EXPLORING THE FUNCTION AND ADAPTIVE CONTEXT OF PALEO-ARCTIC PROJECTILE POINTS

A Dissertation

by

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ABSTRACT

This dissertation presents new data on projectile point variability, technological organization, and site distribution in Upper Paleolithic Siberia and late Pleistocene/early Holocene Beringia, relating projectile point morphology, weapon systems, use wear data, and site assemblage variability to functional and cultural application spaces of prehistoric technologies.

This research is divided into three related articles, first focusing on experimental investigations of the relationships between Beringian projectile point forms and prehistoric weapon systems. Lithic bifacial, simple osseous, and composite projectile point forms observed in the Beringian record are tested as arming elements of three weapon-delivery systems allowing for quantitative comparing of efficiency and lethality performances for each individual combination of weapon system and projectile-point morphology. Results indicate lithic bifacial and composite projectile points are most effective hafted as spear thrower points and hand-thrust spear tips, respectively. Better defined functional characterizations of prehistoric hunting toolkits furthers understandings of adaptive responses to resource fluctuation, landscape use, and technological organization.

Next, this dissertation updates the geochronology and occupation record of the Blair Lakes Archaeological District, specifically the north shore of Blair Lake south, to contribute to our understanding of understudied landscapes in interior Alaska. Testing and excavation results confirm regional occupations that began nearly 11,000 calendar years ago and continued through the historic period. Together these results demonstrate the significance of the Blair Lakes Archaeological District and enhance our understanding of Holocene technological variability, site distribution, mobility, and landscape use in interior Alaska.

This research concludes with a comparative morphological and use wear analysis of 11 organic artifact assemblages from Upper Paleolithic and Mesolithic sites across Siberia and Beringia, focusing on the relationships between raw material, point morphology, and function. Results show that raw material significantly influences point morphology, morphological variability increases during the late Upper Paleolithic, and organic artifacts offer an avenue for exploring prehistoric cultural application spaces.

Ultimately, this dissertation provides insight into functional and cultural application spaces of Beringian projectile points, providing a better understanding of prehistoric hunting tool kits and technological organization of Beringian foragers and the relation of these adaptations to changing ecological conditions.

DEDICATION

To my mothers Lori and Arlene Green, my father Brett Lynch, my sister Jessica, and to my incomparable wife Angela.

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TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

1. INTRODUCTION

Across Siberia and Beringia, Paleolithic and Mesolithic populations utilized lithic, osseous, and composite technologies from the late Pleistocene through the Holocene (Dixon 2011; Hoffecker 2005). Early studies of inter-assemblage variability in Beringia focused on the presence/absence of microblade technology, leading to the interpretation of technological complexes that were chronologically and culturally discrete (Goebel et al. 1991; Pearson 1999; Powers and Hoffecker 1989; West 1996). In interior Alaska, the Nenana and Denali complexes have been central to these arguments, with Nenana being typified by small teardrop- and triangular-shaped lithic points and unslotted osseous points, and Denali containing lanceolate lithic points and slotted osseous points with microblade insets (Hoffecker and Elias 2007). New research, however, has questioned the normative significance of the presence/absence of microblades, with archaeologists developing behavioral models to explain the variable projectile technologies, including seasonality, site-specific or prey-specific activities, and raw-material conservation as contributing variables (Elston and Brantingham 2002; Goebel and Buvit 2011; Graf and Buvit 2017; Lanoë et al. 2017; Potter 2011; Potter et al. 2017; Rasic 2011; Rasic and Andrefsky 2001; Wygal 2011, 2017). These are often based on ethnographic descriptions of projectile technologies and weapon-delivery systems (e.g., Potter 2011) as well as replicative studies, many of which have underreported methodologies.

Addressing the persistence of variable weapon systems in Beringia continues to be an important objective of contemporary northern archaeology and is the focus of the dissertation research presented here. This dissertation uses experimental and comparative use wear analysis methodologies to investigate projectile variability during the Upper Paleolithic and Mesolithic recovered from archaeological sites in Siberia and Beringia. Specifically, this dissertation presents the results of experimental testing designed to explore the functional and ballistic qualities of lithic bifacial, simple osseous, and composite projectile point forms observed in the Beringian record as arming elements of three weapon-delivery systems: 1) dart points launched with a spear thrower, 2) arrow tips shot from a bow, and 3) spear points arming thrusting spears. Velocity, kinetic energy, and momentum values for more than 40 experimental deployments are reported, quantitatively comparing efficiency and lethality performances for each individual combination of weapon system and projectile-point form. Lethality is considered through penetration and wound ballistics. Observations on durability and breakage patterns are presented. This dissertation also presents the results of a comparative analysis exploring the morphological and functional variability of osseous projectile weapons recovered from 11 Siberian and Beringian archaeological sites. More specifically, I investigate the relationships between raw material, manufacturing technique, morphology, and non-utilitarian modification of middle and late Upper Paleolithic and Mesolithic osseous artifacts, and I infer specific functions of these tools. This study is among the first attempts to create a pan-Siberian/Beringian perspective on early osseous projectile technology and use. Lastly, this dissertation reports the results of field-based studies carried out in the Blair Lakes Archaeological District located in the Tanana Flats south of Fairbanks, Alaska. The Blair Lakes Archaeological District encompasses both Blair Lakes and the associated terrace systems and hills that constitute major physiographic features in an otherwise vast lowland basin north of the Alaska Range, stretching east to west between the Tanana and Nenana valleys. Recent multi-year survey and excavation projects have developed a fuller understanding of the geomorphological context of the northern shore of south Blair Lake and confirmed five distinct episodes of Holocene occupation along the lake shore. These occupations began nearly 11,000 calendar years ago and continued through the historic homesteading period. The Holocene-spanning record of the Blair Lakes Archaeological District represents an ideal data set for exploring these patterns at a localized scale that are then expanded and incorporated into larger regional interpretations of prehistoric foraging behavior in Alaska since 14,000 cal BP. They also provided the author with an important experience directing a field project leading to the discovery of new archaeological materials relevant to the greater problem addressed by the dissertation.

1.1 Themes of Research

1.1.1 The Morphological Variability in Lithic, Osseous, and Composite Technologies in Beringia

In Siberia, during the early Upper Paleolithic (EUP), >30,000 calendar years ago (cal BP) humans settled the north using a suite of modern cultural traits including projectile points made from stone (unifacially worked on large blades) and osseous materials (i.e., antler, bone, and ivory; Goebel 2002, 2004). This tradition of using stone and osseous materials as projectiles continued through the middle Upper Paleolithic (MUP), 30-20,000 cal BP, and composite points (slotted with microblade insets) were added to the repertoire during the late Upper Paleolithic (LUP), after 20,000 cal BP (Goebel 2002, 2004; Pitul'ko et al. 2016, 2017; but see Kuzmin 2008). Lithic bifacial points appeared by the LUP, too, becoming especially common in eastern Siberia among Diuktai and Russian Far East LUP assemblages (Dikov 1979; Larichev and Kholushkin 1992; Mochanov 1977). These variable projectile technologies continued into the Mesolithic, especially in the far north at sites such as Zhokhov, Uptar, and Tytyl'vaam (King and Slobodin 1996; Pitul'ko 2011; Slobodin 1999). The oldest documented occupation in eastern Beringia at the Swan Point contains both ungrooved osseous and slotted composite point preforms, while sites that date more firmly to the Allerød (~14,000-13,000 cal BP) seemingly contain only ungrooved osseous points and bifacial points (Graf and Bigelow 2011; Graf and Buvit 2017; Holmes 1996, 2011; Holmes et al. 1996; Potter et al. 2017; Wygal 2010, 2011, 2017; Yesner et al. 2000). During the Younger Dryas and early Holocene, slotted osseous projectile forms re-emerge (Ackerman 1996; Graf and Bigelow 2011; Larsen 1968; Potter et al. 2014), and although lithic bifacial points persist throughout the Beringian archaeological record, these bifaces assume two general forms, large lanceolate points versus small triangular/teardrop-shaped points, the former often co-occurring with osseous points and microblades (Hoffecker and Elias 2007; West 1996).

The use of osseous material to produce projectile points implies a technological-organization strategy separate from, though often co-occurring with, an organizational strategy focused on lithic bifacial reduction (Elston and Brantingham 2002; Graf 2010; Potter 2005, 2008b, 2011; Rasic 2011; Rasic and Andrefsky 2001; Wygal 2011). Composite points produced on slotted antler, bone, or ivory, and inset with microblades, are hypothesized by archaeologists to have represented a beneficial and economic hybridization of lithic and osseous technologies (i.e., Graf 2010; Guthrie 1983); however, understandings of the functional aspects of osseous weapon tips are predominantly created from ethnographic analogy of hunting strategies and inference (Churchill 1993; Ellis 1997), and they are largely without substantial support from replicative or experimental empirical data. Slotted osseous points with microblades have been suggested as the most adaptive solution for reaching an ideal balance between ecological parameters (i.e., raw-material scarcity, durability, workability, and/or extreme cold) and the need for a highly functional weapon system across Siberia and Beringia (Dixon 2001; Goebel and Buvit 2011; Guthrie 1983; Wood and Fitzhugh 2018; Wygal 2011).

