for converging v-shaped and u-shaped wall alignments near blind clusters. The results of the following analyses indicate that more than one intercept area is present at 5BL148. Further, the spatial patterning of intercept areas at 5BL148 demonstrates that hunter-gatherer groups likely did not use all intercept areas during a single hunting episode. The positioning of intercept areas at 5BL148 suggest that reoccupation of the game drive occurred, though it is difficult to assign any of the intercept construction/use episodes to a particular period.

The Spatial Analyst toolset in ArcGIS yielded statistically significant results for feature clustering at 5BL148, and with an appropriate sample size (n=52) permitting a more robust justification for the methods applied in the intercept area analysis. The ANN tool demonstrated that the observed distribution of hunting blinds at the site exhibits statistically significant clustering with consideration for the entire site area. The observed mean distance of nearest neighbors in the hunting blind distribution is 15 meters, whereas the mean distance of the expected random distribution computed by the ANN tool is 19 meters for nearest neighbors. A z-score of -2.7 and a p-value of 0.006 suggests that there is less than a one-percent chance that the clustered blind distribution observed with the ANN tool is the product of random chance, and the null hypothesis is rejected (Table 26).

The MDSCA tool revealed that blind clusters at 5BL148 are significant between 10 and 42 meters beyond the computed centroid of blind clusters, with a 99 percent confidence level. The observed K-values of the blind distribution fall below the expected distribution at smaller neighborhood levels (from 0 to 4 meters), and then rise above the upper confidence envelope between the 10-meter and 42-meter neighborhood levels, and eventually trend back towards a dispersed pattern between the 43-meter and 100-meter neighborhood levels (Figure 44). The high and low confidence envelope values trend beneath the expected distribution beyond the 68-meter neighborhood interval. Blind clusters with high densities at scales between 100 square meters (10m x 10m) and 1764 square meters (42m x 42m) are considered significant, and are further warranted for intercept area designations.

Table 26. Summary data for results of Average Nearest Neighbor tool applied to hunting blind distributions at 5BL148.

Observed Mean Distance (m)	Expected Mean Distance (m)	Nearest Neighbor Ratio	z-score	p-value
15.0	18.7	0.8	-2.75	.006

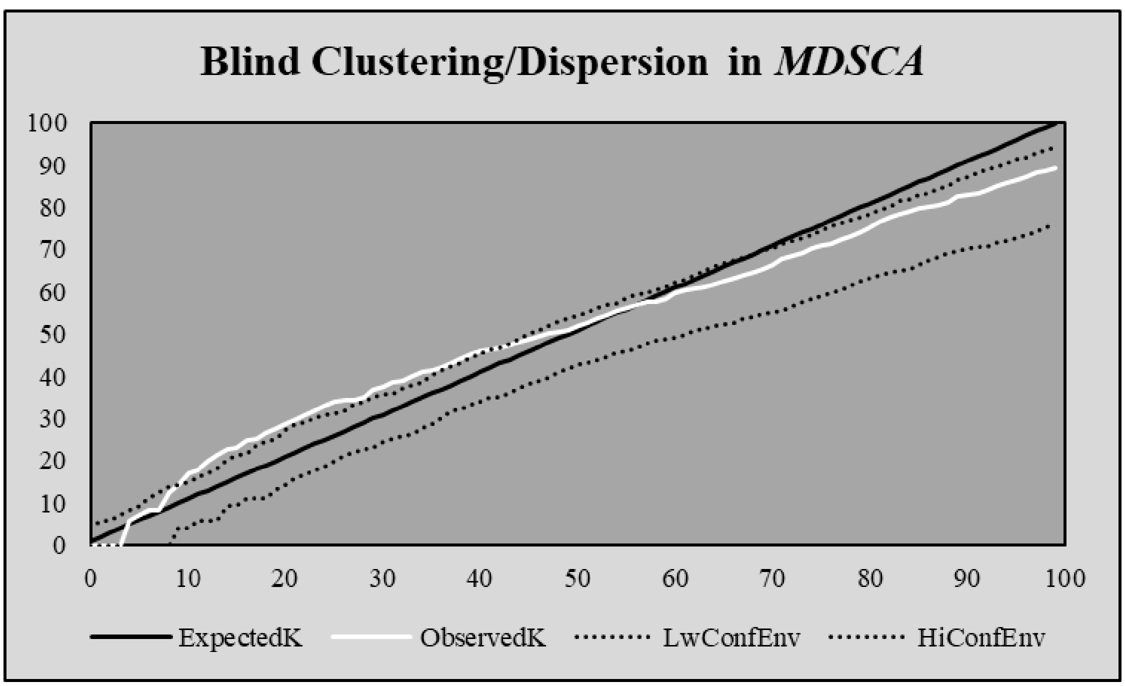

Figure 44. Graphical representation of Multi-Distance Spatial Cluster Analysis tool applied to hunting blind distributions at 5BL148.

The Kernel Density tool confirms that there are at least five hunting blind clusters that meet the size-based criteria for intercept area designations at 5BL148. Blind clusters are labeled A-E in Figure 45. Though a few blind clusters are characterized by spatial separation, several blind clusters at 5BL148 are extensive in size and are primarily concentrated in the center of the site. The Near tool showed which of the stone wall features are located in the closest proximity to individual blinds in blind clusters, allowing for an independent association of blinds to stone walls. Seven intercept areas are classified at 5BL148 by the methods applied in this thesis, each characterized by a significantly defined cluster of blinds and the two nearest stone walls to individual blinds in clusters, as selected by the Near tool.

The orientations of walls in intercept areas at 5BL148 are characteristic of v-shaped and u-shaped alignments, a noted phenomenon at other game drive sites in the CFR (Figure 45). The orientations of the two stone walls in each classified intercept area at 5BL148 are nearly perpendicular or v-shaped, as denoted by the azimuthal degrees calculated for intercept walls with a Python script in ArcGIS. A visual display of the median interior dimensions of hunting blinds also shows that blinds near intercept convergence areas are larger than elsewhere at the site, supporting a pattern of blind size viewed elsewhere at Rollins Pass (LaBelle and Pelton 2013; Whittenburg 2017), though additional metric arguments for blind sizes are beyond the immediate scope of this thesis.

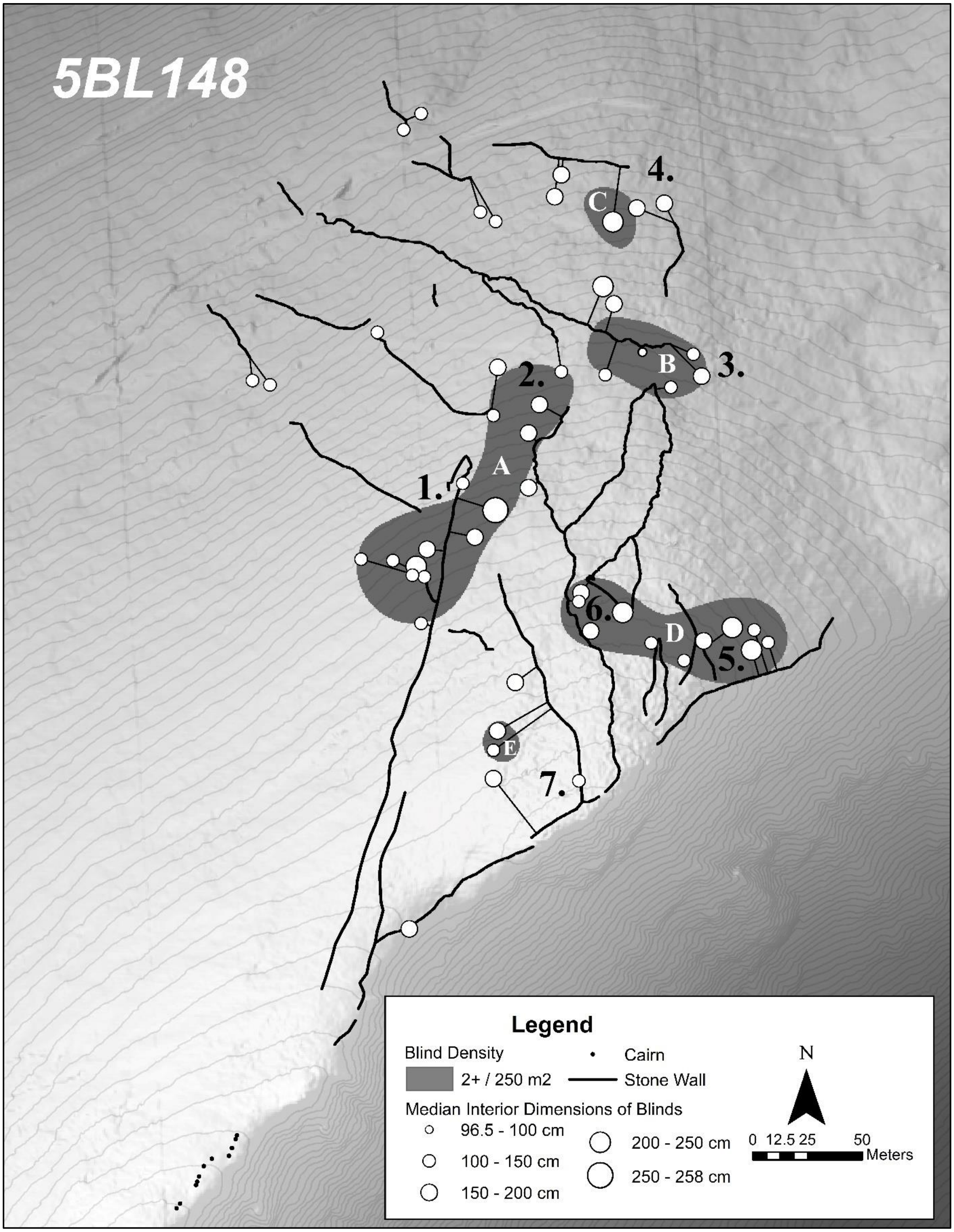

Figure 45. Map of the of 5BL148 game drive depicting features, hunting blind cluster areas (median interior dimensions depicted) and classified intercept zones (by number).

Table 27. Summary data for classified blind clusters and intercept areas.

Intercept Number	Blind Cluster	Wall Features	IBA (degrees)	Cardinal Directions for Intercept
1	A	53A/62	250	West to East
2	A	55A/64	238	West to East
3	B	55B/54A	222	West to East
4	C	68/70	232	West to East
5	D	59/61B	12.5	West to East
6	D	55A/56B	63.5	East to West
7	E	58A/58B	289.5	East to West

The IBAs calculated for each intercept area at 5BL148, based on the bisected azimuth orientations of intercept areas, show an important pattern in intercept area construction methods (Figure 46, Table 27). Four out of seven intercept areas at 5BL148 show less than a 15 percent difference in IBA orientation, meaning that the interior bisected angles of two-thirds of the intercept areas at 5BL148 differ by fewer than 30 degrees (Table 27). Intercept areas numbered 1 through 4 exhibit IBA bearings ranging from 250 degrees to 222 degrees, facing primarily southwest or west-southwest. It is the expectation of the author that intercept areas 1-4 are aligned to the west to intercept animal populations traveling from Rollins Pass through the 5BL148 site area, following an east to east-northeast migratory route from the pass area down to lower elevations in the u-shaped valleys surrounding the Continental Divide. Most game drive sites in the CFR show a similar west to east intercept pattern. Intercept areas 1-4 are serially patterned on the landscape at 5BL148, one after another, when viewed from west to east. The author interprets these patterned intercept areas as redundant feature construction events that are likely temporally unrelated, but potentially indicative of fine-tuning the spatial structure of the game drive over time through abandonment of previous intercept zones, that follow an east to west pattern.

Intercept areas numbered 5 and 6 exhibit an opposite degree orientation in comparison to intercept areas 1-4. Intercept 5 is oriented to the north, or nearly north-northeast with an IBA bearing of 12.5 degrees, and intercept area 6 is oriented to the northeast with an IBA bearing of 63.5 degrees. The author argues that intercept areas 5 and 6 are aligned to manage animal migratory patterns trending from the northeast to southwest. It is highly unlikely that a communal hunting group utilized both east to west and west to east facing intercept areas at 5BL148 during a single occupation episode. The results of the IBA instead suggest that 1) west, west-southwest facing intercept areas are facsimile and serially patterned, indicating intercept abandonment, and 2) north, north-northeast facing intercept areas are situated to collect migratory game following an opposite migration pattern in comparison to other intercepts at the site, perhaps indicating temporal, seasonal, and even choice species differences. On the basis of feature construction events alone, without consideration for temporal data collected by other means in this thesis, the site demonstrates spatial signatures indicative of hunter-gatherer reoccupation, feature abandonment, and spatial palimpsest activity.

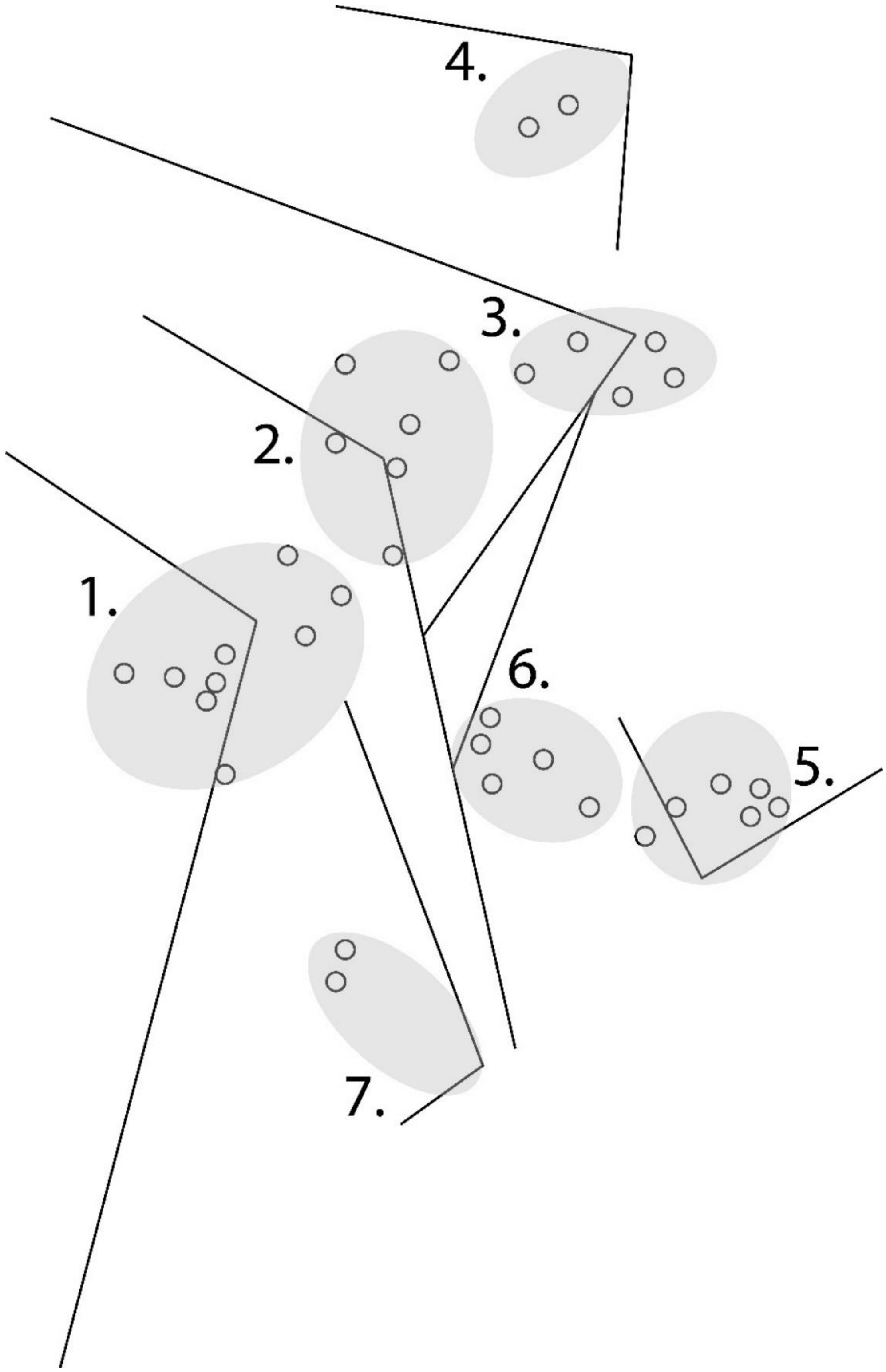

Figure 46. Simplified illustration of v-shaped intercept area orientations and significant clusters of hunting blinds at the 5BL148 game drive, Rollins Pass.

Discussion and Conclusion

A spatial analysis of the 5BL148 game drive demonstrated the complexities of assigning the collected temporal information (artifacts, bones and lichenometric dates) to prehistoric or protohistoric game drive use or feature construction episodes. Small-scale and broad scale reoccupation events are represented in artifact and bone distributions at the site, as well as in the presence/distribution of multiple intercept area locales. However, not all of the temporal information relates to use of the game drive as a hunting site over time.

Statistically significant pre-hunt and post-hunt activity areas are primarily confined to the southern margins of the site area, away from stone features used for driving game. Cluster 1 shows evidence for lithic tool production activities, but also animal processing, weapon discard, and possibly unexpected activities such as hide-working and perforating. Each of the time-diagnostic projectile points at 5BL148 are spatially positioned within Cluster 1, indicating either recurring deposition of materials over time (cumulative palimpsest) or hunter-gatherer artifact scavenging and discard during a single occupation period (temporal palimpsest).

There are lacking behavioral circumstances to explain the reoccupation of space at Cluster 1, given that the activity area is located so far away from the rest of the drive, but the near-associated cairn line (5BL148.71) could provide a landscape maker for returning groups to practice the previously described activities in a designated workspace. Perhaps, it is more likely that a more recent hunter-gatherer groups scavenged older points from the drive or elsewhere to supplement their toolkits onsite. Cluster 2 is characterized by a much smaller workspace and less frequency/diversity of material types, but this may indicate that the materials discarded are of a single occupation episode that is temporally unrelated to Cluster 1, given the immense spatial separation between clusters and the low frequency of artifacts (164 meters distant, n=4 artifacts).

Bone materials from 5BL148 are not clustered into any recognizable activity areas, but their distribution along stone walls suggests that either 1) culturally induced animal deaths, or 2) natural death events occurred while stone wall features existed on the landscape. Dated bones provide a minimum age estimate that both confirm and refute some of the lichenometric dates of walls derived from the size-frequency lichenometry methodology. The differential representation of protohistoric and prehistoric temporal information at the site, from absolute bone dates and lichenometric dating methods, further supports that 5BL148 represents a spatial palimpsest of occupations, some of which are better preserved (more recent activities) and some are ill-preserved (older activities). The erasure of older lichen profiles by Protohistoric era wall modification events is a possible explanation for the apparent discrepancy of age estimates between some bone specimens (2017.20 dated to 615-694 cal CE) and most lichenometric dates, though the lichenometric age of Alignment D is also of a Middle Ceramic period temporal affiliation.

The spatial structure of intercept area locales at the 5BL148 game drive indicate that 1) more than one intercept area construction episode is represented, and 2) hunter-gatherer groups likely did not use all intercept areas during a single occupation event. Serially patterned intercept areas numbered 1 through 4 are oriented to intercept game migrating from west to east, but intercept areas 5 and 6 are more apt to intercept game migrating from east to west. Intercepts 1 through 4 are serially patterned, separated by little more than 50 meters in terms of straight-line distances, indicating a redundancy in feature construction form. Intercept 1 is positioned furthest to the west, and any animals entered into the drive line system along a west to east migratory route would be driven initially into Intercept 1. Intercept 1 likely represents the youngest of intercept areas at the site, and this is corroborated by lichenometric dating (Alignment A dated to

1756 cal CE) and an absolute date on bone (specimen 2017.21 dated to 1726-1814 cal CE). Intercept abandonment increases from east to west at 5BL148, as supported by progressively older lichenometric dates (Figure 42 and 46). The challenge of using lichenometric dates for discerning the range of occupation episodes is reiterated in this section, as numerous natural and cultural disturbances to lichen populations over time renders a maximum age estimation complicated. At least six and possibly seven reoccupation events are represented by the arrangement of stone wall features at the site, based upon the independent method of intercept area classification presented in this thesis.

CHAPTER VI – DISCUSSION AND CONCLUSION

This thesis project contributes a significant amount of new information concerning the prehistoric and protohistoric use of the Rollins Pass hunting complex. When Byron Olson and Jim Benedict first mapped and excavated game drive sites at Rollins Pass, they immediately noticed the complexity of the 5BL148 game drive system; the sheer length of walls, the high frequency of hunting blinds, and the complicated mosaic of features on the landscape. Since the earliest work at the pass in the 1970's, Benedict and others continued to develop theories and methodologies to reconstruct hunter-gather subsistence and settlement systems throughout the CFR. Though there is a range in the observed frequency, length, and arrangements of stone features at all game drives, the largest sites are hypothesized to represent repeatedly occupied hunting locales (Benedict 1992; LaBelle and Pelton 2013), strategically placed on the landscape for use during seasonal and/or annual hunting rounds. Previous archaeological studies demonstrated that these largest sites exhibit a significant amount of cultural time-depth, millennia in some cases. This thesis used multi-disciplinary chronological methods to measure occupation span at the 5BL148 game drive, to observe the temporal relationships of feature construction and activity area use and disuse at the site.

The author presented the chronological reconstruction of 5BL148 with three guiding questions: 1) What is the relative occupation span of 5BL148? 2) What is the absolute occupation span of 5BL148? 3) Does the site represent a single occupation event, a palimpsest of overlapping occupation events, or instead spatially distinct reoccupation episodes? Methods used to reconstruct chronology can be either 1) dependent of the cultural-technological behaviors of hunter gatherer groups throughout time (material culture), or 2) independent of direct human influences and require an inference to relate dated events to target events (radiocarbon dating and lichenometry). The author explored the relative occupation span of 5BL148 with temporally diagnostic artifacts (projectile points, glass bead), recovered by the CMPA during pedestrian surveys on the site's surface, but also from material recovered by Olson and Benedict during excavations in hunting blind features (Olson 1971; Olson and Benedict 1970). The author determined the absolute occupation span of 5BL148 with radiocarbon dated bones found primarily along stone walls and charcoal grains collected from interior hunting blind floors. Lichenometry of stone wall features are used to discuss the minimum age of at least four feature construction events at 5BL148, but a discussion of the method argues that the lichenometric ages should be used as relative approximations of minimum feature age rather than absolute determinations. Finally, the author used a spatial analysis of the artifact and feature assemblage to reconstruct statistically significant activity areas to understand the presence of palimpsest deposits at the site, which aid in reconstructing site structure of 5BL148 over time.

Relative occupation span at 5BL148 is addressed with the material culture assemblage, but the results show lower chronological precision than absolute dating methods. Olson and Benedict collected 136 artifacts during excavation of two hunting blinds at the site, Pit 190 and Pit 280. The materials from Pit 190 and Pit 280 include tool resharpening flakes, tool production flakes, a projectile tool fragment, and a Protohistoric glass bead. Each of the aforementioned lithic reduction signatures are documented from hunting blinds elsewhere in the CFR. The Protohistoric glass bead, however, is a unique find but a crucial one for supporting evidence of exceptionally late Native American occupation at the site. Surface mapped artifacts by the CMPA include a diversity of primarily broken formal and informal chipped stone tools (n=24), including some larger size classes of lithic debris, hunting weaponry, finished knives and other bifaces discarded early on in reduction, but also scrapers and modified flake tools that exhibit macroscopic use-wear patterns likely from animal processing. The single bifacial drill, discarded after tip breakage, indicates an occurrence of domestic-type activities onsite in comparison to hunting/initial animal processing activities. Time-diagnostic projectile points from surface contexts include an Early Archaic era Mount Albion point, Middle Archaic period Duncan/Hanna point, and an Early Ceramic period Hogback Corner-notched point. All artifacts considered, the site shows a nearly 7,000-year range of occupation span.

A size-frequency analysis of four large stone wall alignments at 5BL148 corroborated a Late Prehistoric era and Protohistoric period occupation at the site. The author measured one-thousand or more *Rhizocarpon rhizocarpon* thalli on each of the four largest stone wall features at the site, including long and linear stone wall alignments (n=3) but also a u-shaped corral-type wall structure (n=1). Using Jim Benedict's published data and notes on file at the CMPA repository, the author reconstructed the CFR growth curve for *Rhizocarpon rhizocarpon* and calibrated regression line slopes of the log-reduced thalli measurement data from walls at 5BL148. Alignment A, Alignment B, and Alignment C date to the Protohistoric era between 1722 cal CE to 1756 cal CE. An earlier wall construction/modification event is exhibited in the u-shaped corral arrangement at the site (Alignment D), which is dated to 1451 cal CE. The author then presented several complications of the lichenometric method, including age uncertainties derived from variable sample sizes, natural and biological arguments against using the method, but also potential issues in using mean ages of radiocarbon dates for control points without consideration for 1σ and 2σ uncertainty ranges in the radiocarbon calibration curve. Despite these complex issues, lichenometry stands as a useful method for determining the relative construction/modification chronological order of the four features. There is little supporting evidence that any of the features were created during the Paleoindian or Archaic eras, and the later occupation of the site is supported by 1) prehistoric and protohistoric artifact evidence (chipped stone tools and white glass bead), and 2) radiocarbon dates on bones and charcoal.

The absolute occupation span at 5BL148 is explored with radiocarbon dates on surface collected bones, and also charcoal samples collected from 19 of the 52 hunting blind features at the site. The bones collected from the surface show little evidence for human modification, with the exception of one spirally fractured specimen (2017.21). The CMPA collected the majority of faunal elements alongside stone walls, suggesting that natural animal deaths could have occurred at a time when walls were present. Radiocarbon dated bones range from 615 – 1818 cal CE. Three of the dated specimens (2017.21, 2017.23, 2017.26) are statistically contemporaneous, dated between 1721-1818 cal CE. The oldest dated bone, located alongside Alignment C, dates to 615-694 cal CE, which permits a potential reconstruction of an Early Ceramic period hunter-gatherer occupation at the site. However, these data do not represent a specific Native American group in time, a technological complex, or a set of lifeways, and the author does not propose that the data are representative of specific Early Ceramic or Protohistoric era cultural groups.

Radiocarbon dates on charcoal collected from soil-core probes are dramatically different than dates on bone. Two of the radiocarbon dates from charcoal present ages which are in excess of 40,000 years old. These exceptionally ancient dates likely reflect direct dating of pyrolyzed wood, ancient roots, or more likely non-cultural carbonaceous material deposited by the nearby Denver, Northwest, and Pacific railway. A radiocarbon date on charcoal from Blind 15 presents a provocative Early Archaic period date at 3968-3800 cal BCE, providing the earliest potential feature construction and/or occupation age at 5BL148, but lack of additional thermal feature contexts limits the ability of the author to tie the date to a specific behavioral event. The author reviewed the potential problems of radiocarbon dating at high altitude, considering the 1) equivocal association of animal bones to cultural materials/features at game drive sites, and 2) the potential deposition of forest-fire charcoal at high altitudes which complicate absolute age-estimates. The

The author then conducted a spatial analysis to 1) situate the provenience of temporal information at the site, 2) determine the presence of activity areas at the site, and 3) discuss the presence/absence of palimpsest activity to determine the use of the space at the site over the course of representative time. The data show that temporal information is not evenly distributed at the site (in terms of chronological precision and spatial context), and that overlapping reoccupation of activity areas throughout the site is indeed present. The data supports that the 5BL148 game drive does represent a destination for hunter-gatherer groups and a place that was continually revisited and modified over time.

Two statistically significant artifact clusters are present, separated by more than 160 meters, and each cluster shows evidence for pre-hunt lithic workshop and post-hunt animal processing activities. Hunter-gatherer groups likely did not occupy the two cluster areas during a single occupation episode. Further, temporally diagnostic projectile points are all located within the largest artifact cluster, suggesting either continuous visitation of the locale over millennia or instead more recent hunter-gatherer scavenging of older projectile points and discard events during a single occupation episode. Surface collected artifacts at the site are certainly distributed into palimpsest deposits in clusters. Artifacts collected from subsurface tests in hunting blind features do little to help understand single vs. multiple occupation episodes, given the absence of excavation notes concerning provenience of blinds and any discrete occupation levels encountered, as well as the paucity of materials collected by the CMPA (n=1 flake, from Blind 11).

Bones are not distributed into clusters at the site, suggesting that 1) on-site disarticulation of multiple animals did not occur in a definitive activity area at any one time, or that 2) the bones reflect natural animal deaths, or even that 3) the lack of bone preservation prohibits the visibility of animal processing clusters. However, dated bone fragments are situated in close proximity to stone walls, providing another possible method of estimating the minimum age of wall construction which correlates closely to several lichenometric wall ages at the site.

Intercept area classification provided evidence for multiple feature construction events and periods of feature abandonment, as there is little reason to suggest that hunter-gatherers used all intercept locations simultaneously, given the patterned redundancy in alignment orientation and spatially distinct blind clusters. The author developed a new method to independently classify intercept areas on the basis of 1) statistically significant clusters of hunting blind features, 2) wall features nearest to individual blinds within clusters, and 3) a single variable approach to estimating intercept orientations. The method allows for intrasite comparisons of redundant, patterned, or contrasting intercept areas. Five of the seven intercept areas differ by fewer than 30 degrees in orientation, suggesting that each likely functioned to intercept game along a west to east migratory route. Four of the five redundant intercept areas are serially patterned one after another, suggesting that hunter-gatherer groups likely abandoned them progressively over time, as groups continually fine-tuned the efficiency of the game drive system. The lichenometric-ages of stone walls suggests that hunter-gatherer groups abandoned intercept areas from east to west, with the furthest west being the most recently constructed intercept area. Other intercept areas are aligned to an opposite direction in comparison to the five west-facing intercepts, indicating that the structures functioned to intercept game coming from the east through sites like 5BL147. These, too, could not have functioned during a single occupation episode in consideration for the other game intercepts at the site.