1.1.2 Behavioral Explanations of Projectile Point Variability

Bleed (1986) inferred that effectiveness should be the most highly selected factor in tool-production decisions, as manufactured objects must be capable of providing an adaptive advantage to a set of design parameters. The variable use of lithic, osseous, and composite technologies by Siberian and Beringian foragers has been suggested to reflect behavioral decisions made to cope with the distinct ecological challenges of northern landscapes, including the need for highly mobile technologies, limited access to lithic raw material, seasonality, specialized prey choice, and differential landscape exploitation. These challenges are discussed below, focusing primarily on composite technology because it is evolutionarily the most derived of the three technologies.

1.1.2.1 Mobility

Wedge-shaped microblade cores seem to have emerged in the north as part of the re-occupation of Siberia during the LUP (Goebel 1999, 2002; Graf 2010, 2013; Yi and Clark 1983; but see Kuzmin 2008). These specially designed cores and microblades are thought to represent a projectile technology coupled with slotted osseous points; however, in other regions microblades may reflect other specialized toolkits, for example tools used in the production of cold-weather clothing (Bettinger et al. 2015; see also Yi et al. 2013). Either way, the increased frequency of highly formalized toolkits containing wedge-shaped cores and microblades may represent higher degrees of residential mobility during the LUP (Goebel 2002; Yi et al. 2013). Graf (2010) notes that highly mobile foragers tended to equip individuals with “maintainable, light weight toolkits” to facilitate movement across the landscape. In this respect, the use of inset osseous points could be a function of greater mobility in the LUP over earlier MUP, but it does not explain the synchronous LUP use of bifacial points in eastern Siberia or Beringia.

1.1.2.2 Minimizing Risk of Failure

The variable northern projectiles may relate to two competing designs, maintainability versus reliability. Microblades (and by proxy slotted osseous points) are hypothesized to be part of a pattern of technological organization that defrayed risk. Maintainable systems are designed for use in unpredictable or fairly continuous situations (Bleed 1986), as well as where portability is important (Bleed 1986; Rasic and

Andrefsky 2001), but they also have relatively low failure costs, being repairable during use (Bleed 1986). Composite points with inset microblades have expensive up-front production costs (shaping and grooving of osseous points, manufacture of surplus microblades), but once deployed, the risk of catastrophic failure of the entire point is exceptionally low (Rasic and Andrefsky 2001). Replacements for dislodged microblades can be set back into grooves with relatively few materials or tools and little time investment (Petillon et al. 2011; Rasic and Andrefsky 2001). Osseous projectile points have a similarly high investment in production, coupled with the low risk of catastrophic failure; however, they lack the hybridization benefits of inset microblades in composite points. Lithic points are much better characterized as part of a reliable system and represent low investment components of a weapon system that can be easily replicated (Bleed 1986). The risk of catastrophic failure of these points is higher than that encountered with osseous points; however, as a reliable system they may have been manufactured to meet specific situational needs that could be anticipated (such as the seasonal migration of game), allowing for the mass production of bifacial tools lowering their total manufacturing cost. The differential design considerations that characterize these projectile technologies lends support to the hypothesis that they exist as adaptive alternatives to late Pleistocene and Holocene conditions in the north.

1.1.2.3 Raw-material Constraints

The adoption of variable projectile technologies by northern-latitude foragers has also been suggested to reflect behavioral decisions made to cope with the risk of limited access to raw material (Bleed 2002; Elston and Brantingham 2002; Flenniken 1987;

Rasic and Andrefsky 2001; Wygal 2011). In this respect, the development of wedge-shaped core and microblade technology has been traditionally assumed to represent a trend toward conservation of lithic raw materials, and a few experimental tests have been conducted to validate this assumption (Elston and Brantingham 2002; Flenniken 1987; Rasic and Andrefsky 2001). Flenniken (1987), for example, compared Diuktai microblade production and bifacial production in terms of raw-material conservation. His experimental results showed that bifaces are more costly in terms of lithic material wasted but are faster to produce than microblades (Flenniken 1987). However, Flenniken (1987) under-reported his metric data, and later studies showed that a clear relationship between microblade reduction and lithic raw-material management is not so obvious (Elston and Brantingham 2002; Rasic and Andrefsky 2001). Strictly defined, efficiency (as proxied by cutting edge produced from a core) is difficult to measure and often does not result in core and blade technology being “more efficient” than bifacial technology (Rasic and Andrefsky 2001). On the other hand, traditional *Yubetsu* microblade production still offers a number of advantages including production of large biface-thinning flakes compared to the size of the final core preform, uniformly shaped and sized bladelets and microblades, and significant cutting edge per unit time (Elston and Brantingham 2002; Flenniken 1987; Gómez Coutouly 2011, 2012, 2016; Rasic and Andrefsky 2001). Still, production of microblades did not always follow bifacial-reduction protocols of *Yubetsu*; more often in Siberia and Alaska *tortsovyi* microblades cores were produced on small, narrow flakes (see Gomez Cóutouly 2016, 2017).

1.1.2.4 Seasonality and Prey Choice

Behavioral explanations of variable projectile technology also emphasize seasonally distinct landscape usage with inherent connections to specific prey exploitation strategies unique to northern settings (Lanoë and Holmes 2016; Potter 2008b, 2011; Wygal 2009, 2010). Potter (2008b, 2011) suggests that maintainable composite-inset points would have been used as hand-thrust spears in encounter hunting when herbivores, such as bison, were dispersed in low elevations during the coldest times of the year. Reliable bifacial weapon systems, however, would have been employed when prey were abundant for short (predictable) windows of time, when there was a clear separation of time between gearing up and hunting (Bleed 1986). For northern-latitude foragers, many arctic species like caribou and Dall sheep follow seasonally variable patterns, and bifacial points may have been best for exploiting such species in the late spring, summer, and early fall, in particular when lithic raw material was available (due to lack of snow cover) and there was less risk of point failure due to cold-weather effects (Churchill 1993; Elston and Brantingham 2002; Guthrie 1983; Potter 2008b, 2011). This combination of variable seasonal and elevational conditions likely was an important factor in hunters' choices of weaponry.

1.1.2.5 Ecological Zone Specialization

A recent approach in the investigation of archaeological-assemblage variability is the analysis of ecological zones with exclusive resources and correlated archaeological assemblages (see Wygal 2018). The exploitation of variable, but unique, ecological resources could require specialized toolkits and thus create variability in the archaeological record (Churchill 1993; Elston and Brantingham 2002; Guthrie 1983; Potter 2008b, 2011; Wygal 2009, 2010). In Siberia, these zones have been roughly outlined at broad regional scales, generally defined within specific river corridors (see Graf 2010). In interior Alaska, these zones are often bounded as dichotomous “upland and lowland” habitat zones, but they can be further expanded to also consider a chronological dimension (Blong 2018; Graf and Bigelow 2011). The most recent and comprehensive analyses of faunal, lithic, and site-location patterning from interior Alaska suggest that microblades were utilized as part of a composite-weapon system (hand-held thrusting spear or dart tip) used during fall-winter-spring seasonal exploitation of lowland-dwelling large-bodied ungulates (Mason et al. 2001; Potter 2011). Wygal’s (2011) analysis of securely dated Alaskan archaeological assemblages reveals that the ratio of sites containing microblades (compared to those without) increases during cold periods of the Older Dryas, Younger Dryas, younger-Younger Dryas, and two neo-glacial events in the middle Holocene. Also inferred is a drop in overall population and increased microblade production as the boreal forest established itself as the dominant ecological regime of the Holocene (Wygal 2011). Wygal’s (2011) results suggest a high level of fitness for microblade production in extreme or distinct climatic or ecological transitions in interior Alaska

1.1.3 The Importance of Experimental Use-wear Studies

Since Semenov’s (1964) seminal publication a half-century ago, macroscopic and microscopic use-wear studies have helped to revolutionize our understanding of artifact functions in the archaeological record (e.g., Grace 1989; Hayden 1979; Keeley

1974; Levi-Sala 1996; Tringham et al. 1974). The earliest American experimental studies tended to focus on lithic artifacts understood to be projectile points (e.g., Keeley and Newcomer 1977), and this continues to be the main material of use-wear study in North America; however, the dual-material nature of northern projectile technologies requires experimental and use-wear studies capable of analyzing bone, antler, ivory, as well as lithic materials. Much less use-wear research has been conducted on the functionality of osseous artifacts, but the practice is growing, so that the proposed study can comprehensively analyze the full range of projectile weaponry through experimentation and attribute analyses of archaeologically-derived artifacts (e.g., Backwell and d'Errico 2001; Barton et al. 2009; d'Errico and Villa 1997; Olsen 1989; Olsen and Shipman 1988; Pawlik and Thissen 2011; Shipman 1989; Shipman and Rose 1988; Villa and d'Errico 2001). Experimental studies of Beringian lithic, osseous, and composite projectile points and microblade technology have been limited and for the most part have excluded systematic macroscopic and microscopic use-wear analysis (e.g., Guthrie 1983). Three notable exceptions are Potter (2005), who documented morphology and retouch locations of microblades and inferred forceful motions parallel to the long axis of the microblades recovered in all components at the Gerstle River site, Del Bene's (1982) investigation of the blades recovered from the Anangula Blade site, and Power's analysis of bifaces and unifaces from the Dry Creek site (Powers et al. 2017).

Much effort has been focused on systematically analyzing osseous tools from the Upper Paleolithic in Europe using functional and stylistic approaches (e.g., Campana

1989; Knecht 1993; Olsen 1984; Petillion et al 2011; Petillion et al. 2016). For example, using methodologies developed to examine techniques of manufacture and hafting as well as morphological variation and performance, Knecht (1993) determined that Aurignacian osseous points were similar in design across vast geographical space, while Gravettian osseous points displayed significant regional variability. Like these studies, this dissertation creates a standard set of experimentally produced use-wear patterns, which can be compared to archaeologically derived lithic, osseous, and composite points as well as isolated microblades to illuminate their morphological, technological, and functional aspects. This dissertation goes on to apply similar methodologies to address variation in lithic, osseous, and composite projectiles geographically and temporally across Siberia and Beringia.