Each line of evidence suggests that the 5BL148 game drive was reoccupied, and that the complicated arrangements of stone features at the site are indicative of continual construction, modification, and abandonment episodes. Palimpsest activities are further supported by the distribution and age of chipped stone artifacts at the site. Absolutely dated remains, though difficult to incorporate into the cultural schemata of Prehistoric or Protohistoric era occupants, support other aspects of chronology reconstruction at the site. The 5BL148 game drive represents a destination for past Native American groups, where hunter-gatherer use of the site was modified and fine-tuned over the course of time, and the site was incorporated into subsistence and settlement regimes for groups spanning from the Early Archaic period to the Protohistoric era.

Future Research

The summary and discussion previously addressed considers the chronological span of the 5BL148 game drive at Rollins Pass, but numerous other avenues of archaeological investigation can aid in a reconstruction of past hunter-gatherer lifeways at the site. Additional methods and potential research endeavors are discussed here to promote future research at the site and elsewhere at game drives in the CFR.

Field Methods and Laboratory Methods

The intensive survey protocol administered at the 5BL148 game drive site over the course of a ten-day field session in 2017 aided in discovering previously undocumented chipped stone artifacts, but the process is time-consuming to implement at large game drive sites. Future research at 5BL148 should incorporate additional pedestrian surveys of equal or more-fine resolution, as the spatial extent of previous surveys at the site did not cover all areas, particularly between stone features and in the areas where no features are present. It is possible, and perhaps likely, that additional surveys could uncover new evidence for additional site activity areas. Further, given the standing evidence to support a Protohistoric era occupation of 5BL148, future researchers should consider using metal detecting to recover potential artifacts such as metal arrowheads or spent bullets/bullet casings.

Full-scale excavation of hunting blinds at 5BL148 may ultimately reveal a better chronological scheme for the site than what is provided in this thesis, but there are limitations to more invasive excavation techniques in conserved wilderness areas such as the James Peak and Indian Peaks Wilderness. The absence of accumulated material in hunting blind features at 5BL148 is likely due in part to the narrow window of visibility when using a soil-probe, as opposed to complete or partial excavation of the features. Additional excavations along stone walls at the site could also yield new insights into construction methods, particularly in areas of wall convergences near intercept area locales at 5BL148. The sampling procedures applied in this thesis emphasized non-invasive techniques for subsurface testing, but perhaps non-invasive techniques are not wholly adequate for identifying necessary data.

In terms of assemblage analysis, additional work should be undertaken to incorporate aspects of tool curation and tool production into the methods of lithic analysis applied in this thesis. Raw material availability and distance to reliable toolstone sources are critical components of evaluating the position of hunting sites within annual, cyclical subsistence-settlement regimes. These factors should also be used to discuss the presence/absence of variable modes of lithic reduction exhibited onsite, which could aid in reconstructions of palimpsest activities versus temporally/spatially distinct occupation episodes.

Future research projects should also endeavor to reconstruct functional aspects of the 5BL148 game drive. Additional measures of hunting blind orientation, depth, wall height, and clustering may aid in functional assessments of 5BL148. Further, a least-cost path analysis of the landscape setting at 5BL148 should be undertaken in future research, to help determine the relationship of feature positions to the least-costly migratory routes through site, and in consideration with natural topographic variables. A high-quality digital elevation model, coupled with remote sensing and satellite imagery manipulation techniques, could allow researchers to better estimate the functional relationship of stone features, natural topography, and least-cost pathways at 5BL148.

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APPENDIX

Appendix A - 5BL148 Artifact Assemblage Descriptive Data

Catalogue No.	Date Collected	Context	CMPA JPEG No.	Class	Element	Portion	Raw Material	Color
5BL.148.1970.1	?/?/1970	Pit 190	0138-	CS	EMF	PR	CHT	WHT
5BL.148.1970.2	?/?/1970	Pit 190	0140	CS	FK	PR	CHT	WHT
5BL.148.1970.3	?/?/1970	Pit 190	0140	CS	FK	MS	CHT	WHT
5BL.148.1970.4	?/?/1970	Pit 190	0140	CS	FK	PR	CHT	RED
5BL.148.1970.5	?/?/1970	Pit 280	0141-	CS	PP	DS	CAL	TRN
5BL.148.1970.6	?/?/1970	Pit 280	0143-	CS	EMF	PR	CAL	TRN
5BL.148.1970.7	?/?/1970	Pit 280	0045	GLS	BD	CO	GLS	WHT
5BL.148.1970.8	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
5BL.148.1970.9	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
5BL.148.1970.10	?/?/1970	Pit 280	0145	CS	FK	PR	CHT	GRY
5BL.148.1970.11	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.12	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
5BL.148.1970.13	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.14	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.15	?/?/1970	Pit 280	0145	CS	FK	PR	CHT	GRY
5BL.148.1970.16	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.17	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.18	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.19	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
5BL.148.1970.20	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
5BL.148.1970.21	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
5BL.148.1970.22	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
5BL.148.1970.23	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
5BL.148.1970.24	?/?/1970	Pit 280	0145	CS	FK	DS	CHT	GRY
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5BL.148.1970.26	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.27	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.28	?/?/1970	Pit 280	0145	CS	FK	MS	CHT	GRY
5BL.148.1970.29	?/?/1970	Pit 280	0145	CS	FK	MS	CHT	GRY
5BL.148.1970.30	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.31	?/?/1970	Pit 280	0145	CS	FK	PR	CHT	GRY
5BL.148.1970.32	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.33	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.34	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
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5BL.148.1970.36	?/?/1970	Pit 280	0145	CS	FK	MS	CHT	GRY
5BL.148.1970.37	?/?/1970	Pit 280	0145	CS	FK	MS	CHT	GRY
5BL.148.1970.38	?/?/1970	Pit 280	0145	CS	FK	CO	CHT	GRY
5BL.148.1970.39	?/?/1970	Pit 280	0146	CS	FK	MS	CAL	TRN
5BL.148.1970.40	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.41	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.42	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.43	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.44	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN

Catalogue No.	Date Collected	Context	CMPA JPEG No.	Class	Element	Portion	Raw Material	Color
5BL.148.1970.45	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.46	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.47	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.48	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.49	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.50	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.51	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.52	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.53	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.54	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.55	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.56	?/?/1970	Pit 280	0146	CS	FK	PR	CAL	TRN
5BL.148.1970.57	?/?/1970	Pit 280	0146	CS	FK	MS	CAL	TRN
5BL.148.1970.58	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.59	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.60	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.61	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.62	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.63	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.64	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.65	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.66	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.67	?/?/1970	Pit 280	0146	CS	FK	DS	CAL	TRN
5BL.148.1970.68	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.69	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.70	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.71	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.72	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.73	?/?/1970	Pit 280	0146	CS	FK	MS	CAL	TRN
5BL.148.1970.74	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.75	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.76	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.77	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.78	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.79	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.80	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.81	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.82	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.83	?/?/1970	Pit 280	0146	CS	FK	DS	CAL	TRN
5BL.148.1970.84	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.85	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.86	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.87	?/?/1970	Pit 280	0146	CS	FK	DS	CAL	TRN
5BL.148.1970.88	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.89	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.90	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.91	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.92	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.93	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.94	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.95	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN

Catalogue No.	Date Collected	Context	CMPA JPEG No.	Class	Element	Portion	Raw Material	Color
5BL.148.1970.96	?/?/1970	Pit 280	0146	CS	FK	PR	CAL	TRN
5BL.148.1970.97	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.98	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.99	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.100	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.101	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.102	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.103	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.104	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.105	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.106	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.107	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.108	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.109	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.110	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.111	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.112	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.113	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.114	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.115	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.116	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.117	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.118	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.119	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.120	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.121	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.122	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.123	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.124	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.125	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.126	?/?/1970	Pit 280	0146	CS	FK	MS	CAL	TRN
5BL.148.1970.127	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.128	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.129	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.130	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.131	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.132	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.133	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.134	?/?/1970	Pit 280	0146	CS	FK	CO	CAL	TRN
5BL.148.1970.135	?/?/1970	Pit 280	0146	CS	FK	DS	CHT	WHT
5BL.148.1970.136	?/?/1970	Pit 280	0146	CS	FK	CO	CHT	WHT
5BL.148.2012.1	8/12/2012	Surface	0147-	CS	BF	MS	QZT	GRY
5BL.148.2013.1	7/23/2013	Surface	0149-	CS	PP	PR	QZT	RED
5BL.148.2013.2	7/23/2013	Surface	0151-	CS	DR	MS	CHT	BWN
5BL.148.2013.3	?/?/2013	Surface	0153-	CS	PP	MS	CHT	WHT
5BL.148.2013.4	?/?/2013	Surface	0155-	CS	PP	MS	CHT	WHT
5BL.148.2013.5	?/?/2013	Surface	0157-	CS	BF	CO	CHT	TAN
5BL.148.2013.6	?/?/2013	Surface	0159-	CS	PP	PR	SWD	YLW
5BL.148.2013.7	?/?/2013	Surface	0161-	CS	PP	MS	CHT	PNK
5BL.148.2017.1	7/24/2017	Surface	0163-	CS	SCR	DS	CHT	WHT
5BL.148.2017.2	7/24/2017	Surface	0165-	CS	FK	DS	QZT	GRY

Catalogue No.	Date Collected	Context	CMPA JPEG No.	Class	Element	Portion	Raw Material	Color
5BL.148.2017.3	7/24/2017	Surface	0167-	CS	FK	CO	QZT	GRY
5BL.148.2017.4	7/24/2017	Surface	0169-	CS	EMF	DS	CHT	YLW
5BL.148.2017.5	7/24/2017	Surface	0171-	CS	EMF	MS	QZT	GRY
5BL.148.2017.6	7/24/2017	Surface	0173-	CS	FK	PR	QZT	GRY
5BL.148.2017.7	7/24/2017	Surface	0175-	CS	PP	MS	SWD	RED
5BL.148.2017.8	7/24/2017	Surface	0177-	CS	BF	MS	SWD	GRY
5BL.148.2017.9	7/24/2017	Surface	0179-	CS	EMF	MS	CHT	RED
5BL.148.2017.10	7/24/2017	Surface	0181-	CS	FK	CO	QZT	GRY
5BL.148.2017.11	7/24/2017	Surface	0183-	NON	NON	CO	?	PNK
5BL.148.2017.12	7/24/2017	Surface	0185-	CS	FK	CO	QZT	GRY
5BL.148.2017.13	7/24/2017	Surface	0187-	CS	ANG	CO	QZT	GRY
5BL.148.2017.14	7/24/2017	Surface	0189-	CS	EMF	PR	CAL	TRN
5BL.148.2017.15	7/24/2017	Surface	0191-	CS	EMF	MS	CHT	WHT
5BL.148.2017.16	7/27/2017	Surface	0193-	CS	PP	MS	CHT	RED
5BL.148.2017.17	10/24/2017	Blind 11	0277	CS	FK	PR	QZT	TAN

CLASS: CS – Chipped Stone; GLS – Glass; NON – non-cultural
ELEMENT: PP – Projectile Point; BF – Biface; DR – Drill; SCR – Scraper; EMF – Edge-modified Flake; FK – Flake; ANG – Angular Debris
PORTION: PR – Proximal; MS – Midsection; DS – Distal; CO – Complete
RAW MATERIAL: CAL – Chalcedony; CHT – Chert; SWD – Silicified Wood; QZT – Quartzite; GLS – Glass
COLOR: RED – Red; TAN – Tan; WHT – White; GRY – Gray; BWN – Brown; PNK – Pink; YLW – Yellow

Appendix B – 5BL148 Artifact Assemblage Metric Data

Catalogue No.	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)	Mass (g)	Cortex	Burning
5BL.148.1970.1	25.02	23.45	3.63	2.572	0	0
5BL.148.1970.2	21.98	32.33	3.34	2.418	0	0
5BL.148.1970.3	11.24	10.71	2.25	0.429	0	0
5BL.148.1970.4	4.99	4.78	0.84	0.021	0	0
5BL.148.1970.5	10.36	8.94	2.2	0.229	0	0
5BL.148.1970.6	16.31	18.11	2.55	0.766	0	0
5BL.148.1970.7	1.9	1.9	1.16	0.007	0	0
5BL.148.1970.8	2.54	2.48	0.67	0.007	0	0
5BL.148.1970.9	3.5	3.39	0.31	0.007	0	0
5BL.148.1970.10	5.67	4.97	0.55	0.021	0	0
5BL.148.1970.11	5.81	5.2	0.57	0.028	0	0
5BL.148.1970.12	3.87	6.21	1.51	0.033	0	0
5BL.148.1970.13	6.48	4.42	0.91	0.026	0	0
5BL.148.1970.14	6.9	3.03	0.64	0.02	0	0
5BL.148.1970.15	3.45	3.5	0.43	0.009	0	0
5BL.148.1970.16	3.89	3.21	0.59	0.009	0	0
5BL.148.1970.17	4.22	3.77	0.47	0.007	0	0
5BL.148.1970.18	6.14	3.2	0.29	0.009	0	0
5BL.148.1970.19	3.05	2.93	0.5	0.007	0	0
5BL.148.1970.20	2.9	2.72	0.37	0.006	0	0
5BL.148.1970.21	1.8	2.48	0.33	0.001	0	0
5BL.148.1970.22	4.3	2.47	0.36	0.001	0	0
5BL.148.1970.23	2.03	2.02	0.38	0.001	0	0
5BL.148.1970.24	3.24	3.09	0.3	0.001	0	0
5BL.148.1970.25	5.06	3.68	0.52	0.009	0	0
5BL.148.1970.26	4.28	3.6	0.99	0.017	0	0
5BL.148.1970.27	4.09	4.25	0.72	0.014	0	0
5BL.148.1970.28	1.91	3.29	0.51	0.001	0	0
5BL.148.1970.29	2.98	2.96	0.38	0.004	0	0
5BL.148.1970.30	3.89	2.2	0.55	0.004	0	0
5BL.148.1970.31	3.69	2.56	0.53	0.006	0	0
5BL.148.1970.32	4.57	2.65	0.29	0.007	0	0
5BL.148.1970.33	3.23	3.14	0.53	0.007	0	0
5BL.148.1970.34	4.04	2.62	0.47	0.008	0	0
5BL.148.1970.35	2.34	0.42	0.18	0.001	0	0
5BL.148.1970.36	3.2	1.64	0.37	0.001	0	0
5BL.148.1970.37	2.36	2.31	0.33	0.001	0	0
5BL.148.1970.38	4.45	2.52	0.37	0.004	0	0
5BL.148.1970.39	9.28	20.86	2.05	0.621	0	0
5BL.148.1970.40	4.66	3.71	0.38	0.003	0	0
5BL.148.1970.41	5.8	3.35	0.64	0.025	0	0
5BL.148.1970.42	7.85	7.38	1.13	0.061	0	0
5BL.148.1970.43	5.84	5.24	0.32	0.02	0	0
5BL.148.1970.44	5.04	4.63	0.45	0.014	0	0
5BL.148.1970.45	7.4	4.1	0.54	0.025	0	0
5BL.148.1970.46	5.96	4.2	0.38	0.015	0	0
5BL.148.1970.47	5.17	4.3	0.31	0.012	0	0
5BL.148.1970.48	6	3	0.38	0.014	0	0
5BL.148.1970.49	5.9	3.6	0.37	0.015	0	0

Catalogue No.	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)	Mass (g)	Cortex	Burning
5BL.148.1970.50	6.21	3.88	0.37	0.017	0	0
5BL.148.1970.51	7.89	3.54	0.47	0.015	0	0
5BL.148.1970.52	4.67	3.34	0.39	0.015	0	0
5BL.148.1970.53	5.44	3.58	0.48	0.012	0	0
5BL.148.1970.54	4.19	3.92	0.58	0.014	0	0
5BL.148.1970.55	3.91	3.27	0.56	0.015	0	0
5BL.148.1970.56	3.71	3.62	0.4	0.001	0	0
5BL.148.1970.57	4.48	3.45	0.76	0.02	0	0
5BL.148.1970.58	5.34	3.72	0.68	0.023	0	0
5BL.148.1970.59	4.29	4.1	0.4	0.005	0	0
5BL.148.1970.60	4.54	3.95	0.72	0.01	0	0
5BL.148.1970.61	4.84	3.27	0.3	0.018	0	0
5BL.148.1970.62	4.49	4.34	0.47	0.016	0	0
5BL.148.1970.63	4.43	4.03	0.68	0.015	0	0
5BL.148.1970.64	5.01	4.08	0.43	0.011	0	0
5BL.148.1970.65	5.34	3.25	0.29	0.01	0	0
5BL.148.1970.66	4.37	3.13	0.35	0.009	0	0
5BL.148.1970.67	2.19	5.66	0.74	0.012	0	0
5BL.148.1970.68	4.35	3.13	0.49	0.011	0	0
5BL.148.1970.69	4.3	4.21	0.57	0.011	0	0
5BL.148.1970.70	5.46	3.78	0.55	0.012	0	0
5BL.148.1970.71	3.56	4.01	0.28	0.007	0	0
5BL.148.1970.72	4.58	4.01	0.49	0.015	0	0
5BL.148.1970.73	2.83	4.03	0.34	0.007	0	0
5BL.148.1970.74	5.11	2.8	0.61	0.014	0	0
5BL.148.1970.75	5.32	2.32	0.65	0.007	0	0
5BL.148.1970.76	5.22	3.92	0.34	0.012	0	0
5BL.148.1970.77	4.87	3.72	0.64	0.018	0	0
5BL.148.1970.78	4.73	3.32	0.39	0.009	0	0
5BL.148.1970.79	4.69	3.89	0.24	0.01	0	0
5BL.148.1970.80	3.53	2.73	0.18	0.006	0	0
5BL.148.1970.81	4.28	4.33	0.65	0.015	0	0
5BL.148.1970.82	3.77	3.6	0.38	0.007	0	0
5BL.148.1970.83	3.75	2.4	0.93	0.008	0	0
5BL.148.1970.84	3.51	3.83	0.62	0.008	0	0
5BL.148.1970.85	4.86	2.91	0.31	0.006	0	0
5BL.148.1970.86	3.34	3.16	0.36	0.006	0	0
5BL.148.1970.87	3.57	3.56	0.41	0.007	0	0
5BL.148.1970.88	3.71	3.09	0.41	0.006	0	0
5BL.148.1970.89	3.96	2.71	0.33	0.003	0	0
5BL.148.1970.90	3.77	2.87	0.33	0.006	0	0
5BL.148.1970.91	3.72	3.44	0.31	0.006	0	0
5BL.148.1970.92	3.43	3.21	0.43	0.005	0	0
5BL.148.1970.93	3.91	3.67	0.39	0.007	0	0
5BL.148.1970.94	3.82	3.38	0.42	0.006	0	0
5BL.148.1970.95	3.07	3.16	0.26	0.001	0	0
5BL.148.1970.96	2.71	3.31	0.62	0.006	0	0
5BL.148.1970.97	3.12	2.09	0.4	0.001	0	0
5BL.148.1970.98	4.53	1.99	0.51	0.001	0	0
5BL.148.1970.99	2.96	1.54	0.18	0.003	0	0
5BL.148.1970.100	3.93	3.2	0.57	0.003	0	0
5BL.148.1970.101	2.93	2.4	0.53	0.001	0	0

Catalogue No.	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)	Mass (g)	Cortex	Burning
5BL.148.1970.102	2.72	2.5	0.44	0.001	0	0
5BL.148.1970.103	3.03	3.16	0.016	0.003	0	0
5BL.148.1970.104	3.63	1.18	0.25	0.001	0	0
5BL.148.1970.105	3.22	1.93	0.12	0.001	0	0
5BL.148.1970.106	2.43	2.01	0.25	0.001	0	0
5BL.148.1970.107	3.6	2.57	0.28	0.003	0	0
5BL.148.1970.108	3.74	2.25	0.21	0.001	0	0
5BL.148.1970.109	4.48	3.34	0.18	0.001	0	0
5BL.148.1970.110	2.62	3.44	0.36	0.005	0	0
5BL.148.1970.111	3.81	2.27	0.26	0.001	0	0
5BL.148.1970.112	2.99	2.45	0.23	0.001	0	0
5BL.148.1970.113	3.06	2.18	0.21	0.001	0	0
5BL.148.1970.114	3.48	2.45	0.31	0.005	0	0
5BL.148.1970.115	2.71	2.59	0.35	0.001	0	0
5BL.148.1970.116	3.24	2.29	0.49	0.001	0	0
5BL.148.1970.117	2.38	1.67	0.25	0.003	0	0
5BL.148.1970.118	3.04	1.95	0.28	0.001	0	0
5BL.148.1970.119	3.59	2.33	0.17	0.001	0	0
5BL.148.1970.120	2.25	1.91	0.2	0.001	0	0
5BL.148.1970.121	2.41	1.35	0.29	0.001	0	0
5BL.148.1970.122	2.21	1.67	0.42	0.001	0	0
5BL.148.1970.123	2.57	1.95	0.47	0.001	0	0
5BL.148.1970.124	2.42	2.51	0.23	0.001	0	0
5BL.148.1970.125	2.31	2.35	0.45	0.001	0	0
5BL.148.1970.126	2.31	1.77	0.32	0.006	0	0
5BL.148.1970.127	2.88	1.85	0.32	0.001	0	0
5BL.148.1970.128	2.62	1.54	0.18	0.001	0	0
5BL.148.1970.129	2.59	1.22	0.21	0.001	0	0
5BL.148.1970.130	2.19	1.43	0.29	0.001	0	0
5BL.148.1970.131	2.19	1.59	0.18	0.001	0	0
5BL.148.1970.132	2.23	1.57	0.19	0.001	0	0
5BL.148.1970.133	2.68	1.51	0.35	0.001	0	0
5BL.148.1970.134	2.38	2.2	0.14	0.001	0	0
5BL.148.1970.135	5.68	8.56	1.86	0.1	2	0
5BL.148.1970.136	5.3	2.23	0.35	0.007	1	0
5BL.148.2012.1	37.86	29.4	6.23	9.403	0	0
5BL.148.2013.1	34.04	23.43	4.71	5.189	0	0
5BL.148.2013.2	34.95	24.44	8.03	5.901	1	1
5BL.148.2013.3	25.61	23.74	4.01	1.825	0	0
5BL.148.2013.4	30.28	21.43	3.76	2.39	0	0
5BL.148.2013.5	53.87	30.48	13.6	24.368	2	0
5BL.148.2013.6	24.43	18.5	4.21	2.664	1	0
5BL.148.2013.7	10.01	16.7	3.61	0.791	0	0
5BL.148.2017.1	34.5	29.51	9.51	10.745	2	0
5BL.148.2017.2	23.89	17.35	3.71	1.613	1	0
5BL.148.2017.3	21.5	13.5	4.01	1.132	0	0
5BL.148.2017.4	22.63	17.97	4.53	1.897	0	0
5BL.148.2017.5	27.03	19.38	5.62	2.667	0	0
5BL.148.2017.6	14.13	10.94	3.31	0.519	3	0
5BL.148.2017.7	20.59	13.08	3.15	0.968	0	0
5BL.148.2017.8	12.79	35.999	8.96	5.05	0	0
5BL.148.2017.9	19.38	16	3.32	1.325	0	0

Catalogue No.	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)	Mass (g)	Cortex	Burning
5BL.148.2017.10	15.82	27.65	6.8	2.311	0	0
5BL.148.2017.11	17.26	27.57	4.75	2.442	NA	NA
5BL.148.2017.12	29.9	16.07	3.78	1.927	2	0
5BL.148.2017.13	36.35	48.37	21.21	27.452	1	0
5BL.148.2017.14	29.24	20.55	11.65	6.659	2	0
5BL.148.2017.15	26.2	24.45	4.31	3.52	0	0
5BL.148.2017.16	15.93	13.51	4.61	1.198	0	0
5BL.148.2017.17	5.74	4.14	0.61	0.019	0	0

CORTEX: 1 is 10 to 15%; 2 is 15 to 25%; 3 is 25 to 50%
BURNING: 1 is Potlid

Appendix C – Alignment A Lichenometry Bin Data

Diameter Bin	Frequency (n)	Frequency (%)	Log_{10} Frequency (%)	Pearson's *r*
10-15	912	91.2	1.95	-1
15-20	62	6.2	0.79	-1
20-25	17	1.7	0.23	-0.98
25-30	6	0.6	-0.22	-0.97
30-35	2	0.2	-0.70	-0.98
45-50	1	0.1	-1	-0.90

Appendix D – Alignment B Lichenometry Bin Data

Diameter Bin	Frequency (n)	Frequency (%)	Log_{10} Frequency (%)	Pearson's *r*
10-15	732	73.1	1.86	-1
15-20	214	21.4	1.33	-1
20-25	43	4.3	0.63	-0.99
25-30	7	0.7	-0.16	-0.99
30-35	1	0.1	-1.00	-0.99
35-40	2	0.2	-0.70	-0.97
40-45	2	0.2	-0.70	-0.93

Appendix E – Alignment C Lichenometry Bin Data

Diameter Bin	Frequency (n)	Frequency (%)	Log_{10} Frequency (%)	Pearson's *r*
10-15	760	76	1.88	-1
15-20	170	17	1.23	-1
20-25	49	4.9	0.69	-0.99
25-30	15	1.5	0.17	-0.99
30-35	1	0.1	-1	-0.99
35-40	1	0.1	-1	-0.98
40-45	2	0.2	-0.70	-0.94
45-50	1	0.1	-1	-0.93
70-75	1	0.1	-1	-0.79

Appendix F – Alignment D Lichenometry Bin Data

Diameter Bin	Frequency (n)	Frequency (%)	Log_{10} Frequency (%)	Pearson's *r*
10-15	805	76.7	1.90	-1
15-20	198	18.9	1.30	-1
20-25	27	2.6	0.40	-0.99
25-30	10	1.0	0.00	-0.99
30-35	6	0.6	-0.20	-0.97
35-40	2	0.2	-0.70	-0.98
40-45	1	0.1	-1.0	-0.98
45-50	1	0.1	-1.0	-0.96

Appendix G – Thalli Diameter

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
1	11.23	11.13	10.16	15.14
2	10.06	18.12	11.43	10.29
3	10.01	11.91	10.09	10.35
4	10.1	14.47	10.25	10.25
5	10.02	18.33	10.08	10.04
6	10.42	11.11	10.46	10.1
7	10.87	10.25	10.75	12.74
8	10.16	19.86	12.15	11.55
9	15.44	24.57	11.72	16.89
10	11.42	11.68	10.65	14.43
11	10.18	12.85	10.12	14.43
12	10.13	16.52	11.46	11.33
13	11.28	12.59	11.78	10.06
14	10.26	17.55	11.36	11.35
15	10.29	13.19	10.95	10.12
16	10.22	14.21	12.11	10.46
17	10	12.75	10.92	10.9
18	11.48	13.48	10.92	12.13
19	10.26	11.38	11.04	12.72
20	10.1	14.58	10.74	14.09
21	10.1	11.86	10.96	12.8
22	10.29	10.26	10.2	12.35
23	10.81	10.3	12.46	13.7
24	10.21	12.09	14.35	11.25
25	12.76	12.95	10.07	10.08
26	16.68	12.96	10.12	10.5
27	10.72	11.48	35.47	12.85
28	10.01	19.24	12.19	12.49
29	11.31	15.72	10.19	10.27
30	10.08	15.87	10.91	12.09
31	11.43	19.25	10.91	14.17
32	22.98	13.01	15.86	11.77
33	10.14	13.01	13.75	13.79
34	10.01	19.89	10.71	13.7
35	10.05	10.97	13.06	13.03
36	10.03	10.83	15.1	14.74
37	10.03	15.49	14.32	13.68
38	10.82	13.25	13.75	10.86
39	10.04	25.25	10.96	22.64
40	10.6	17.86	14.18	11.61
41	10.6	20.97	10.73	10.7
42	11.03	15.3	14.56	10.18
43	11.04	23.66	10.74	16.67
44	10.41	10.66	15.09	11.51
45	10.41	17.76	25	15.91
46	10.41	18.95	12.99	10.83
47	10.63	11.09	12.35	10.12
48	10.85	24.14	11.34	13.97
49	10.03	15.2	13.45	11.22

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
50	10.91	15.78	15.01	13.17
51	10.2	11.48	21.35	11.38
52	10.08	14.01	10.15	12.19
53	10.15	15.58	10.06	11.01
54	10.08	14.64	11.91	12.89
55	10.01	19.74	10.46	12.2
56	10.25	28.57	11.27	12.32
57	10.32	16.25	10.48	10.85
58	12.52	14.26	14.72	10.76
59	10.29	28.44	10.06	14.82
60	10.08	18.17	10.35	12.29
61	10.06	21.76	12.26	12.29
62	10.43	11.72	11.47	12.25
63	10.42	17.86	13.13	12.87
64	10.42	12.27	10.55	12.59
65	14.81	15.4	28.51	12.39
66	15.92	17.49	11.57	11
67	11.96	23.78	13.08	16.66
68	12	21.27	16.24	10.33
69	12	15.26	14.96	12.57
70	10.07	14.7	13.53	11.71
71	11.6	11.94	13.43	11.72
72	18	11.46	12.64	11.61
73	17.92	16.59	11.37	13.27
74	11.65	10.74	17.63	10.44
75	10.42	12.29	11.82	16.76
76	11.22	11.9	10.61	14.78
77	10.01	15.14	17.75	14.06
78	10.04	12.27	17.43	12.54
79	10.33	12.28	18.07	11.87
80	10.81	10.97	10.23	13.99
81	15.73	16.14	12.59	12.67
82	12.49	16.61	18.59	11.97
83	24.65	19.88	24.79	13.09
84	11.58	10.67	24.45	19.16
85	10.55	10.67	15.43	15.53
86	10.35	10.45	14.62	11.93
87	11.22	14.66	13.13	25.33
88	10.55	10.26	12.3	17.15
89	10.11	11.48	11.81	16.93
90	10.31	11.48	11.17	14.76
91	10.76	14.22	11.07	21.84
92	10.17	12.4	21.91	32.04
93	11.49	21.97	20.37	14.52
94	11.66	15.66	11.93	11.45
95	10.13	15.66	11.22	11.08
96	10	11.93	23.45	20.17
97	10	14.28	11.7	20.68
98	28.9	16.41	12.39	14.28
99	10.45	20.31	19.85	13.7
100	13.92	15.39	23.23	25.16
101	10.07	12.23	70.86	11.53