1.2 Research Questions

This dissertation is separated into a series of related but independent sections with the common themes of osseous and composite projectile point morphological variability, functional analysis of osseous projectile-point forms, and the application spaces of Beringian projectile forms, both ecological and cultural. The following sections focus on three research questions:

Question 1: Do optimal delivery systems vary for each point design?

Question 2: Do use-wear and breakage data indicate that archaeologically recovered bifacial-stone, unslotted-osseous points, and slotted composite points differed in function and delivery system?

Question 3: What do variable site assemblages, site locations, and faunal associations indicate about remains associated with different forms of lithic, osseous, and composite projectile points?

In Section 2, I investigate the relationship between Beringian projectile point morphologies and debated weapon-delivery systems often associated with late Pleistocene/early Holocene bifacial-stone, unslotted-osseous, and slotted-composite points; including hand thrusting, atlatl-launching, and theories of the early appearance in Alaska of bow technologies (Ackerman 1996; Dixon 2011; Guthrie 1983; Maschner and Mason 2013; Potter 2005, 2008b, 2011). I identify differential efficiency (in penetration, durability, and wound morphologies) between tested delivery methods and corresponding point forms (expanding on Wood and Fitzhugh 2018). Testing these hypotheses produced quantitative and qualitative data that yielded valuable insight into the decisions made by prehistoric northern foragers in terms of their technology, subsistence, and land-use. Additionally, the experiment generated a use-wear sample instrumental in the analysis of osseous projectile assemblage from Siberian and Beringian archaeological sites presented in Section 1V.

In Section 3, I present the results of archaeological testing and excavations carried out in the Blair Lakes Archaeological District located in the Tanana Flats south of Fairbanks, Alaska. A multi-year survey and excavation project executed in the District confirmed five distinct episodes of extensive Holocene occupation along the northern shore of the south Blair Lake. These occupations began nearly 11,000 calendar years ago and continued through the historic homesteading period. Results of this field project have contributed to the development of a fuller understanding of the unique lakeshore and associated complex of hills and terrace. The Holocene-spanning archaeological record of the Blair Lakes Archaeological District is reported in detail at a localized scale that is then expanded and incorporated into larger regional interpretations of prehistoric foraging behavior, land use, and technological organization in interior Alaska.

Building on the data generated during experimental testing, in Section 1V I report the results of a functional analysis of composite points from the Siberian and Alaskan archaeological records. This section presents an analysis of osseous projectile points and tools from 11 Siberian and Alaskan osseous assemblages. These sites are located across Siberia and Beringia, and span from the MUP, through the LUP, into the Mesolithic. These assemblages were selected for their potential to yield insight into geographical, environmental, and chronological patterns in lithic, osseous, and composite technologies in the north. By conducting a variety of morphological, technological, and functional analyses on the osseous artifacts, this dissertation identifies differential roles of morphologically distinct projectile forms, patterns of osseous raw-material selection, as well as multiple examples of cultural expression accessible only through analysis of osseous toolkits.

Finally, in Section 5, I conclude by summarizing the results of each section, discussing the strengths and weaknesses of methodologies used, the greater implications of these results to forager research in the arctic and sub-arctic of North America and northern Asia and in particular Beringian and possible avenues of future research. It is my intention that this dissertation not only provide functional and cultural contexts for important Siberian and Beringian projectile-point morphologies, but also provide a better understanding of prehistoric weapon-system variability as it relates to prehistoric subsistence, mobility, and hunting toolkit organization in Beringia and but also provide a better understanding of prehistoric weapon system variability as it relates to prehistoric subsistence, mobility, and hunting toolkit organization for Beringia and neighboring regions.

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2. ANCIENT BERINGIAN WEAPON SYSTEMS AND PROJECTILE-POINT VARIABILITY: EXPERIMENTAL INVESTIGATION OF FUNCTION AND BEHAVIORAL CONTEXTS OF EARLY HUNTING TECHNOLOGY

2.1 Introduction

Ancient Beringians dispersed from Siberia to Alaska during the late Pleistocene with established terrestrial hunting economies incorporating three major classes of projectile-point technology. Bifacially-flaked-stone and simple osseous projectile points had long been essential components of hunting tool kits in the Siberian Upper Paleolithic, and they continued as such in eastern Beringia (Goebel and Buvit 2011), but early Beringians were also armed with a novel form of composite projectile point that became a hallmark of northern technological organization (Dikov 1979; Goebel 2002; Goebel 2004). These composite points were produced by insetting lithic microblades into grooved antler, bone, or ivory points. Archaeologists have long extolled the adaptiveness of these microblade-inset points (Elston and Brantingham 2002; Gómez Coutouly 2016; Guthrie 1983; Lanoë and Holmes 2016; Rasic and Andrefsky 2001), though much of our understanding of these projectiles is based on generalized ethnographic analogy and limited experimental research (Wood and Fitzhugh 2018). Rarely have these projectiles been considered as a scaffolded component of a larger system of weapons technology, hunting behavior, and toolkit organization.

Without question, slotted osseous points with inset microblades were a key technological adaption to ecological conditions in the north (e.g., raw-material scarcity, extreme cold) and the need for a highly efficient projectile-point design (Dixon 2001;

Goebel and Buvit 2011; Guthrie 1983; Wood and Fitzhugh 2018; Wygal 2011). Microblades detached from wedge-shaped cores link the late Upper Paleolithic Diuktai technological tradition of eastern Siberia with the earliest Alaskan archaeological assemblage ~14,000 calendar years ago (cal BP) (Hirasawa and Holmes 2017; Holmes 2011), and microblade production in the Denali Complex (or Paleoarctic Tradition) indicates persistent use of this technology during the Younger Dryas and early Holocene (Graf and Bigelow 2011; Hirasawa and Holmes 2017; Holmes 2011; Potter 2008). Early Alaskans, however, also produced simple osseous points and lithic bifacial points lanceolate in shape, and in many assemblages these technologies co-occur (Goebel and Buvit 2011; Hoffecker and Elias 2007; Potter 2008; Potter 2011; West 1996). Further complicating the situation is the Allerød-aged Nenana Complex with its distinctive small triangular and teardrop-shaped bifaces and unique lack of microblades (Graf and Bigelow 2011; Graf and Buvit 2017; Potter et al. 2017; Wygal 2010, 2011, 2017; Yesner et al. 2000). The drivers of this variability are still not well understood.

Often overlooked in efforts to explain variability in lithic-technological organization in Beringia are the complete weapon systems employed by Beringian hunters, and the functional and ballistic qualities of projectile-point forms within these systems. For example, some archaeologists suggest an association between composite-inset projectile points and an early manifestation of bow and arrow technology in Alaska by 12,000 cal BP (Ackerman 1996; Dixon 1999; Dixon 2011; Maschner and Mason 2013), while others argue that composite-inset points armed hand-thrust spears used in the pursuit of large herbivores, mainly bison (Potter 2008; Potter 2011). Resolving this issue will have major implications for our understanding of the evolution of individual hunting behaviors and toolkit variability. Similarly, large, straight-to-convex-based, lanceolate bifaces in early interior Alaskan contexts are considered diagnostic of the Denali Complex; however, the functions of these bifaces have been alternatively interpreted as spear tips, knives, or dart points (Ackerman 2001; Dixon 2001; Guthrie 2017; Potter 2008). Although individual points may have served multiple functions, these categorical alternatives are not interchangeable as each signals a substantial set of assumptions concerning the use life and behavioral context of an individual artifact in early subsistence and social organization (Butler 1975; Cattelain 1997; Churchill 1993; Frison 1978; Guthrie 1983; Knecht 1997; Petillon et al. 2011; VanderHoek 1998; Yu 2006).

This paper presents the results of an experimental project designed to explore the functional and ballistic qualities of lithic bifacial, simple osseous, and composite projectile points observed in the early Beringian record as arming elements of three weapon-delivery systems: (1) spear points arming thrusting spears; (2) dart points launched with a spear thrower, and (3) arrow tips shot from a bow. More specifically, we investigate relationships between Beringian point forms and weapon systems: Do certain projectile tips operate more effectively when deployed using one of the three delivery systems? Do the ballistic parameters of these delivery systems require the use of certain point forms? How does the relationship between point form and weapon system affect the likelihood of point failure during launch or impact? Our experimental approach provides an avenue for (1) identifying differences in wound ballistics created by each combination of point form and weapon system; (2) assessing the relative lethality of each point and weapon combination through proxies of penetration, wound type, and total wound area bolstered by the use of an actualistic target; and (3) systematically documenting the function, performance parameters, and potential application spaces of ancient hunting technologies.

2.2 Application Spaces of Ancient Beringian Weapon Systems: Equipping Northern Foragers in the Late Pleistocene and Early Holocene

Traditional interpretations of the relationship of thrusting spears, spear throwers, and bows portray these weapon systems as mutually exclusive or as sequential stages of technological development and replacement driven by diffusion (see Churchill and Rhodes 2009; Knecht 1997; Whittaker 2016). Recent studies have moved away from a diffusionist approach in favor of a more evolutionarily- and ecologically driven characterization of each weapon system by weighing respective costs and benefits dependent on context and tasks at hand (Cattelain 1997; Cundy 1989; Grund 2017; Shott 1993). While processual research has strengthened understanding of prehistoric weapon-systems design and use, it also risks masking the social and cultural influences that undoubtedly affected the decision-making processes of hunters (Waguespack et al. 2009). Integration of modern theoretical regimes in experimental archaeological studies of prehistoric weapons systems is essential.

“Application space”, as defined by Schiffer (2001), captures a more holistic understanding of all the tasks for which a technology can be used and the factors, both mechanical and social, guiding selection of specific technologies. While all weapon systems can complete generalized tasks such as ‘dispatching game’, more specifically each technology reflects a certain application space (or set of interrelated spaces) and is best suited for use in a specific combination of social, environmental, and task-specific variables (Grund 2017; Schiffer 2001). While some dimensions of a given technology’s application space are more difficult to identify in prehistoric settings, robust analyses of environmental and task-specific variables in explicit Beringian contexts, combined with well-defined functional characteristics of the three weapon systems and related projectile points, can yield new insight into early technology and subsistence.

2.2.1 Thrusting Spear

A series of design features in lithic and osseous points crafted as thrust or thrown weapons emerged with increasing regularity from the late Middle Paleolithic through the early Upper Paleolithic, including relatively small size, symmetry along the long axis of the point, and basal modifications to standardize proximal ends for hafting (Gaudzinski 1999; Peterkin 1993). These design elements represent a greater understanding in projectile aerodynamics and penetrative capabilities (Guthrie 1983; Odell and Cowan 1986; Shea et al. 2001). Prior to this, hunters seeking to procure medium-to-large-bodied game were likely armed with a variety of hand-held (‘obligate’ close-range) hunting technologies including spears, clubs, and stones (Churchill 1993; Schmitt et al. 2003) that emphasized delivery by hand.

Large, heavy-pointed spears and spear fragments have been recovered from several late Middle and Upper Pleistocene sites in Europe. Most famously, at least seven wooden spears were recovered at Schöningen 13 (Germany) in stratigraphic context dated to approximately 400,000 years ago (Thieme 1997, 1999) as well as at Clacton (England) and Lehringen (Germany) (Movius 1950; Oakley et al. 1977; Schoch et al. 2015; Warren 1911). Metrics suggest that these weapons are more similar to ethnographic thrusting spears (and even digging sticks) than ethnographically modern throwing spears (Oakley et al. 1977; Schmitt et al. 2003). By the subsequent Middle Paleolithic, hafted Mousterian and Levallois points emerged, though insufficient data exist to distinguish between points deployed by thrusting and throwing (Shea 1990, 1997; Shea et al. 2001). Traditionally, classifying hand-delivered spears as either thrust or thrown has been considered of minor consequence as modern hunter-gatherers have been documented using the same hand-held spears in both manners, thrusting a spear almost 50 percent more often than throwing it (Churchill 1993). However, these Middle Paleolithic spearpoints exhibit design elements enhancing aerodynamism and facilitating short, low-velocity flight, such as proximal and distal tapering with maximum width near the base (Thieme 1997).

Close-range thrusting spears continued to be a pivotal part of the forager’s toolkit through prehistory to the ethnographic present (Churchill 1993), with modern humans adapting spear design and morphology in innumerable ways to suit task-specific effectiveness and efficiency. Upper Paleolithic humans moving into arctic Beringia prior to the Last Glacial Maximum produced extremely large points of bone and ivory (some exceeding 60 cm in length) suitable only for delivery through thrusting or short-distance throwing (Nikolskiy and Pitulko 2013). In fact, the hunters at Yana appear to have targeted young and adolescent female mammoths with tusks suitable for creating entire lengths of ivory thrusting spears similar to the spears from Sungir' (Bader 1998; Nikolskiy and Pitulko 2013). Similar 'obligate' thrusting spears also occur in early-Holocene contexts of arctic western Beringia, for example at Zhokhov (Pitulko et al. 2015), but no examples have been recovered from eastern Beringian contexts except perhaps a large stone lance recovered at Panguingue Creek, ~8500-7500 cal BP (Hoffecker 2001; Powers and Maxwell 1986), and the large lanceolate points recovered from bear-denning caves in southeast Alaska and coastal British Columbia (Dixion 2008; McLaren 2005).

Ethnographically, thrusting spears are essential components of hunting toolkits of all northern forager groups (Dixon 2013), being employed in the hunting of large to very large prey disadvantageously (i.e., using a technique that limits the escape of the animal or exploits a naturally disadvantaged animal so that the hunter has more time to employ the weapon) (Churchill 1993). Disadvantageous hunting is strongly associated with cooperative drives, dogs, boats, snowshoes, snares, or other weapons (Churchill 1993). Often these features are not preserved in the archaeological record, especially landscape features like wetlands, lakes, and deep snow drifts that could be used to slow, exhaust, and immobilize large prey. Rare cases of ambush and pursuit hunting of smaller-bodied game with thrusting spears also have been documented where ecological factors enhanced concealment (Churchill 1993).

2.2.2. Spear Thrower

Ethnographic and experimental data provide our best insight into the use contexts and application spaces of spear throwers in Beringia (Cattelain 1997; Grund 2017;

Knecht 1997; VanderHoek 1998; Whittaker 2010, 2015, 2016). A spear thrower (commonly referred to as an ‘atlatl’ in North America) is a static lever incorporated into the system of levers and joints in the legs, waist, shoulders, arms, and finally wrists of the user that increases the velocity, accuracy, and range of launches of long, relatively heavy projectiles called darts. In the North American Arctic, spear throwers were used prehistorically in coastal arctic environments for marine-mammal and migratory-seabird hunting, were still widely in use at the time of European contact, and in some areas continue to be used today (Davidson 1936; Mason 1884). These spear throwers were crafted to launch darts from a kneeling or seated position in a watercraft, and a wide variety of dart and projectile-point morphologies were adopted to facilitate the dispatch and recovery of game taken in the open water (Cattelain 1997; Churchill 1993; VanderHoek 1998). While these ‘coastal-arctic’ manifestations of the spear thrower are among the best-documented examples of this technology, their specialized marine context limits their usefulness as an analogy for Beringian populations equipped with subsistence technologies oriented toward terrestrial mammals and anadromous fish (Choy et al. 2016; Halffman et al. 2015; Guthrie 2017; Potter 2011).

The spear thrower, while simple in construction, likely represents the earliest machine-assisted projectile-delivery system developed by modern humans (Cattelain 1997; Grund 2017; Knecht 1997; Whittaker 2010, 2016; Yu 2006). Ethnographic and archaeological examples of spear throwers demonstrate a range of morphological variability, but they are remarkably consistent in their core elements: a handle that facilitates gripping of the spear thrower and dart, a “body” or mid-segment, and a distal hook or spur which fits into a cup at the proximal end of a dart. Some North American examples of spear-thrower designs incorporate a bannerstone, though the placement and function of these ground-stone weights is debated (Cain and Sobel 2015; Dickson 1985; Hutching 2015; VanderHoek 1998; Whittaker 2010).

The earliest appearance of spear throwers in the archaeological record is subject to much debate and may continue to be difficult to directly recognize based on problematic preservation of the osseous components of the technology. Identifiable spear-thrower fragments appear in European Upper Paleolithic sites by 17,500 cal BP, and the technology likely predates these examples by many millennia (Cattelain 1988, 1989, 1997; Cattelain and Stodiek 1996; Whittaker 2010). Upper Paleolithic faunal assemblages reflect a broadening subsistence base including smaller, more agile, and warier alpine game, which would have been most effectively hunted with spear throwers (Churchill 1993; Straus 1987a; Straus 1987b). No Paleolithic examples of spear throwers have been found in Siberia, though it is generally accepted that the earliest populations moving into the Americas used this technology in procuring large game. A possible ivory spear-thrower preform was recovered from the Broken Mammoth site in Alaska; however, it is heavily degraded making positive identification difficult (Heppner 2017). Clovis foragers occupying North America ~13,000 cal BP utilized spear throwers as a primary projectile weapon system (Frison 1989; Hutchings 2015; Tankersley 2002). Late-glacial Beringian populations likely relied on this technology as well, to support highly mobile lifestyles and subsistence focusing on large-to-very-large terrestrial game. Dart-shaft fragments directly dated to the early-mid Holocene (~7000 BP) have been recovered from ice patches in the Yukon associated with lanceolate lithic technology suggesting an extended regime of hunting technology dominated by the spear thrower (Hare et al. 2004; Hare et al. 2012).

The spear-thrower launch technique has been documented ethnographically and is described and used in most modern experimental studies of the technology (Baugh 2003; Cundy 1989; Hutchings and Brüchert 1997; VanderHoek 1998; Whittaker 2016). The throwing sequence in a terrestrial context requires a series of interrelated and compounding motions that begins with raising the dart parallel to the ground, bringing the dart, shoulder, and elbow into three lines parallel to the ground surface. With open shoulders and hips, the user begins to rotate their torso while simultaneously flexing the shoulder, and pushing the wrist, spear thrower, and dart forward of the body. However, the levelness of the dart should be maintained to ensure accuracy. The true ‘launch’ of a dart occurs as the wrist, propelled in front of the user by the shoulder, flexes with great speed, breaking the spear thrower’s parallel line with the ground, ultimately snapping the spear thrower towards the ground, pushing the dart away from the spur. The rapid flexing of the wrist over a small area generates a proportionally small force magnified by the distal end of the spear thrower that moves over a significantly larger space and imparts energy from the user to the dart through the spur. The arm and body of the user follow through this throwing motion as the dart travels down range.