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
102	10.01	11.98	17.54	11.76
103	10.13	14.13	11.72	11.45
104	10.71	12.15	10.92	13.94
105	10.07	12.26	12.29	13.72
106	10.6	12.27	14.01	12.61
107	10.24	11.92	10.88	12.61
108	10.88	16.14	10.88	11.03
109	10.06	20.65	10.71	10.41
110	10.16	17.24	12.61	12.92
111	10.23	10.63	12.67	10.56
112	10.06	12.06	21.37	12.14
113	17.09	11.6	14.29	13.46
114	10.52	14.44	13.44	11.48
115	12.93	12.46	12.5	15.08
116	10.12	10.42	11	13.38
117	11.89	14.56	10.58	11.95
118	10.32	15.68	12.62	11.95
119	10.5	15.67	17.6	10.73
120	10.33	12.72	13.61	11.46
121	10.51	12.52	14.93	13.66
122	10.25	12.08	14.09	12.88
123	12.76	14.51	14.77	14.84
124	11.91	10.77	13.99	16.14
125	11.79	19.03	11.62	14.5
126	20.51	12.41	12.04	17.12
127	11.57	12.42	12.6	12.7
128	10.67	11.31	13.95	19.18
129	10.6	13.18	15.09	27.93
130	12.14	12.09	13.75	11.74
131	11.39	10.97	15.01	14.34
132	11.03	12.93	15.75	11.11
133	10.16	41.98	15.94	10.75
134	10	18.18	29.94	11.35
135	11.99	16.26	15.99	12.61
136	10.83	13.61	12.2	12.19
137	12.74	11.52	12.03	15.08
138	11.77	18.93	14.69	16.8
139	11.17	16.73	13.58	13.99
140	10.03	17	17.1	13.81
141	10.22	14.21	18.15	10.31
142	10.59	17.53	11.86	14.64
143	10.75	10.92	14.49	11.11
144	10.66	10.47	13.34	14.37
145	14.35	11.25	12.21	12.29
146	11.53	15.36	11.75	16.34
147	10.58	13.81	10.29	14.22
148	10.13	11.86	10.45	10.58
149	10.1	14.38	10.34	16.2
150	15.39	14.7	13.43	10.97
151	10.41	16.37	10.74	16.43
152	10.17	13.03	12.07	15.31
153	10.29	11.04	12.07	17.64

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
154	10	12.42	10.98	11.97
155	14.23	14.28	12.08	12.92
156	12.79	10.99	10.59	12.47
157	10.18	11.15	12.19	13.01
158	10.16	16.05	13.76	11.8
159	10.04	13.6	12.7	11.32
160	10.34	12.7	10.53	11.41
161	10.5	13.68	11.39	10.54
162	10.51	12.35	18.38	12.27
163	10.51	12.34	13.09	12.69
164	10.05	14.26	10.99	12.57
165	10.05	13.67	14.2	12.76
166	10.43	12.49	16.87	13.13
167	10.11	11.21	11.86	12.55
168	10.24	10.23	11.29	12.55
169	10.24	16.23	13.37	11.41
170	10.61	15.46	12.46	18.95
171	10.11	10.63	10.74	38.91
172	10.15	13.53	10.76	11.91
173	21.35	16.62	11.39	17.03
174	14.94	10.47	10.43	11.02
175	17.89	10.97	11.75	12.23
176	12.08	10.05	11.18	15.6
177	13.71	11.28	10.3	11.02
178	10.63	12.85	11.46	12.56
179	10.02	10.83	12.75	17.46
180	10.51	11.04	14.78	13.02
181	10.39	11.98	11.4	13.44
182	15.72	14.07	18.22	11.27
183	11.93	11.62	13.68	15.2
184	10.93	31.54	11.28	10.58
185	12.64	11.02	14.3	10.62
186	10.2	15.29	11.02	16.75
187	10.59	21.71	10.33	18.42
188	22.86	16.65	11.15	12.79
189	10.11	11.42	12.49	12.35
190	11.06	15.55	10.47	13.92
191	10.56	10.61	11.42	13.27
192	10.71	17.13	24.22	11.68
193	11.02	23.52	10.62	15.58
194	15.42	24.49	10.45	18.24
195	13.23	17.67	10.3	10.32
196	12.77	13.03	16.66	16.04
197	11.53	10.55	11.01	13.87
198	11.02	13	14.06	10.71
199	10.79	12.21	12.05	16.76
200	11.14	10.62	12.55	26.47
201	13.25	11.71	13.19	10.67
202	12.59	13.08	10.3	15.96
203	25.98	10.17	11.03	11.73
204	10.89	10.73	10.67	17.85
205	10.39	10.4	10.54	15.46

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
206	11.43	10.49	10.25	11.49
207	10.16	12.88	11.42	12.89
208	10.12	16.42	14.11	11.24
209	10.03	12.13	10.98	45.25
210	10.15	14.88	10.83	10.01
211	11.1	10.7	11.72	11.21
212	11.27	17.78	10.15	12.47
213	46.64	10.17	15.77	11.23
214	10.2	12.44	12.86	11.65
215	10.42	15.21	10.31	16.87
216	12.45	10.13	17.55	12.89
217	10.73	13.06	10.14	11.26
218	10.66	13.89	11.4	13.31
219	10.1	11.36	10.02	17.64
220	32.52	15.89	10.03	12.14
221	10.21	12.17	11.25	11.74
222	10.23	11.13	11.74	10.77
223	10.01	10.27	10.76	16.2
224	10.3	15.24	13.79	12.53
225	10.42	16.35	11.19	10.95
226	11.09	14.32	11.19	10.2
227	11.7	12.29	17.18	10.28
228	10.28	13.13	10.31	15.02
229	12.32	16.21	10.95	10.27
230	10.29	10.02	11.96	11.58
231	11.79	13.34	14.5	15.2
232	10.08	10.31	10.38	11.88
233	11.62	12.26	12.49	11.78
234	11.66	13.72	14.45	10.7
235	10.65	10.11	10.76	19.22
236	10.01	12.45	11.18	31.3
237	10.43	10.52	11.82	15.1
238	11.95	10.57	19.58	14.5
239	10.53	10.31	10.09	11.7
240	10.57	10.17	13.15	14.53
241	12.55	10.81	24.68	12.62
242	10.64	10.91	10.15	11.94
243	10.69	11.52	10.72	25.93
244	11.21	11.67	12.28	14.23
245	10.15	16.75	10.62	16.17
246	12.05	10.31	10.34	12.38
247	10.22	11.19	10.34	11.09
248	11.81	10.4	10.66	12.51
249	11.75	16.67	10.66	12.14
250	10.15	10.07	14.06	15.36
251	11.66	11.26	10.83	16.03
252	10.06	10.28	10.08	12.45
253	10	19.4	10.08	10.7
254	12.35	23.01	10.71	13.24
255	10.15	11.29	10.28	11.38
256	10.06	10.28	10.66	13.85
257	18.63	10.28	11.52	15.05

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
258	10.29	14.71	11.52	11.96
259	14.57	10.32	12.52	14.11
260	11.89	10.33	10.09	14.52
261	11.21	13.13	11.44	14.34
262	10	11.56	11.12	12.58
263	11.06	12.34	12.5	12.65
264	11.91	18.76	13.24	16.61
265	22.97	10.18	14.61	12.75
266	10.95	11.63	11.62	10.73
267	12.5	12.49	12.04	13.57
268	13.01	11.63	12.08	10.94
269	10.19	11.89	13.82	11.22
270	10.16	12.39	11.23	13.39
271	10.54	11.29	13.56	14.26
272	10.79	11.48	12.48	16.35
273	10.13	11.48	12.84	13.37
274	17.52	13.21	15.28	18.29
275	13.08	11.84	11.13	13.16
276	13.87	10.74	14.31	13.61
277	10.29	12.35	10.93	14.4
278	10.18	11.39	10.98	15.9
279	10.11	12.28	11.64	14.3
280	10.12	15.82	10.88	16.43
281	10.12	11.23	10.84	11.19
282	10.93	11.23	12.53	11.52
283	10.15	11.25	10.89	12.95
284	10.05	12.61	10.42	10.38
285	10.21	13.25	11.35	10.15
286	10.35	14	11.19	12.33
287	10.82	13.13	14.59	10.85
288	10.54	10.13	10.37	12.35
289	10.76	16.11	12.61	10.18
290	10.48	13.09	11.24	15.32
291	10.01	15.73	11.74	16.52
292	10.56	14.59	11.13	10.83
293	10.11	19.35	11.49	12.48
294	10.05	16.23	13.92	17.2
295	17.88	14.26	14.32	14.55
296	14.74	10.3	15.62	14.91
297	10.2	22.58	14.55	11.26
298	11.17	27.4	13.98	11.73
299	10.95	15.69	11.06	13.41
300	10.66	16.56	11.34	13.41
301	10.25	16.6	11	16.36
302	10	14.05	10.58	14.39
303	10.07	10.47	11.01	12.84
304	11.08	13.6	10.35	14.67
305	10.32	12.28	12.15	14.31
306	10.32	14.38	10.86	16.48
307	10.11	13.28	10.55	14.57
308	10.02	10.02	10.4	12.67
309	10.15	16.73	10.19	13.79

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
310	10.15	10.69	11.2	12.7
311	10.06	15.62	11.79	12.56
312	21.44	17.61	10.83	12.63
313	10.68	13.94	10.39	10.65
314	10.65	18.21	11.06	12.07
315	10.1	17.28	11.12	11.89
316	14.45	42.13	11.51	12.28
317	10.26	15.27	10.69	14.58
318	10.11	13.1	26.31	11.08
319	10.21	11.24	12.53	13
320	10.08	16.48	12.25	25.87
321	10.6	14.79	13.08	23.29
322	17.29	16.42	11.17	21.14
323	10.96	13.68	13.31	19.15
324	17.41	10.36	11.79	19.75
325	10.07	12.54	11.43	17.33
326	15	18.69	14.35	11.64
327	10.35	16.92	12.06	40.28
328	10.03	14.07	12.14	17.35
329	10.03	13.56	15.28	10.6
330	10.1	12.86	12.13	12.48
331	17.28	15.45	13.01	14.26
332	10.81	20.8	12.8	14.23
333	10.08	18.27	10.96	10.3
334	10.07	14.4	10.86	14.51
335	10.35	10.49	13.62	13.94
336	10.49	11.4	15.22	12.61
337	10.2	12.18	16.16	24.6
338	10.02	13.6	13.4	12.94
339	10.39	10.62	13.4	16.16
340	10.14	12.38	12.91	11.4
341	10.19	11.61	12.55	13.49
342	10.26	11.61	11.78	13.4
343	10.08	10.97	11.83	12.09
344	10.18	12.55	14.98	11.99
345	10.06	21.23	11.13	15.02
346	10.86	12.64	11.02	14.09
347	11.2	15.73	11.02	16.27
348	10.45	16.43	11.17	16.04
349	10.48	16.42	10.01	15.82
350	12.09	10.86	10.65	12.92
351	12.17	36.21	11.17	10.12
352	12.23	20.33	10.3	11.83
353	11.16	14.25	10.29	10.45
354	11.27	20.42	12.16	12.19
355	11.38	20.12	14.3	12.19
356	10.14	14.77	14.49	10.19
357	10.04	20.17	11.35	10.2
358	10.12	12.35	13.55	10.97
359	11.13	10.79	10.01	17.97
360	10.67	10.65	10.08	12.81
361	12.79	10.42	10.08	11.73

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
362	10.16	16.1	11.33	11.95
363	12.15	12.9	10.54	16.7
364	16.01	10.83	10.69	12.79
365	14.67	12.43	12.03	13.63
366	14.84	11.23	11.74	14.46
367	13.68	13.04	12.46	11.04
368	10.18	13.46	10.74	11.27
369	12.96	13.02	15.38	11.97
370	12.27	11.32	12.17	16.72
371	10.47	10.8	10.9	14
372	10.78	10.9	10.95	14
373	11.56	10.9	11.48	13.91
374	12.19	11.89	10.79	10.14
375	10.13	11.34	11.68	10.71
376	10.41	20.31	10.38	11.56
377	10.41	10.67	10.36	14.24
378	13.61	10.68	25.94	12.97
379	11.55	19.77	20.36	12.87
380	10.79	17.86	13.72	13.76
381	11.34	11.84	10.59	13.6
382	17.59	10.17	10.86	13.76
383	12.76	14.58	10.12	14.63
384	10.45	17.68	12.03	13.97
385	13.1	11.68	11.63	13.31
386	10.9	11.68	12.27	13.43
387	10.9	13.12	11.47	14.3
388	10.42	10.05	10.06	12.07
389	12.13	11.18	10.2	14.69
390	13.61	15.24	11.82	11.3
391	10.52	19.43	11.16	12.14
392	10.46	11.78	10.94	14.56
393	10.38	17.99	12.3	12.54
394	10.38	11.2	12.86	11.6
395	10.7	14.44	10.74	11.6
396	10.71	21.34	13.91	14.45
397	13.67	14.5	13.83	18
398	10.34	16.28	12.9	15.09
399	11.66	14.67	12.73	15.09
400	10.54	10.64	11.81	16.42
401	11.06	10.98	12.59	19.94
402	10.8	10.95	10.51	14.05
403	10.8	11.76	10.65	10.81
404	10.41	16.17	10.18	13.05
405	10.63	14.09	10.17	11.9
406	10.63	19.31	10.17	12.6
407	10.51	12.8	17.68	12.61
408	10.51	10.01	14.5	14.18
409	10.17	12.41	12.54	12.96
410	10.21	11.24	11.1	16.51
411	10.21	15.45	11.89	21
412	10.41	10.28	11.01	18.34
413	11.99	12.57	11.83	16.86