Spear throwers in terrestrial contexts are traditionally used in mostly open terrain settings such as deserts, prairies, alpine areas, and steppes (Cattelain 1997; Churchill 1993; Whitaker 2016; Yu 2006). The standing deployment and dynamic throwing technique dictate, to some degree, the upright positioning of the user during hunting events, obviously influencing hunting strategies, though environmental conditions and prey type can be strong factors in hunting-strategy selection (Cattelain 1997; Grund 2017; Nelson 1899; Whitaker 2016; Yu 2006). Moreover, the relatively large size of darts limits the mobility of the user and the number of darts carried on logistical forays (Churchill 1993). Ethnographically, populations that traditionally use spear throwers most often employ ambush and/or approach strategies. In ambush hunting, hunters conceal themselves behind natural features or constructed blinds where they wait for an animal to pass within an effective distance (Churchill 1993). Approach hunting strategies conversely involve a hunter stalking prey to effective ranges without triggering a flight response (Churchill 1993). Evidence of approach-strategy hunting is difficult to identify in prehistory, though ecological and landscape data and prey-selection patterns could support its use in Beringia (Guthrie 2017; Potter 2008).

Projectile points designed for use with spear throwers and darts tend to be larger and more massive than points used to arm an arrow, though considerable metric overlap between smaller dart points and larger arrow tips makes categorical interpretations of artifacts based on mass or morphology uncertain (Bradbury 1997; Hughes 1998; Shott 1997). Spear throwers and darts are considered ‘shock’ weapons that transfer a substantial amount of force to the target at the moment of impact based on the relatively high mass of projectile points and darts, resulting in large wounds prone to extensive hemorrhaging (Dickson 1985; Flenniken and Raymond 1986; Grund 2017; VanPool 2006; Whittaker et al. 2017; Yu 2006). Despite accounts of extraordinary feats of accuracy by life-long, subsistence-oriented users of spear throwers, ethnographic surveys suggest the spear thrower is most often used in targeting medium-to-large bodied game over distances of 10-30 meters (Hughes 1998; Whittaker et al. 2017; Yu 2006). Communal hunting is also commonplace among foragers using spear-thrower technology, probably to overcome accuracy limitations and long reload times between launches, as well as to capitalize on aggregation behavior of some prey species (Bettinger 2013).

2.2.3 Bow and Arrow

The bow-and-arrow weapon system represents a third major form of projectile technology utilized by prehistoric and historic hunter-gatherers, although its presence and relationship with the spear thrower in Beringia is poorly understood. The earliest appearance of bow-and-arrow technology has been the subject of intensive research at global and regional scales, including in the far north (Bergman 1993; Cattelain 1997; Clark 1963; Rausing 1967; Yu 2006). Though this weapon system differs functionally and mechanically from the spear thrower, construction fromosseous materials similarly has potentially disguised its presence in early archaeological contexts (Yu 2006). Despite a Holocene trend toward smaller projectile-point morphologies and widespread adoption of the bow, projectile points manufactured as elements of a bow-and-arrow weapon system are often difficult to distinguish from small dart points in regions where these technologies co-occur (Shott 1993, 1997; Thomas 1978). While limited windows of simultaneous use in terrestrial settings have been documented archaeologically, populations generally adopted the bow relatively rapidly and discontinued the use of spear throwers (Hare et al. 2004; Hare et al. 2012; Knecht 1997; Yu 2006).

Mechanically, the bow functions differently than a spear thrower. While a spear thrower is a largely static tool that propels large projectile points and heavy darts by enhancing the throwing motion of the user, the bow is a more mechanically complex system that temporarily stores energy created by the user and then releases that energy rapidly, resulting in the forward launch of a small, light projectile. Even in the simplest self-bows, flexible limbs are bent by pulling a bowstring, and these limbs store potential energy. When the string is released these limbs spring back into place, snapping the bowstring back to a taut position and transferring the now realized kinetic energy into the arrow. Although bow mechanics require significant alterations to the morphologies of projectiles (both arrow shafts and points), the technology facilitates alternative hunting strategies, expands the breadth of prey selection, and can heavily influence landscape use, warfare, and social organization (Hughes 1998; Maschner and Mason 2013; Yu 2006).

Similar to the spear thrower, the earliest use of the bow and arrow by prehistoric populations is difficult to recognize based on the osseous nature of the technology and the difficult task of distinguishing arrow tips from dart points. Bow-and-arrow technology is definitively present in rock art in Africa by 10,000 cal BP, but morphologies of lithic points suggest the bow may have appeared there by ~35,000 cal BP (Robbins et al. 2012). In Europe, fragments of arrow shafts with proximal notches recovered from a bog in Stellmoor (Germany) date to 11,000 cal BP and represent the earliest directly dated appearance of bow and arrow technology, but like in Africa the bow may have replaced the spear thrower much earlier, by 17,000 cal BP, again based on morphological changes in projectile tips (Cattelain 1997).

Despite these early roots in Africa and Europe, no direct evidence places the bow in Alaska or Siberia until well into the middle Holocene, when costal populations employing Arctic Small Tool tradition (ASTt) toolkits spread across the Arctic from northcentral Siberia to Greenland around 4500 cal BP (Maschner and Mason 2013). ASTt sites in Greenland with exceptional preservation have produced bow fragments (Gronnow 1996), but otherwise bow usage in ASTt terrestrial hunting is extrapolated from the presence of microlithic end blades (Maschner and Mason 2013). Further, the use of bow-and-arrow technology by late-Pleistocene hunters in Beringia has been suggested based on morphological similarities between slotted osseous projectile points recovered at Trail Creek Caves dating to ~11,300 cal BP (Lee and Goebel 2016) and osseous points grooved to seat end blades in later Holocene coastal occupations (Ackerman 1996, 2011; Dixon 2011; Maschner and Mason 2013). The manifestation of the bow tied to microblade technology during the earliest Holocene represents a significant reinterpretation of the history of this weapon system in Beringia, as well as in the Americas. For example, in interior Alaska and Yukon, the bow is generally thought to have appeared much later in the Holocene. Here, the archaeological record preserves a large sample of hunting technologies preserved in ice-patch contexts, demonstrating that bow-and-arrow technology fully emerged by ~1200 cal BP, after which it rapidly replaced the use of spear throwers in the region (Hare et al. 2004 Hare et al. 2012).

Bows function by launching small, lightweight projectiles at high velocities. Increased projectile speed results in less time between launch and impact with a target downrange. In a terrestrial hunting scenario, this gives wary prey less time to react to the incoming arrow (Bergman 1993; Bettinger 2013; Churchill 1993; Grund 2017; Tomka 2013). Bows are largely considered capable of more consistent accuracy than spear throwers, and straighter projectile trajectories between a hunter and target make the bow better suited for hunting small-bodied game than the spear thrower (Churchill 1993; Yu 2006). The bow can be reloaded and redeployed much faster than a spear thrower, and the small projectile size allows a hunter to carry more arrows than darts on logistical forays (Bergman 1993; Bettinger 2013; Bettinger et al. 2015; Blitz and Porth 2013; Churchill 1993). Bows can be shot standing or crouching, in open or closed-in terrain, and they require little movement on the part of the hunter, all of which makes the bow more versatile over a larger number of ecological settings and offers a hunter the option to more fully exploit concealed-stalking or ambush-hunting strategies (Bergman 1993; Bettinger 2013; Bettinger at al. 2015; Blitz and Porth 2013; Churchill 1993; Yu 2006).

While these technologies are traditionally treated by archaeologists as discrete nodes in a developmental continuum, with the bow being regarded as more accurate, more versatile, and better suited to taking medium- to small-bodied game, a more complex understanding of their relationship has begun to emerge based on recognizing the adaptive advantages and limitations of both technologies.

2.2 Experimental Design, Materials and Methods

To investigate the full range of suggested deployment strategies for Beringian projectile points and the functional and behavioral contexts of the three point forms as elements of the three specific weapon systems, we tested examples of each point form (lanceolate biface, simple bone point, and inset-composite point) as tips of thrusting spears, dart points launched from a spear thrower, and as arrow points deployed with a bow, using an actualistic target (Figure 2.1).

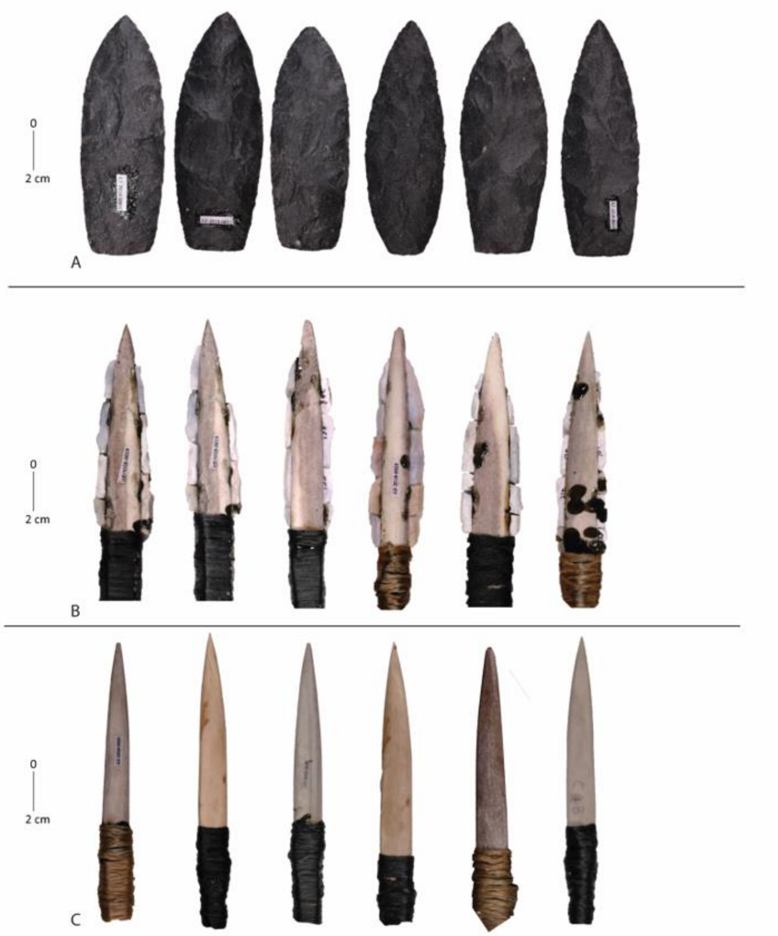

Figure 2.1 Experimental Beringian projectile points (a) lithic bifaces, (b) composite inset points, (c) osseous points.

Most experiments of this sort have focused on a single deployment strategy, and many have opted to use a mechanized launching device capable of repeated deployments with tightly controlled velocity and accuracy. However, following VanderHoek (1998) and Whittaker et al. (2017), our experiments employed human-powered launches, because launching devices (and modern compound bows) do not reproduce the distinctive flight dynamics and impacts generated by atlatl and bow launches, and they cannot be used to replicate hand thrusts.

Recent investigations of the transition from spear thrower to bow and arrow incorporate precise measurements of projectile mass, velocity, kinetic energy (KE), and momentum as drivers of penetration and wound ballistics (Grund 2017; Tomka 2013; Whittaker 2013; Whittaker et al. 2017; Yu 2006). Mass and velocity at impact are considered the two most important physical variables influencing penetration (Whittaker et al. 2017). KE and momentum are functions of the relationship between the mass and velocity of a projectile and are commonly used to compare projectile effects. Momentum is the tendency of an object to stay in motion, continuing to travel along an initial path, and is equal to the object's mass multiplied by its velocity ($P = m*v$). Momentum inside a system is conserved during impact, is transferred from projectile to target, and drives heavier or faster projectiles to continue penetrating a target after impact. Kinetic energy, the 'force of impact', measures the amount of energetic work completed by a projectile as energy is transferred to the target, creating penetrative wounds and pushing aside damaged/broken tissue (Whittaker et al. 2017). The kinetic energy of a projectile is equal to one half of the projectile's mass multiplied by the square of its velocity (KE = ½ m *

v^2). As discussed above, spear throwers capitalize on the momentum produced by high-mass projectile points and large dart shafts, while bows generate KE by propelling less-massive projectiles at generally higher velocities. These variables have become important in defining the functional parameters of prehistoric weapon systems; however, only limited rigorously-collected quantitative data have been published (Whittaker et al. 2017).

The effectiveness of any weapon system depends on a combination of factors including a hunter's knowledge of the behavior and anatomy of targeted prey, the hunter's skill in delivering projectiles, the functional characteristics of each component of a weapon system, and the projectile's performance once in contact with the target (Frison 2004; Guthrie 1983; Tomka 2013). While these factors influence the effectiveness of a weapon system, experimenters rely on penetration as a primary signal of 'lethality' and consider it a proxy for effectiveness (Blitz 1988; Frison 2004; Guthrie 1983; Tomka 2013). Lethality can be difficult to model, and penetration can be affected by point design, sharpness, width of haft, and size of trailing shaft (Friss-Hansen 1990; Hughes 1998; Shea 1997; Thomas 1978; Waguespack et al. 2009). Measuring wound severity and other performance characteristics allows assessment of the differences created in the wound channel due to morphological variability of point form (Wood and Fitzhugh 2018). Our target's heterogeneity affected the morphology of wound types and wound channels in a way not documented in testing with ballistic gel targets, though variability in our target's contact surface permitted assessment of wound ballistics through actualistic impact events. We calculated total wound area by multiplying penetration depth by wound-width values (PD x W x 2), following Wood and Fitzhugh (2018). By documenting wound ballistics and total wound areas resulting from projectile-point contact with an actualistic target, we could more robustly model wound severity and ultimately lethality.

2.3.1 Materials

2.3.1.1 Bifacial-Stone Points

Twelve bifacial-stone points were created for this project by knapper Michael Miller from fine-grained basalt, a material commonly used in the production of bifaces in Beringian assemblages (Goebel and Buvit 2011; Potter et al. 2008; Powers et al. 2017). These points were manufactured with morphologies reflecting archaeological examples of straight-to-convex-based lanceolate points associated with Denali-Complex assemblages from interior Alaska, including Dry Creek Component (C) 2, Moose Creek C2, Panguingue Creek C1, Owl Ridge, and Upward Sun River (Goebel and Buvit 2011; Gore and Graf 2018; Potter 2011; Potter et al. 2014; West 1996; Wygal 2018) (Figure 2.1a). They reflect the small sample of complete lanceolate projectile points from these sites, with a mean length of 94.51mm (s = 10.58), width of 35.71mm (s = 2.04), and thickness of 10.26mm (s = 0.69). Small triangular and teardrop-shaped Chindadn points were not included in this experiment because they are typically not associated with microblade industries (Goebel and Buvit 2011; Goebel and Potter 2016; Potter 2008).

2.3.1.2 Microblades

Hundreds of microblades produced from heat-treated chert cores were created for this project by knapper Eugene Gryba using documented core-reduction strategies and hand-held pressure-flaking (Gómez Coutouly 2011, 2012, 2017). Microblades selected for use in the experiment fell within morphological dimensions derived from a sample of 1000 microblades from Dry Creek C2 analyzed by the author, with average length of 10.48mm (s = 5.50) (length), width of 3.89mm (s = 2.47), and thickness of 1.06mm (s = 0.46). Each inset microblade was subjected to low-to-medium-power microscopic analysis to document pre-experimental edge damage.

2.3.1.3 Osseous and Composite Points

With the assistance and guidance of traditional technologist Monty Rodgers, the author produced 12 slotted-composite points from caribou (*Rangifer tarandus*) antler and 12 unslotted points from caribou long bones, following published dimensions of specimens recovered from Beringian and Siberian sites, which have a mean length of 117.45mm (s = 94.75), width of 10.73mm (s = 4.41), and thickness of 6.56mm (s = 2.23) (Abramova 1979a, 1979b, Ackerman 2011; Astakhov 1999; Lee and Goebel 2015; Vasil'ev 1996; West 1996; Figure 2.1b-c). These measurements include osseous points from Siberian assemblages that exceed the sizes of most Alaskan osseous points, but also include points that were rejuvenated (Lee and Goebel 2016). By including them all, we defined a mean size for the experimental osseous projectile points. Caribou antler and bone segments were shaped using a bandsaw and table sander, then finished with fine-grained sandpaper. Bilateral slots in antler points were created with a Dremel tool to consistently produce grooves reflective of an archaeological sample of Beringian slotted points, with a mean length of 92.43mm (s = 72.14), width of 1.84mm (s = 0.45), and depth of 2.75mm (s = 0.69).

2.3.1.4 Thrusting Spears

Bifacial-stone, osseous, and slotted-composite points used as components of a hand-thrust spear were hafted to a 20cm wooden foreshaft using pine-pitch resin and artificial sinew to create a smooth transition between point and foreshaft. Beveled and U-notched foreshafts with hafted points were joined with the main shaft using a modified ‘plug and taper’ method (Frison 1983). The main shaft was produced on a prefabricated rounded birch staff, hand beveled and tapered to create a smooth transition between the point, foreshaft, and main shaft.

2.3.1.5 Spear Throwers and Darts

The spear thrower used during the experiments measured ~40cm in length and was custom designed for the author’s comfort and throwing habits. Dart shafts were produced from birch, following ethnographic and experimental examples (Butler 1975; Cattelain 1997; Churchill 1993; Frison 1978; Guthrie 1983; Petillon 2011; VanderHoek 1998; Whittaker et al. 2017; Yu 2006). Ethnographic examples from terrestrial contexts are morphologically variable but generally 140-300cm in length with weights from 150-600g. Most experimental darts are within this range, with darts used in tests involving targets mimicking large to very-large game trending toward the larger end of the spectrum (Cattelain 1997; Frison 1987; Whitaker et al. 2017). All constructed darts had 1.8m tapered lengths, to minimize failure and maintain consistency. Shafts were hand fletched with split turkey feathers affixed with artificial sinew and spruce pitch, then tuned specifically to the point form with which they were armed. Turkey feathers were selected to maximize consistency in spear-thrower launches. Experimental dartswere designed with metrics reflective of weapon technology used to dispatch medium-, large-, and very large-bodied game animals that constitute significant portions of the Beringian faunal record (Guthrie 2017; Hoffecker and Elias 2007; Pitulko et al. 2016; Potter 2008, 2011). Osseous points were hafted using a beveling technique, spruce pitch, and artificial sinew. Lithic bifacial points were hafted directly to the mainshaft of the darts using a "U" shaped notch, seated with spruce pitch, and bound with artificial sinew to secure the point and reinforce the dart shaft. We did not use a foreshaft, instead following the single piece shaft design of a recently recovered complete dart from a Yukon ice patch (Smith et al. 2020), minimizing failure points and avenues for artificial performance variability.