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
414	11.75	23.1	11.02	14.65
415	12.95	11.24	11.01	13.79
416	11.52	13.31	10.63	14.6
417	11.68	22.55	10.98	13.9
418	10.46	10.55	11.86	17.31
419	10.46	23.91	12.19	13.17
420	10.46	12.3	17.85	12.31
421	10.46	13.76	10.51	10.82
422	10.46	12.1	10.73	11.96
423	14.43	16.12	10.67	12.31
424	11.99	11.92	11.59	10.31
425	10.87	11.36	12.04	10.43
426	11.85	11.41	15.95	11.26
427	10.65	15.16	12.3	13.66
428	10.64	17.13	11.08	11.25
429	10.06	18.51	20.39	14.4
430	11.94	17.27	14.78	12.52
431	10.37	16.06	11.06	15.69
432	10.25	15.05	14.81	15.48
433	10.85	11.99	10.39	24.41
434	11.9	13.17	10.71	13.63
435	10.3	13.17	10.08	13.77
436	10.22	10.11	10.76	13.77
437	13.45	10.11	13.09	12.74
438	10.4	12.75	14.11	11.37
439	11.19	15.29	11.37	13.78
440	10.14	13.66	12.32	12.21
441	11.2	11.85	12.69	12.21
442	13.31	17.48	12.93	11.72
443	10.28	19.68	11.17	12.69
444	10.28	11.05	13.42	23.2
445	10.42	14.68	16.7	14.94
446	10.38	14.98	11.6	12.4
447	12.19	11.6	12.28	13.21
448	10.17	12.54	10.31	12.87
449	13.66	12.72	15.07	12.87
450	11.25	14.59	15.76	11.84
451	11.22	15.07	20.66	13.32
452	11	10.65	11.6	10.72
453	12.33	11.11	14.19	14.85
454	10.13	10.6	11.01	12.82
455	10.12	11.48	11.23	16.67
456	10.52	29	10.89	12.46
457	10.37	16.88	11.14	10.15
458	10.37	20.83	11.22	17.78
459	10.37	16.9	11.94	15.76
460	10.63	15.35	12.51	14.52
461	10.22	10.61	10.72	13.99
462	10.23	11.29	10.82	13.99
463	17.91	11.2	12.58	10.29
464	10.42	10.64	11.02	12.2
465	10.37	12.37	13.44	10.5

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
466	19.45	12.36	11.19	14.55
467	12.58	15.09	14.02	12.85
468	12.18	16.67	13.16	12.4
469	11.89	11.77	12.54	12.75
470	10.65	12.34	14.94	11.92
471	10.64	10.46	13.34	11.95
472	13.81	11.1	16.16	12.29
473	16.95	11.82	12.83	11.69
474	11.23	13.09	13.99	21.42
475	19.16	11.43	13.94	15.07
476	10.29	16.02	12.6	15.38
477	10.32	11.15	13.54	10.48
478	12.02	10.17	16.37	10.29
479	17.18	12.52	10.36	12.75
480	10.09	14.3	10.62	21.84
481	10.24	11.66	10.62	17.13
482	10.27	11.66	10.62	14.26
483	10.15	10.6	10.8	15.16
484	10.15	10	12.26	11.24
485	23.51	10	14	12.11
486	10.56	11.66	11.22	10.85
487	13.37	10.94	11.67	11.65
488	10.58	12.31	13.99	13.19
489	15.41	21.35	12.56	10.82
490	15.3	15.45	11.82	11.3
491	12.53	17.51	12.18	10.03
492	13.06	13.63	11.29	13.01
493	13.45	15.84	11.52	12.99
494	13.43	10.77	11.52	17.91
495	13.73	11.93	12.77	12.97
496	13.49	11.03	10.56	10.63
497	11.43	11.33	11.2	12.38
498	11.43	12.36	13.76	12.64
499	11.43	14.2	12.77	10.31
500	11.42	14.98	12.27	11.37
501	10.36	16.67	11.51	12.96
502	14.91	11.17	12.2	10.21
503	10.95	12.26	12.53	10.03
504	10.95	12.26	12.36	10.26
505	11.06	14.6	13.45	12.38
506	10.17	12.51	13.46	10.65
507	10.9	14	21.31	14.61
508	12.97	16.77	19.99	13.1
509	12.16	17.88	27.36	14
510	10.32	10.61	15.85	12.43
511	10.18	12.12	10.38	14.75
512	11.39	10.82	10.26	13.35
513	10.28	12.03	10.11	10.6
514	12.79	14.28	10.55	10.05
515	10.05	15.82	20.14	11.76
516	12.28	13.07	11.87	15.19
517	10.07	11.49	12.47	11.98

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
518	10.07	10.98	11.93	10.21
519	12.92	10.81	17.75	10.35
520	10.42	10.82	13.41	10.36
521	10.69	13.64	15.75	10.36
522	11.13	11.73	15.43	10.36
523	11.19	11.74	11.55	14.28
524	10.36	16.76	14.4	12.49
525	10.14	15.4	12.13	13.09
526	12.26	14.41	13.53	13.93
527	10.03	11.19	16.04	13.94
528	10.18	10.39	12.67	10.1
529	10.11	10.33	14.85	10.54
530	10.04	11.03	11.87	11.18
531	10.07	10.95	18.08	11.43
532	11.29	10.37	41.23	12.74
533	11.33	21.29	18.07	13.97
534	11.2	13.7	12.68	10.94
535	10.18	10.02	11.63	10.72
536	10.86	11.43	10.96	10.71
537	11.38	12.28	10.95	11.58
538	11.77	15.03	10.95	17.14
539	12	10.74	11.18	11.23
540	11.38	15.87	11.18	11.28
541	11.79	22.73	18.92	18.56
542	12.99	17.73	12.38	13.93
543	10.96	20.91	12.13	11.91
544	11.86	10.11	15.57	10.49
545	11.21	10.08	19.19	10.97
546	10.19	10.62	15.42	10.97
547	10.09	13.79	10.51	12.36
548	10.24	12.11	12.64	11.4
549	13.74	10.28	11.42	14.76
550	10.04	10.65	12.75	15.34
551	11.84	15.28	24.02	10.49
552	10	13.92	11.97	10.45
553	12.23	10.52	12.93	10.77
554	11.22	13.42	13.54	10.1
555	13.86	11.14	12.96	10.44
556	10.5	10.84	10.83	11.65
557	11.4	10.14	12	10.33
558	10.39	10.33	18.97	11
559	18.87	12.85	13.43	10.15
560	12.81	10	10.7	10.15
561	10.27	10.33	10.71	10.15
562	10	14.36	12.45	10.15
563	10.33	10.27	10.12	10.41
564	10.35	14.2	13.94	12.56
565	10.76	16.56	11.71	11.75
566	10.83	16.36	10.61	15.29
567	10.42	15.74	11.37	11.63
568	11.57	10.58	11.83	11.62
569	11.57	10.15	12.34	13.06

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
570	10.75	10.39	10.76	11.27
571	11.57	10.17	15.92	15.75
572	12.02	15.49	11.58	12.28
573	11.41	11.78	11.41	13.31
574	11.24	11.78	17.63	14.64
575	12.29	12.22	11.91	10.86
576	10.06	10.29	11.94	11.18
577	10.06	12.94	10.18	15.24
578	10.01	10.37	10.19	14.26
579	11.22	11.04	13.16	17.02
580	12.5	10.01	10.07	11.68
581	10.35	10.03	10.22	17.2
582	10.62	10.78	10.12	10.49
583	10.11	11.33	10.13	10.04
584	10.21	10.11	13.78	10.41
585	13.78	10.12	11.26	10.57
586	12.75	10.06	16.83	11.09
587	11.89	11.08	12.94	10.56
588	10.15	11.57	12.14	10.47
589	11.19	12.39	12.13	10.47
590	11.3	10.93	24.21	11.82
591	11.4	11.56	18.5	10.91
592	10.78	12.78	10.19	10.19
593	10.86	12.7	10.67	12
594	10.86	10.2	11.39	13.25
595	13.78	11.41	20.55	11.43
596	16.51	11.03	14.25	13.27
597	15.41	10.64	10.34	10.06
598	13.8	10.64	13.24	14.87
599	11.66	10.06	12.71	13.43
600	11.83	11.26	12.3	13.61
601	10.31	11.79	25.19	10.27
602	12.18	10.93	13.03	18.46
603	12.18	10.66	10.26	15.29
604	11.12	16.15	10.25	15.4
605	10.63	18.14	11.25	16.5
606	10.21	18.06	12.54	14.82
607	10.5	12.7	10.57	14.35
608	10.07	13.04	14.18	11.45
609	11.6	13.63	10.08	10.75
610	10.91	13.64	13.04	11.08
611	11.27	10.07	10.91	11.11
612	11.26	35.13	11.81	14.38
613	10.47	21.14	11.25	10.49
614	10.35	10.21	13.49	12.06
615	11.37	13.69	22.39	11.31
616	10.44	16.27	18.54	11.31
617	10.39	10.8	20.58	10.41
618	10.24	10.35	22.85	10.42
619	10.14	14.66	18.36	32.09
620	10.11	19.41	15.2	13.45
621	10.85	14.1	11.55	12.89

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
622	10.85	10.46	15.27	19.63
623	10.45	15.25	24.01	30.73
624	11.51	12.09	14.3	16.8
625	10.42	12.08	14.3	10.47
626	10.88	15.48	10.02	10.62
627	11.93	12.76	11.41	13.69
628	11.14	10.17	15.2	10.14
629	11.02	14.18	12.49	18.82
630	10.35	17.58	17.46	14.55
631	10.35	14.6	17.36	14.56
632	10.83	15.71	21.95	16.94
633	10.81	10.31	12.62	14.64
634	10.8	12.1	12.14	14.17
635	10.76	12.47	12.13	14.58
636	10.89	14.18	10.83	12.74
637	13.76	16.8	10.73	12.66
638	14.12	10.37	14.19	10.42
639	11.01	16.46	13.44	10.77
640	13.85	13.55	16.37	10.78
641	10.39	11.27	13	10.28
642	10.14	10.26	11.51	10.76
643	10.13	11.2	11.52	10.04
644	10.07	13.55	14.93	11.1
645	11.16	13.51	11.93	13.02
646	10.72	10.98	11.55	10.08
647	10.2	10.45	16.98	10.31
648	10.18	15.07	19.81	11.38
649	10.04	15.88	11.76	15.39
650	10.24	13.42	11.06	13.62
651	12.4	10.13	15.44	10.32
652	12.34	11.2	18.11	19.24
653	11.09	11.75	14.82	15.56
654	12.87	10.5	16.4	15.91
655	11.02	11.83	12.65	11.42
656	10.86	10.28	11.24	10.09
657	10.09	10.24	16.48	12.59
658	10.17	10.25	14.99	13.03
659	10.1	10.55	14.56	10.27
660	10.06	11.63	20.45	12.45
661	10.72	11.64	13.28	15.02
662	11.79	10.41	14.47	11.66
663	12.26	11.04	23.46	11.39
664	11.68	10.15	12.83	12.05
665	10.96	10.45	12.17	11.6
666	10.88	10.03	13.22	10.77
667	10.65	10.67	11.78	11.21
668	10.62	10.19	11.52	11.5
669	11.07	10.75	11.13	12.26
670	10.6	10.75	12.47	10.31
671	10.2	12.19	12.22	10.42
672	10.64	10.01	22.6	10.57
673	10.58	10.01	12.57	10.77

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
674	11.42	10.35	13.49	13.3
675	11.28	12.61	26.3	10.98
676	10.73	10.76	13.31	14.34
677	11.64	11.23	13.4	10.13
678	11.02	11.23	15.36	10.13
679	11.48	11.88	12.5	10.59
680	11.04	11.88	15.2	10.59
681	10.19	12.93	11.38	12.59
682	11.12	13.01	11.11	10.97
683	11.41	15.46	11.63	14.03
684	10.61	12.78	14.17	12.43
685	11.12	12.79	17.39	10.84
686	11.02	10.11	14.42	10.26
687	12.41	11.28	15.87	10.55
688	10.22	10.8	15.3	12.88
689	19.52	11	15.33	17.12
690	20.08	12.06	11.2	11.76
691	10.25	11.04	11.43	11.11
692	10.84	10.15	14.37	11.3
693	11.93	11.2	14.34	12.01
694	10.78	12.12	13.19	10.51
695	10.78	12.91	10.69	13.56
696	10.84	10.1	17.71	11.25
697	15.13	10.87	15.52	37.48
698	10.73	19.19	10.74	13.1
699	10.22	13.6	12.94	13.06
700	10.25	13.14	12.13	12.01
701	11.35	10.39	14.79	11.25
702	10.25	10.65	26.39	11.08
703	10.24	12.56	13.65	13.95
704	10.01	10.29	11.07	13.95
705	10.18	11.27	19.46	12.74
706	10.21	12	10.48	12.05
707	10.2	10.85	10.4	13.54
708	13.76	11.02	23.5	13.78
709	13.8	12.31	15.53	10.95
710	14.1	12.91	11.03	11.52
711	11.23	12.9	13.67	11.49
712	10.43	11.4	15.93	16.27
713	10.44	11.83	10.78	13.53
714	13.59	10.46	12	13.43
715	11	16.12	10.92	10.81
716	10.26	13.86	12.82	10.38
717	10.54	11.22	14.63	14
718	10.07	14.93	10.8	11.02
719	13.22	11.92	11.01	23.22
720	11.89	14.59	10.55	14.56
721	10.29	12.16	10.81	17.07
722	10.27	10.38	13.25	13.79
723	10.88	10.46	10.34	18.97
724	10.19	11.87	13.4	14.4
725	10.14	12.6	12.28	19.19

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
726	10.24	10.81	10.86	15
727	10.02	10.71	12.14	16.27
728	10.11	11.72	10.25	13.9
729	10.22	13.89	10.25	16.16
730	10.12	10.7	12.92	15
731	12.42	16.97	11.18	27.72
732	10.44	11.45	10.68	11.16
733	13.78	12.09	15.39	12.26
734	10.08	14.67	10.89	11.53
735	10.08	10.59	14.15	11.14
736	10.24	10.27	12.53	18.42
737	10.24	13.35	12.01	11.05
738	10.12	10.83	16.1	12.59
739	13.75	13.83	13.69	12.3
740	10.62	10.65	14.15	10.09
741	11.55	17.57	13.27	13.84
742	10.49	11.86	13.54	14.57
743	10.29	13.43	13.58	13.47
744	10.28	13.03	12.67	12.74
745	10.31	13.02	12.89	10.84
746	10.02	16.1	11.33	18.1
747	10.15	17.17	25.31	13.65
748	10.57	14.26	24.8	13.5
749	10.06	15.59	12.66	10.72
750	10.59	15.52	12.14	12.22
751	10.1	16.43	15.05	17.82
752	10.03	10.44	11.27	11.91
753	12.33	14.89	10.55	11.83
754	10.39	19.28	11.18	10.08
755	10.98	13.52	12.04	10.09
756	10.23	15.63	12.49	10.11
757	10.12	13.24	13.88	12.54
758	12.97	13.24	10.54	11.62
759	10.5	14.12	10.28	10.19
760	10.03	12.27	17.54	13.07
761	10.15	13.33	12.22	10.94
762	10.15	11.51	13.81	10.94
763	10.77	11.49	11.55	15.63
764	10.38	13.33	17.24	13.89
765	10.1	13.43	13.09	11.83
766	10.17	11.08	11.73	14.14
767	10.17	11.08	11.83	11.03
768	10.05	12.23	13.18	18.86
769	10.08	10.35	11.5	10.95
770	10.66	15.76	21.71	10.94
771	11	15.76	14.38	12.02
772	11.3	13.6	14.38	12.03
773	10.71	18.43	19.65	11.79
774	11.73	19.62	11.71	11.28
775	10.69	19.62	13.74	11.48
776	10.7	19.4	10.32	10.45
777	12.21	14.76	10.27	11.12