2.3.1.6 Bow and Arrows

Arrows were constructed following ethnographic and experimental examples and were custom tuned to the author's shooting habits and metrics of each hafted point (following Cattelain 1997; Guthrie 1983; Knecht 1997; VanderHoek 1998). Pre-cut and straightened wooden arrow shafts were beveled for hafting osseous and composite points similarly to the hafting technique used for darts described above. Bifacial-stone points were hafted in a U-shaped notch at the distal end of the arrow using pine-pitch resin and artificial sinew to create a smooth transition between point and arrow shaft. Arrows were launched using a recurve bow with a draw weight of 20kg and tuned to the metrics and habitual draw of the shooter. This bow is reflective of ethnographically and archaeologically documented simple (unbacked) bows utilized by North American foragers with average draw weights of 18-22 kg, consistently producing launches within expected velocity ranges of 30-35 m per second (Cattelain 1997).

2.3.1.7 Actualistic Target

An adult, 8-9-year-old female reindeer carcass, weighing roughly 50-60kg served as an actualistic target for this experiment. The use of an actualistic target was essential to our experimental design and allowed for the capture of meaningful penetration and wound ballistic data, as well as to make observations of use wear related to impact. The freshly dispatched carcass was suspended from a wooden frame in an anatomically-correct standing position and supported by wooden scaffolding (following Guthrie 1983; Petillon et al. 2011; Wood and Fitzhugh 2018) (Figure 2.2 a, d).

Figure 2.2 Experimental testing: (a) actualistic target, (b) checking hafting of experimental osseous point and spear thrower dart weapon system pre-launch in testing staging area, (c) recording the number of microblades displaced from experimental composite point after impact, (d) testing area, actualistic target, Lynch preparing to deliver hand-thrust spear, data collectors in the background.

2.3.2 Experimental Design and Methods

The The experiment was designed to test the functions of Beringian projectile points as suggested in relevant literature, and these point classes' relationships with weapon systems hypothesized to be present in Beringia during the late Pleistocene and early Holocene (Ackerman 1996, 2011; Dixon 2011; Goebel and Buvit 2011; Maschner and Mason 2013; Potter 2005, 2008, 2011; Wood and Fitzhugh 2018; Wygal 2009, 2010). Thirty-six bifacial-stone, unslotted-osseous, and slotted-composite points were tested as components of three distinct weapon systems. Twelve points were used as components of spears thrust by hand, darts propelled from a spear thrower, and arrows launched from a bow with a draw weight of 25.4kg, the latter representative of traditional bow-draw weights in the Americas (Table 2.1) (Cattelain 1997; Wood and Fitzhugh 2018). All projectile points were photographed; length, width, thickness, mass, tip angle, tip cross-sectional area (TCSA), and tip cross-sectional perimeter (TCSP) were documented before and after hafting (Table 2.1).

All delivery systems were engaged from ethnographically-appropriate effective distances: immediately adjacent to the target for thrusting spears, and ~15 m for spear-thrower and bow-and-arrow launches (Cattelain 1997; Churchill 1993; Guthrie 1983; Knecht 1997; Petillon et al. 2011) (Figure 2.2b). Projectile velocity was measured using a Bushnell 'Velocity' hand-held radar gun positioned behind the thrower aiming downrange, a proven method for recording projectile speed in flight (Whittaker et al. 2017), and testing was captured using a Nikon D3400 digital camera. Each launch/thrust was extensively documented. We measured and photographed each contact resulting in

Table 2.1 Experimental projectile point measurements.

Point Number	Point Type	Raw Material	Point Length	Point Width	Point Thickness	Weight (g)	Thickness in Haft	Width in Haft	Hafted Weight	TCSP[1]	TCSA[2]
1	Biface	Basalt	91.25	32.05	10.58	37	16.59	32.83	279	73.56	272.32
2	Biface	Basalt	89.65	36.61	8.83	33	16.24	38.12	261	82.87	309.53
3	Biface	Basalt	89.57	36.73	9.81	37	14.56	36.69	64	78.94	267.10
4	Biface	Basalt	91.36	35.79	11.27	39	16.53	37.37	245	81.72	308.86
5	Biface	Basalt	67.95	33.55	9.82	25	15.49	33.45	53	73.72	259.07
6	Biface	Basalt	104.73	39.96	10.95	46	14.76	40.65	61	86.49	300.00
7	Biface	Basalt	101.14	35.15	10.88	48	13.65	35.07	66	75.26	239.35
8	Biface	Basalt	101.28	38.01	10.51	45	15.38	38.13	59	82.23	293.22
9	Biface	Basalt	112.12	36.04	10.69	49	17.15	36.98	64	81.53	317.1
10	Biface	Basalt	88.58	36.37	10.49	33	13.65	36.78	58	78.46	251.02
11	Biface	Basalt	97.07	34.90	10.01	38	16.7	35.53	259	78.52	296.68
12	Biface	Basalt	99.51	33.41	9.32	33	15.93	33.49	48	74.17	266.75
13	Slotted	Antler	118.45	14.47	5.98	10	12.62	24.22	230	54.62	152.83
14	Slotted	Antler	122.83	14.88	5.84	11	11.89	18.61	48	44.17	110.64
15	Slotted	Antler	113.76	10.13	5.53	6	11.01	17.51	225	41.37	96.39
16	Slotted	Antler	113.79	12.52	6.89	10	9.81	19.1	23	42.943	93.69
17	Slotted	Antler	113.5	14.65	8.18	11	13.06	23.91	234	54.49	156.13
18	Slotted	Antler	115.23	13.95	7.21	11	13.47	20.56	46	49.16	138.47
19	Slotted	Antler	111.39	14.35	7.02	9	11.46	21.85	27	49.35	125.2
20	Slotted	Antler	124.49	14.7	7.97	13	8.71	25.92	34	54.69	112.88
21	Slotted	Antler	112.35	14.66	7.33	12	10.11	23.19	50	50.6	117.23
22	Slotted	Antler	108.84	16.01	7.27	11	12.01	19.23	233	45.34	115.48
23	Slotted	Antler	110.93	14.71	6.14	12	11.5	14.99	51	37.79	86.19
24	Slotted	Antler	114.43	11.8	6.64	7	11.11	22.77	28	50.67	126.49
25	Unslotted	Bone	109.64	13.19	4.82	9	11.57	15.58	28	38.81	90.13
26	Unslotted	Bone	115.94	12.55	7.01	9	12.53	15.23	23	39.44	95.42

(Continued)

Table 2.1 Continued.

Point Number	Point Type	Raw Material	Point Length	Point Width	Point Thickness	Weight (g)	Thickness in Haft	Width in Haft	Hafted Weight	TCSP[1]	TCSA[2]
30	Unslotted	Bone	107.62	11.24	7.04	11	11.67	17.33	47	41.79	101.12
31	Unslotted	Bone	100.03	12.12	6.84	8	10.98	15.11	41	37.36	82.95
33	Unslotted	Bone	113.27	14.37	6.98	13	10.87	21.05	228	47.38	114.41
34	Unslotted	Bone	116.77	11.75	6.98	8	12.25	18.34	225	44.11	112.33
35	Unslotted	Bone	106.67	13.42	7.42	9	11.24	14.32	229	36.41	80.49
36	Unslotted	Bone	104.71	12.46	6.52	9	11.32	16.85	24	43.33	85.04

[1] Tip cross sectional perimeter (TCSP)
[2] Tip cross sectional area (TCSA)

the penetration of the target, to document specific wound types, as well as wound width and depth, calculating total wound area (TWA) (Table 2.2). We measured penetration from the projectile tip to the location on the shaft adjacent to the contact point, and we labeled each wound with its corresponding point/microblade-batch number (Guthrie 1983; Petillon et al. 2011; Whittaker et al. 2017; Wood and Fitzhugh 2018). We inspected each point after its use, for lithic points examining tip and basal damage, for bone points examining for tip damage and longitudinal cracking, and for inset-composite points examining for broken or displaced microblades and tip or base damage. We repeatedly launched firmly-hafted, undamaged points until achieving a catastrophic failure of the point or hafting element to generate a robust use-wear sample.

Testing took place in North Pole, Alaska on a mild winter day with ambient temperatures ranging from -5° to -9° C over the course of the experiments (Figure 2.2). We used a reindeer carcass as a proxy for targeted northern prey species, specifically

Table 2.2 Experimental launch results**.**

Launch Number	Point Design	Weapon System	Contact Surface	MPH	Penetration	Width of Wound[1]	Depth of Wound[2]	Total Wound Area[3]	Condition of Point
12-1	Biface	Spear	Rib	-	No	-	-		Tip Crushed; haft broken
6-1	Biface	Spear	Stomach	-	Yes	-	50		Broken hafting element
9-1	Biface	Spear	Rib	-	No	-	-		Hafting element broken; Tip crushing; basal damage
8-1	Biface	Spear	Rib	-	Yes		<15		
27-1	Unslotted	Spear	Rib	-	Yes	13.57	50	13.57	Tip crushed; bevel broken
25-1	Unslotted	Spear	High Leg/shoulder	-	No	-	-		Broken at bevel
26-1	Unslotted	Spear	Neck muscle	-	Yes	15.23	45	13.71	No visible damage
26-2	Unslotted	Spear	Neck muscle	-	Yes	15.25	35	10.68	No visible damage
26-3	Unslotted	Spear	Neck muscle	-	No	-	-		Hafting failure
28-1	Unslotted	Spear	Neck muscle	-	Yes	17.43	80	27.89	Binding lose
28-2	Unslotted	Spear	Rib	-	No	-	-		Bevel snapped
19-1	Composite	Spear	Lung/organs behind ribs	-	Yes	21.85	150	65.55	Microblades displaced
20-1	Composite	Spear	Lung/ organs behind ribs	-	Yes	26	230	119.60	4 microblades displaced and point separated inside the target
16-1	Composite	Spear	Rib	-	Yes	19.2	60	23.04	Bevel destroyed; tip crushed
24-1	Composite	Spear	High on ribs	-	No	-	-		Crushed tip; bevel destroyed; 2 microblades displaced
3-1	Biface	Bow	Upper neck	55	No	-	-		
3-2	Biface	Bow	Through hay bale	58	No	-	-		
10-1	Biface	Bow	Upper leg	62	Yes	36.78	55	40.46	Damage to tip and down one lateral edge

(Continued)

Table 2.2 Continued.