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
778	10.47	10.95	11.44	11.88
779	10.11	13.81	19.95	12.67
780	10.56	22.72	18.12	11.3
781	13.64	17.31	12.26	10.76
782	10.31	13.68	11.82	10.16
783	10.02	10.46	15.61	10.7
784	13.97	11.27	11.3	11.49
785	14.96	19.42	13.36	11.26
786	15.9	10.37	16.6	10.91
787	11.8	21.96	14.66	10.61
788	20.15	11.84	17.43	11.95
789	11.32	11.83	13.58	14.42
790	19.83	10.93	10.23	12.06
791	14.42	10.93	11.05	15.32
792	14.59	13.68	11.11	10.73
793	11.25	12.37	15.25	16.55
794	11.2	10.11	14.32	10.22
795	12.9	14.85	12.1	10.24
796	10.83	10.09	10.69	12.65
797	10.26	10.18	11.86	14.94
798	10.32	11.9	20.06	15.76
799	10.85	10.25	16.23	15.58
800	11.43	11.13	15.18	15.09
801	10	14.04	13.8	13.03
802	12.68	12.93	14.19	11.42
803	10.95	11.51	14.58	11.42
804	11.11	13.92	14.57	10.53
805	10.02	11.65	11.89	13.34
806	10.27	17.43	11.75	12.46
807	10.04	14.68	12.68	16.63
808	10.07	15.28	15.87	18.29
809	11.54	15.28	15.16	12.92
810	10.4	12.87	15.16	12.07
811	10.1	14.13	14	10.41
812	10.02	13.44	10.2	12.2
813	14.54	12.26	15.96	10.21
814	13.11	10.18	19.51	13.44
815	16.94	15.85	10.14	13.44
816	10.1	10.53	10.15	15.75
817	15.49	13.98	11.06	13.78
818	11.18	13.55	10.48	10.15
819	10.52	10.51	11.74	18.63
820	10.22	13.11	19.73	10.81
821	15.26	12.23	11.09	10.07
822	10.72	13.97	12.89	10.07
823	10.53	11.97	12.58	13.33
824	10.27	11.96	11.06	12.36
825	10.37	10.98	11.98	25.58
826	10.08	13.18	17.08	13.4
827	12.48	16.57	12.9	17.55
828	10.21	16.65	11.21	13.47
829	13.58	15.27	20.2	11.09

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
830	10.18	17.46	13.51	11.24
831	12.58	18.63	14.26	11.24
832	21.36	13.97	11.79	11.05
833	11.64	10.05	15.47	10.12
834	10.03	12.39	10.93	10.11
835	16.14	13.9	14.91	10.54
836	10.14	14.57	10.48	11.26
837	10.75	13.41	11.29	12.73
838	10.39	12.73	15.67	10.61
839	10.08	11.34	10.48	10.25
840	26.17	12.45	11.48	10.94
841	10.26	15.13	11.47	12.22
842	11.22	13.35	10.6	11.19
843	10.17	13.11	15.58	13.04
844	10.25	16.83	11.97	10.44
845	10.25	10.56	10.78	11.63
846	10.25	11.85	10.05	11.09
847	10.07	10.7	10.55	10.24
848	10.21	11.64	10.62	11.23
849	10.1	10.92	16.37	10.68
850	10.1	11.4	11.42	10.24
851	10.52	11.98	12.98	14.83
852	10.02	10.47	11.47	10.9
853	10.79	11.26	12	20.37
854	10.27	14.02	11.92	17.47
855	10.68	11.62	12.12	13.12
856	13.02	17.73	13.54	12.71
857	11.92	12.93	16.86	11.68
858	10.53	14.83	16.65	13.94
859	10.18	10.52	11.98	10.02
860	10.18	11.27	19.78	16.54
861	10.05	11.46	10.75	12.04
862	10.18	13.24	10.67	11.05
863	10.01	13.25	12.72	11.06
864	10	10.52	10.22	10.2
865	16.97	10.52	12.89	10.07
866	10.53	10.31	12.02	17.01
867	11.21	10.32	15.99	20.16
868	10.56	10.32	16.58	10.87
869	11.52	10.6	13.75	10.87
870	12.77	11.67	13.75	10.19
871	14.87	10.52	13.75	11.14
872	12.86	13.21	10.66	10.7
873	10.56	10.29	10.78	10.36
874	10.56	11.63	11	12.84
875	10.48	11.76	17.54	11.88
876	16.1	12.19	12.38	11.88
877	16.24	12.77	12.92	14.41
878	11.09	12.29	12.33	11.99
879	11.78	15.79	10.59	11.99
880	13.74	10.03	10.57	10.9
881	11.94	14.53	12.36	23.49

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
882	10.63	14.52	12.76	12.42
883	10.56	12.67	11.66	11.32
884	12.41	13.46	11.25	10.8
885	12.73	10.49	10.71	13.53
886	11.22	11.08	14.7	11.16
887	10.55	11.08	18.27	10.64
888	10.55	10.84	14.72	11.06
889	10.46	10.05	13.98	10.9
890	10.68	13.03	10.49	11.44
891	10.38	10.32	14.06	15.95
892	11.36	11.04	15.98	10
893	10.94	10.5	29.11	10.07
894	10.94	10.39	15.49	10.54
895	11.32	11.08	11.01	14.93
896	11.32	12.92	12.91	12.36
897	10.97	16.56	15.38	23.89
898	10.21	15.52	15.28	11.73
899	10.15	10.4	15.21	10.43
900	10.08	10.63	15.91	11.63
901	10.38	11.64	16.22	12.22
902	11.41	12.76	14.43	10.3
903	11.03	10.33	14.43	10.2
904	11.44	10.04	13.55	10.4
905	11.16	10.07	12.46	10.4
906	10.02	10.02	12.26	13.96
907	10.35	13.22	12	10.17
908	10.03	11.94	12.03	11.63
909	10.25	11.45	24.25	14.83
910	14.09	10.66	19.1	10.91
911	14.34	10.66	15.47	10.23
912	15.65	10.66	15.46	15.05
913	14.45	10.43	14.07	10.97
914	14.45	10.38	11.91	10.3
915	14.45	11.85	14.22	10.3
916	10.67	10.09	24.71	13.2
917	10.8	11.86	13.88	10.29
918	10.65	10.44	13.69	15.55
919	11.23	10.75	13.62	12.56
920	12.47	10.71	16.47	14.86
921	10.23	10.64	12.8	11.1
922	10.24	10.63	12.09	10.65
923	10.05	10.42	12.09	11.93
924	10.07	12.54	17.67	11.44
925	10.09	10.32	22.83	17.08
926	10.08	10.81	40.48	11.75
927	10.29	10	13.45	19.77
928	11.04	10.24	13.38	10.18
929	10.99	14.11	13.15	10.54
930	12.68	20.31	45.87	13.75
931	11.34	18.7	14.93	11.71
932	10.58	13.35	14.75	10.24
933	10.17	17.49	23.34	15.08

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
934	10.13	12.16	10.75	10.1
935	10.59	10.95	11.57	10.1
936	30.02	10.95	14.96	10.07
937	10.18	10.4	14.97	10.38
938	10.07	10.17	13.91	10.22
939	10.02	10.17	12.39	10
940	11.77	10.12	13.53	10
941	11.37	10.91	12.11	10.63
942	13.09	10.33	16.22	25.81
943	11.69	15.55	10.86	22.64
944	15.04	10.65	14.01	13.12
945	10.96	11.24	13.84	12.01
946	11.22	10.07	12.38	13.87
947	12.25	10.36	11.7	12.65
948	11.02	10.24	23.29	12.6
949	10.07	10	12.55	13.42
950	10.95	10.21	17.11	10.83
951	10.48	10.77	12.24	10.45
952	19.47	10.41	10.32	10.6
953	11.33	10.03	10.31	10.61
954	12.47	10.05	10.17	16.8
955	13.33	10.12	10.03	10.48
956	10.12	10.04	12.78	11.05
957	10.16	11.28	10.31	11.49
958	11.58	10.86	13.15	10.08
959	11.23	13.73	10.58	10.4
960	11.04	10.36	14.72	14
961	10.2	10.36	12.36	20.97
962	20.72	12.11	11.72	11.54
963	11.8	11.29	11.09	13.67
964	11.15	14.12	12.57	17.94
965	13.78	10.04	10.16	13.26
966	12.41	10.18	10.41	14.31
967	14.73	11.23	10.44	12.18
968	10.98	11.69	10.83	14.16
969	10.01	10.29	11.92	14.19
970	10.23	11.61	11.01	20.97
971	10.23	13.44	16.48	11
972	10.21	13.74	16.49	11.71
973	13.73	10.38	22.15	11.94
974	10.19	21.6	21.49	11.95
975	10.32	10.68	23.58	29.58
976	11	18.19	20.73	12.46
977	11.31	10.51	16.84	16.11
978	12.57	10.29	16.84	32.52
979	13.13	10.04	12.14	13.54
980	13.12	10.62	18.07	17.76
981	12.8	10.78	23.08	11.52
982	16.18	10.21	12.69	11.52
983	18.76	10.7	14.06	10.54
984	24.65	10.01	10.76	15.09
985	14.39	10.24	21.24	10.48

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
986	15.54	10.23	10.27	10.48
987	13.68	12.85	17.08	10.58
988	19.81	13.99	13.37	10.83
989	12.03	10.62	15.83	11.34
990	15.66	10.62	12.77	10.54
991	10.99	10.2	21.21	17.75
992	26.78	10.61	13.31	11.04
993	15.13	20.73	12.08	12.32
994	11.38	11.8	19.53	13.07
995	10.13	18.07	18.76	22.22
996	10.55	10.56	11.3	10.21
997	22.66	10.98	10.47	18.97
998	14.53	10.98	18.55	12.45
999	12.8	11.86	16.58	22.8
1000	12.37	10.02	10.37	15.32
1001	-	-	-	14.97
1002	-	-	-	13.17
1003	-	-	-	10.36
1004	-	-	-	16.87
1005	-	-	-	10.19
1006	-	-	-	10.28
1007	-	-	-	11.86
1008	-	-	-	10.14
1009	-	-	-	10.01
1010	-	-	-	13.68
1011	-	-	-	11.42
1012	-	-	-	11.14
1013	-	-	-	10.16
1014	-	-	-	11.02
1015	-	-	-	11.71
1016	-	-	-	16.5
1017	-	-	-	14.41
1018	-	-	-	13.54
1019	-	-	-	13.44
1020	-	-	-	13.17
1021	-	-	-	11.57
1022	-	-	-	11.47
1023	-	-	-	10.34
1024	-	-	-	10.34
1025	-	-	-	10.54
1026	-	-	-	10.16
1027	-	-	-	10.07
1028	-	-	-	10.41
1029	-	-	-	19.5
1030	-	-	-	12.49
1031	-	-	-	13.64
1032	-	-	-	10.2
1033	-	-	-	11.43
1034	-	-	-	10.44
1035	-	-	-	10.45
1036	-	-	-	10.45
1037	-	-	-	11.67

Diameter No.	Alignment A Thallus (mm)	Alignment B Thallus (mm)	Alignment C Thallus (mm)	Alignment D Thallus (mm)
1038	-	-	-	10.76
1039	-	-	-	15.57
1040	-	-	-	10.75
1041	-	-	-	14.94
1042	-	-	-	17.56
1043	-	-	-	13.78
1044	-	-	-	13.78
1045	-	-	-	12.34
1046	-	-	-	12.34
1047	-	-	-	10.86
1048	-	-	-	22.95
1049	-	-	-	12.88
1050	-	-	-	17.46

Appendix H – Soil Probe Unprocessed Sample Data

Blind No.	Sample No.	Sample Depth (cmbs)	Munsell Color (Dry)	Texture	Total Volume	Total Mass (g)
1	1	0-5	10 YR 3/2	LoSa	16	6.7
	2	5-10	10 YR 3/3	LoSa	22	19.2
	3	10-15	10 YR 2/2	Sa	24	24.5
2	1	0-5	10 YR 2/1	LoSa	22	12.7
	2	5-10	10 YR 3/2	LoSa	25	20.6
	3	10-15	10 YR 3/2	Sa	23	20
3	1	0-5	10 YR 3/1	LoSa	24	9.6
	2	5-10	10 YR 3/1	LoSa	16	8.5
	3	10-15	10 YR 3/2	Sa	19	9.8
4	1	0-5	10 YR 3/1	LoSa	25	12.1
	2	5-10	10 YR 3/1	LoSa	23	18.5
	3	10-15	10 YR 3/2	LoSa	19	16.9
5	1	0-5	10 YR 3/1	LoSa	24	14.4
	2	5-10	10 YR 3/2	LoSa	12	5.2
	3	10-15	10 YR 3/2	Sa	18	12.3
6	1	0-5	10 YR 4/1	Sa	22	16
7	1	0-5	10 YR 4/1	LoSa	32	15.4
	2	5-10	10 YR 3/2	LoSa	22	16.4
	3	10-15	10 YR 3/2	Sa	24	20.8
8	1	0-5	10 YR 3/1	LoSa	30	25.4
	2	5-10	10 YR 3/1	LoSa	19	19.7
9	1	0-5	10 YR 4/2	Sa	11	10.9
10	1	0-5	10 YR 4/2	LoSa	14	9.2
	2	5-10	10 YR 3/2	LoSa	23	18.4
11	1	0-5	10 YR 4/2	LoSa	24	11.9
	2	5-10	10 YR 3/2	LoSa	31	26.3
	3	10-15	10 YR 3/2	LoSa	28	25.6
12	1	0-5	10 YR 3/1	LoSa	26	15.2
	2	5-10	10 YR 3/1	Sa	36	27.3
13	1	0-5	10 YR 3/2	LoSa	22	13.1
	2	5-10	10 YR 3/2	LoSa	31	24
	3	10-15	10 YR 3/3	Sa	29	25.5
	4	15-20	10 YR 4/1	Sa	12	10.5
14	1	0-5	10 YR 4/3	LoSa	24	13.8
	2	5-10	10 YR 4/3	LoSa	42	32.7
15	1	0-5	10 YR 4/2	LoSa	30	16.2
	2	5-10	10 YR 5/2	Sa	21	20.9
	3	10-15	10 YR 4/2	Sa	31	34.2
	4	15-20	10 YR 4/3	Sa	38	41.7
16	1	0-5	10 YR 2/1	LoSa	28	15.1
	2	5-10	10 YR 3/2	LoSa	14	16.3
	3	10-15	10 YR 3/3	LoSa	16	17.2
	4	15-20	10 YR 4/2	Sa	18	17.1
17	1	0-5	10 YR 4/2	LoSa	18	12.3
	2	5-10	10 YR 4/2	LoSa	18	16.9
	3	10-15	10 YR 4/2	Sa	21	25.4
18	1	0-5	10 YR 3/2	LoSa	20	14.7
	2	5-10	10 YR 3/2	Sa	22	21.2
	3	10-15	10 YR 3/1	Sa	18	17.1
19	1	0-5	10 YR 4/2	LoSa	32	26.7
	2	5-10	10 YR 4/2	Sa	19	20.2
	3	10-15	10 YR 4/2	Sa	12	12.2

Appendix I – Soil Probe Processed Sample Data

Blind No.	Sample No.	Sample Depth (cmbs)	Charcoal 3.35 mm (g)	Charcoal 850 µm (g)	Chipped Stone (g)	Total Charcoal Mass (g)
1	1	0-5				
	2	5-10				
	3	10-15				
2	1	0-5		< 0.001		< 0.001
	2	5-10		< 0.001		< 0.001
	3	10-15		< 0.001		< 0.001
3	1	0-5		< 0.001		< 0.001
	2	5-10		< 0.001		< 0.001
	3	10-15		< 0.001		< 0.001
4	1	0-5		< 0.001		< 0.001
	2	5-10				
	3	10-15				
5	1	0-5		< 0.001		< 0.001
	2	5-10		< 0.001		< 0.001
	3	10-15		< 0.001		< 0.001
6	1	0-5		< 0.001		< 0.001
7	1	0-5	0.022	0.023		0.046
	2	5-10				
	3	10-15				
8	1	0-5		0.041		0.041
	2	5-10				
9	1	0-5	0.035	0.012		0.057
10	1	0-5		0.001		0.001
	2	5-10				
11	1	0-5				
	2	5-10				
	3	10-15			0.02	
12	1	0-5	0.004			0.004
	2	5-10				
13	1	0-5		< 0.001		
	2	5-10				
	3	10-15				
	4	15-20				
14	1	0-5	0.009	< 0.001		0.010
	2	5-10		< 0.001		< 0.001
15	1	0-5		0.007		0.007
	2	5-10		0.004		0.004
	3	10-15		< 0.001		< 0.001
	4	15-20				
16	1	0-5		< 0.001		< 0.001
	2	5-10				
	3	10-15		< 0.001		< 0.001
	4	15-20				
17	1	0-5				
	2	5-10				
	3	10-15				
18	1	0-5				
	2	5-10				
	3	10-15				
19	1	0-5				
	2	5-10				
	3	10-15				

Appendix J – Radiocarbon Sample Submission Data

CMPA Sample No.	Hunting Blind No.	Specimen No.	Material Type	Sample Mass (g)
5BL148-1	9	-	Charcoal	0.57
5BL148-2	14	-	Charcoal	0.11
5BL148-3	15	-	Charcoal	0.11
5BL148-4	-	2017.21	Bone	4.50
5BL148-5	-	2017.20	Bone	6.77
5BL148-6	-	2017.23	Bone	0.32
5BL148-7	-	2017.26	Bone	0.19

Sample mass (g) is cumulative for all sediment samples, per blind.

Appendix K – Radiocarbon Sample Pre-Submission Photos

K.1. Specimen 2017.21 sent to Beta Analytic Inc. for bone pretreatment and AMS radiocarbon analysis.

K.2. Specimen 2017.20 sent to Beta Analytic Inc. for bone pretreatment and AMS radiocarbon analysis.

K.3. Specimen 2017.23 sent to Beta Analytic Inc. for bone pretreatment and AMS radiocarbon analysis.

K.4. Specimen 2017.23 sent to Beta Analytic Inc. for bone pretreatment and AMS radiocarbon analysis.

K.5. Charcoal sample from feature 5BL148.9 sent to Beta Analytic Inc. for AMS radiocarbon analysis. Sample grain with diameter greater than 3.35 mm displayed at lower end of sample tray.

K.6. Charcoal sample from feature 5BL148.14 sent to Beta Analytic Inc. for AMS radiocarbon analysis. Sample grain with diameter greater than 3.35 mm displayed at lower end of sample tray.

K.7. Charcoal sample from feature 5BL148.15 sent to Beta Analytic Inc. for AMS radiocarbon analysis. No sample grains captured greater than 3.35 mm, however, the largest charcoal grain is measured at 3 mm in diameter.
and AMS radiocarbon analysis.

Appendix L – Beta Analytic Inc. AMS Radiocarbon Analysis and Isotopic Ratio Results

BETA Beta Analytic
RADIOCARBON DATING

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
Tel: 305-667-5167
Fax: 305-663-0964
beta@radiocarbon.com

Mr. Darden Hood
President

Mr. Ronald Hatfield
Mr. Christopher Patrick
Deputy Directors

ISO/IEC 2005:17025-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Kelton Meyer
Center for Mountain and Plains Archaeology

Report Date: March 15, 2018
Material Received: March 05, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 488942	**5BL148-1**	**> 43500 BP**	IRMS δ13C: -27.1 o/oo

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	< 0.44 pMC
Fraction Modern Carbon:	< 0.0044
D14C:	< -995.5 o/oo
Δ14C:	< -995.6 o/oo(1950:2017)
Measured Radiocarbon Age:	(without d13C correction): NA
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Beta Analytic
RADIOCARBON DATING

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
Tel: 305-667-5167
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beta@radiocarbon.com

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Deputy Directors

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REPORT OF RADIOCARBON DATING ANALYSES

Kelton Meyer	Report Date: March 15, 2018
Center for Mountain and Plains Archaeology	Material Received: March 05, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 488943	**5BL148-2**	**40890 +/- 490 BP**	IRMS δ13C: -26.0 o/oo

(95.4%) 43386 - 41530 cal BC (45335 - 43479 cal BP)

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	0.62 +/- 0.04 pMC
Fraction Modern Carbon:	0.0062 +/- 0.0004
D14C:	-993.84 +/- 0.38 o/oo
Δ14C:	-993.89 +/- 0.38 o/oo(1950:2017)
Measured Radiocarbon Age:	(without d13C correction): 40910 +/- 490 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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4985 SW 74 Court
Miami, Florida 33155
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Fax: 305-663-0964
beta@radiocarbon.com

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President

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Mr. Christopher Patrick
Deputy Directors

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REPORT OF RADIOCARBON DATING ANALYSES

Kelton Meyer	Report Date: March 15, 2018
Center for Mountain and Plains Archaeology	Material Received: March 05, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 488944	**5BL148-3**	**5100 +/- 30 BP**	IRMS δ13C: -21.8 o/oo

(58.2%) 3881 - 3800 cal BC (5830 - 5749 cal BP)
(37.2%) 3968 - 3896 cal BC (5917 - 5845 cal BP)

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 53.00 +/- 0.20 pMC
Fraction Modern Carbon: 0.5300 +/- 0.0020
D14C: -470.00 +/- 1.98 o/oo
Δ14C: -474.28 +/- 1.98 o/oo(1950:2017)
Measured Radiocarbon Age: (without d13C correction): 5050 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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RADIOCARBON DATING

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
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Deputy Directors

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REPORT OF RADIOCARBON DATING ANALYSES

Kelton Meyer	Report Date: March 15, 2018
Center for Mountain and Plains Archaeology	Material Received: March 05, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 488945	**5BL148-4**	**180 +/- 30 BP**	IRMS δ13C: -20.1 o/oo
			IRMS δ15N: +5.4 o/oo

(53.6%)	**1726 - 1814 cal AD**	**(224 - 136 cal BP)**
(19.7%)	**1652 - 1696 cal AD**	**(298 - 254 cal BP)**
(17.9%)	**1916 - Post AD 1950**	**(34 - Post BP 0)**
(4.2%)	**1836 - 1877 cal AD**	**(114 - 73 cal BP)**

Submitter Material: Bone (Non-heated)
Pretreatment: (bone collagen) collagen extraction; with alkali
Analyzed Material: Bone collagen
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 97.78 +/- 0.37 pMC
Fraction Modern Carbon: 0.9778 +/- 0.0037
D14C: -22.16 +/- 3.65 o/oo
Δ14C: -30.05 +/- 3.65 o/oo(1950:2017)
Measured Radiocarbon Age: (without d13C correction): 100 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13
Carbon/Nitrogen: CN : 3.3 %C: 45.64 %N: 16.37

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Kelton Meyer	Report Date: September 26, 2018
Center for Mountain and Plains Archaeology	Material Received: September 17, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 504029	**5BL148-5**	**1360 +/- 30 BP**	IRMS δ13C: -18.8 o/oo
			IRMS δ15N: +4.6 o/oo

(92.2%)	**615 - 693 cal AD**	**(1334 - 1256 cal BP)**
(3.2%)	**748 - 762 cal AD**	**(1201 - 1187 cal BP)**

Submitter Material: Bone (Non-heated)
Pretreatment: (bone collagen) collagen extraction; with alkali
Analyzed Material: Bone collagen
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 84.43 +/- 0.32 pMC
Fraction Modern Carbon: 0.8443 +/- 0.0032
D14C: -155.75 +/- 3.15 o/oo
Δ14C: -162.66 +/- 3.15 o/oo(1950:2,018.00)
Measured Radiocarbon Age: (without d13C correction): 1260 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13
Carbon/Nitrogen: CN : 3.1 %C: 42.58 %N: 15.81

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Kelton Meyer
Center for Mountain and Plains Archaeology

Report Date: September 26, 2018
Material Received: September 17, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 504030	**SBL148-6**	**200 +/- 30 BP**	IRMS δ13C: -19.8 o/oo
			IRMS δ15N: +5.4 o/oo

(52.3%)	**1730 - 1809 cal AD**	**(219 - 140 cal BP)**
(25.0%)	**1647 - 1687 cal AD**	**(302 - 262 cal BP)**
(18.0%)	**1926 - 1954 cal AD**	**(23 - -5 cal BP)**

Submitter Material: Bone (Non-heated)
Pretreatment: (bone collagen) collagen extraction; with alkali
Analyzed Material: Bone collagen
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 97.54 +/- 0.36 pMC
Fraction Modern Carbon: 0.9754 +/- 0.0036
D14C: -24.59 +/- 3.64 o/oo
Δ14C: -32.58 +/- 3.64 o/oo(1950:2,018.00)
Measured Radiocarbon Age: (without d13C correction): 110 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13
Carbon/Nitrogen: CN : 3.2 %C: 42.17 %N: 15.37

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Miami, Florida 33155
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REPORT OF RADIOCARBON DATING ANALYSES

Kelton Meyer		Report Date:	September 26, 2018
Center for Mountain and Plains Archaeology		Material Received:	September 17, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 504031	**SBL148-7**	**170 +/- 30 BP**	IRMS δ13C: -20.9 o/oo IRMS δ15N: +5.5 o/oo

(50.3%)	**1723 - 1816 cal AD**	**(226 - 133 cal BP)**
(20.1%)	**1916 - 1954 cal AD**	**(33 - -5 cal BP)**
(17.1%)	**1660 - 1698 cal AD**	**(289 - 251 cal BP)**
(7.8%)	**1834 - 1879 cal AD**	**(115 - 70 cal BP)**

Submitter Material:	Bone (Non-heated)
Pretreatment:	(bone collagen) collagen extraction; with alkali
Analyzed Material:	Bone collagen
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	97.91 +/- 0.37 pMC
Fraction Modern Carbon:	0.9791 +/- 0.0037
D14C:	-20.94 +/- 3.66 o/oo
Δ14C:	-28.96 +/- 3.66 o/oo(1950:2,018.00)
Measured Radiocarbon Age:	(without d13C correction): 100 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13
Carbon/Nitrogen:	CN : 3.2 %C: 42.39 %N: 15.42

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Appendix M – Hunting Blind Feature Data

Feature No.	Max Interior Width (cm)	Max Width Orientation (degrees)	Min Interior Width (cm)	Max Exterior Width (cm)	Depth (cm)	Blind Shape	Blind Opening Orientation (cm)	Excavated?
5BL148.1	183	16	126	237	31	CIRC	106	NO?
5BL148.2	189	191	130	246	99	OVAL	218	NO?
5BL148.3	288	262	156	309	105	OVAL	52	NO?
5BL148.4	230	46	125	289	82	SEMI	79	NO?
5BL148.5	148	124	110	250	50	CIRC	124	NO?
5BL148.6	162	360	126	250	60	OVAL	54	NO?
5BL148.7	163	169	124	181	48	SEMI	169	NO?
5BL148.8	165.5	138	102.5	333.2	33.6	OVAL	84	NO?
5BL148.9	250	130	195	290	68	SEMI	24	NO?
5BL148.10	211	10	134	285	62	OVAL	40	NO?
5BL148.11	153	180	152	303	59	CIRC	352	NO?
5BL148.12	222	283	147	342	103	CIRC	166	NO?
5BL148.13	266	136	251	323	91	CIRC	124	NO?
5BL148.14	183	2	115	272	77	SEMI	100	NO?
5BL148.15	172	61	112	495	119	OVAL	59	NO?
5BL148.16	137	330	92	301	78	OVAL	322	NO?
5BL148.17	143	310	136	229	72	CIRC	192	NO?
5BL148.18	269	49	161	320	152	OVAL	342	NO?
5BL148.19	267	12	164	294	68	SEMI	89	NO?
5BL148.20	176	16	137	411	143	CIRC	NA	NO?
5BL148.21	157	156	132	194	56	RECT	279	NO?
5BL148.22	196	270	193	300	99	SEMI	241	NO?
5BL148.23	230	32	210	330	100	OVAL	129	NO?
5BL148.24	210	92	140	288	34	CIRC	NA	NO?
5BL148.25	197	186	105	328	130	OVAL	108	NO?
5BL148.26	163	169	124	181	48	SEMI	169	NO?
5BL148.27	136	100	92	261	92	OVAL	49	NO?
5BL148.28	118	54	112	321	49	CIRC	NA	NO?
5BL148.29	121	61	111	320	65	CIRC	28	NO?
5BL148.30	204	78	150	265	44	CIRC	NA	NO?
5BL148.31	146	64	135	290	63	CIRC	58	NO?
5BL148.32	217	215	128	265	82	OVAL	81	NO?
5BL148.33	159	260	156	122	92	OVAL	NA	NO?
5BL148.34	215	154	164	270	91	OVAL	119	NO?
5BL148.35	140	69	117	178	81	CIRC	101	NO?
5BL148.36	157	327	115	240	69	OVAL	148	NO?
5BL148.37	194	314	150	252	79	CIRC	NA	NO?
5BL148.38	178	296	144	277	61	CIRC	186	NO?
5BL148.39	230	354	210	353	61	CIRC	NA	NO?
5BL148.40	178	42	107	285	74	OVAL	298	NO?
5BL148.41	139	204	100	203	68	SEMI	NA	NO?
5BL148.42	133	250	183	268	62	SEMI	298	NO?
5BL148.43	107	101	86	295	70	CIRC	306	NO?
5BL148.44	148.5	234	88	304	75	CIRC	22	NO?
5BL148.45	154	44	145	275	101	CIRC	NA	NO?
5BL148.46	242	190	97	313	86	OVAL	190	NO?
5BL148.47	166	155	109	271	105	CIRC	142	NO?

Feature No.	Max Interior Width (cm)	Max Width Orientation (degrees)	Min Interior Width (cm)	Max Exterior Width (cm)	Depth (cm)	Blind Shape	Blind Opening Orientation (cm)	Excavated?
5BL148.48	193	298	124	307	55	OVAL	34	NO?
5BL148.49	153	282	119	240	79	OVAL	214	NO?
5BL148.50	150	272	140	280	78	CIRC	352	NO?
5BL148.51	135	342	125	285	113	OVAL	324	NO?
5BL148.52	190	288	85	257	44	SEMI	302	NO?

BLIND SHAPE: CIRC – circular; OVAL – ovoid; SEMI – semi-circle; RECT - rectangular