Launch Number	Point Design	Weapon System	Contact Surface	MPH	Penetration	Width of Wound[1]	Depth of Wound[2]	Total Wound Area[3]	Condition of Point
7-1	Biface	Bow	Upper leg/lower shoulder	60	Yes	40	62	49.60	Minimal damage; tip crushing
5-1	Biface	Bow	Shoulder	63	No	-	-		Tip crushing; loose in haft
31-1	Unslotted	Bow	Ribs	67	Yes	15.15	80	24.24	
31-2	Unslotted	Bow	Scapula	68	Yes	15.2	83	25.23	Loose in haft
30-1	Unslotted	Bow	High on shoulder	-	Yes	17.35	65	22.56	
30-2	Unslotted	Bow	High on shoulder very	77	Yes	13.3	90	23.94	Tip crushing and hafting loose
32-1	Unslotted	Bow	Lower on ribs behind shoulder	75	Yes	Width of point at haft	75		Loose in haft
29-1	Unslotted	Bow	Forward of shoulder; base of neck	68	Yes	11.7	75	17.55	Tip crushing
21-1	Composite	Bow	Shoulder	66	No	-	-		
21-2	Composite	Bow	Ribs	69	Yes	23.2	80	37.12	1 microblade displaced and 1 microblade burinated
18-1	Composite	Bow	Ribs	73	No	-	-		1 microblade displaced
18-2	Composite	Bow	Ribs	72	Yes	21.48	65	27.92	1 microblade displaced; broken at bevel
23-1	Composite	Bow	Stomach	74	Yes	15.2	125	38.00	5 microblades displaced; 2 remained in hide
14-1	Composite	Bow	Ribs behind shoulder	65	Yes	18.75	68	25.50	1 microblade displaced
14-2	Composite	Bow	Scapula	72	No	-	-		Point broken in half

(Continued)

Table 2.2 Continued.

Launch Number	Point Design	Weapon System	Contact Surface	MPH	Penetration	Width of Wound[1]	Depth of Wound[2]	Total Wound Area[3]	Condition of Point
11-1	Biface	Spear thrower	Stomach	43	Yes	40	120	96.00	Tip crushed
1-1	Biface	Spear thrower	Hay bale	43	No	-	-		
1-2	Biface	Spear thrower	Ribs	45	No	-	-		Minor crushing on the tip; rebounded off ribs
1-3	Biface	Spear thrower	Behind front leg	45	No	-	-		Slid along hide
1-4	Biface	Spear thrower	Back of ribs	39	No	-	-		Rebounded off ribs
1-5	Biface	Spear thrower	Low on stomach	44	Yes	41	133	109.06	Loose in haft
2-1	Biface	Spear thrower	Rib	43	No	-	-		Rebounded off of ribs
2-2	Biface	Spear thrower	Rib	48	No	-	-		Rebounded off ribs
2-3	Biface	Spear thrower	Rib	44	Yes	39.5	50	39.50	Undamaged
2-3	Biface	Spear thrower	Rib	42	No	-	-		loose in haft
34-1	Unslotted	Spear thrower	Support board	40	No	-	-		Broken at base and broken haft; point tip snapped in removal from board
33-1	Unslotted	Spear thrower	Scapula	42	Yes	21.5	115	49.45	Undamaged
33-2	Unslotted	Spear thrower	Ribs	44	Yes	21.3	35	14.91	Separated from haft
35-1	Unslotted	Spear thrower	Hay bale	44	No	-	-		
35-2	Unslotted	Spear thrower	Hay bale	45	No	-	-		Undamaged
35-3	Unslotted	Spear thrower	Ribs	45	No	-	-		Rebounded off ribs
35-4	Unslotted	Spear thrower	High on leg	43	Yes	15	90	27.00	Tip crushed

Table 2.2 Continued.

Launch Number	Point Design	Weapon System	Contact Surface	MPH	Penetration	Width of Wound^1	Depth of Wound^2	Total Wound Area^3	Condition of Point
17-1	Composite	Spear thrower	High on back; continued past target	45	No	-	-		Failure of hafting feature; point in the snow
15-1	Composite	Spear thrower	Ground; over back of target	44	No	-	-		Tip crushed; 5 microblades displaced
13-1	Composite	Spear thrower	High on back	48	No	-	-		1 microblade displaced
13-2	Composite	Spear thrower	Back on ribs	-	No	-	-		Rebounded off ribs
13-3	Composite	Spear thrower	High on back	46	Yes	25	210	105.00	Broken at bevel; point stayed in wound
22-1	Composite	Spear thrower	Hay bale	43	No	-	-		Undamaged
22-2	Composite	Spear thrower	Ribs	-	No	-	-		Bounced off ribs; point dislodged from haft

[1] *Width reported in mm*
[2] *Depth reported in mm*
[3] *Total wound area reported in cm^3*

caribou. The reindeer carcass maintained a high internal temperature and experienced no discernable muscle stiffening during testing. At the conclusion of the experiment, we processed (defleshed and sterilized) the carcass, further investigating impact damage preserved on skeletal elements and recovering dislodged microblades, projectile-point fragments, and, in two cases, entire points separated from hafting elements inside the carcass. Skeletal elements have become part of the comparative and teaching collection at the Department of Anthropology, Texas A&M University.

2.4 Results of Experimental Testing

Achieving a more holistic understanding of the relationships between projectile-point forms and weapon systems requires an experimental design allowing for the capture of ballistic, penetration, and post-impact breakage patterns. Here we report mass, velocity, kinetic energy, and momentum values for more than 40 experimental deployments as a method of quantitatively comparing efficiency and lethality performances for each individual combination of weapon system and projectile-point form presented in Tables 2.3 and 2.4. In the following section, we first evaluate the velocities, kinetic energies, and momentums of the launches performed during this experiment. Second, we consider overall lethality as observed through the proxies of penetration and wound ballistics for each point and weapon-system grouping. Lastly, we present observations on the durability and breakage patterns of each point form.

2.4.1 Velocity, Kinetic Energy, and Momentum

The dart and arrow velocities launched in our experiments conform to expected patterns observed in other published experimental testing (Frison 1987; Hutchings and Brüchert 1997; Whittaker et al. 2017). Spear-thrower-dart velocities ranged from 66-74km per hour, with no significant variation in velocities between projectile-point forms (Table 2.3 and Figure 2.3). With a median mass of ~240g, these darts are more than 100g heavier than the majority of darts reported in other recent experiential velocity studies (Whittaker et al. 2017) but are considerably less massive than the 365-950g darts used by Frison (1987) testing Clovis-point lethality on elephants, and are comparable to the 220g darts preferred by Hutchings and Brüchert (1997).

Table 2.3 Weight and velocity experimental launch results and comparative experimental launch weight and velocity sample, continued on next pages.

Delivery Style-Projectile Form	**Weight (g)**	**Velocity (mph)**	**Launch Number**
Spear thrower-dart	115	33	-
Spear thrower-dart	93	35	-
Spear thrower-dart	113	35	-
Spear thrower-dart	115	38	-
Spear thrower-dart	107	39	-
Spear thrower-dart	122	39	-
Spear thrower-dart	116	44	-
Spear thrower-dart	155	45	-
Spear thrower-dart	85	46	-
Spear thrower-dart	128	46	-
Spear thrower-dart	128	46	-
Spear thrower-dart	105	47	-
Spear thrower-dart	175	47	-
Spear thrower-dart	180	47	-
Spear thrower-dart	180	48	-
Spear thrower-dart	109	48	-
Spear thrower-dart	93.0	50	-
Spear thrower-dart	79.0	50	-
Spear thrower-dart	87.0	51	-
Spear thrower-dart	149.0	54	-
Spear thrower-dart	75.0	55	-
Spear thrower-dart	127.0	55	-
Spear thrower-dart	109.4	56	-
Spear thrower-dart	82.0	57	-
Spear thrower-dart	180.0	59	-
Spear thrower-dart	114.0	59	-
Spear thrower-dart	167.0	60	-
Spear thrower-dart	176.0	62	-
Spear thrower-dart-side arm	76.0	62	-
Spear thrower-large cane dart	177.0	63	-
Spear thrower-dart	180.0	64	-
Spear thrower-dart	113.0	73	-
Spear thrower-dart	68.3	80	-
Spear thrower-dart	63.2	85	-
Simple bow 25 lb-arrow	20	80	-
Bow 45lb-arrow	30	93	-

Table 2.3 Continued.

Delivery Style-Projectile Form	Weight (g)	Velocity (mph)	Launch Number
Recurve Bow 55lb-arrow	29	101	-
Spear thrower-dart	195.0	60	-
Spear thrower-dart	195	60.0	-
Spear thrower-dart	128	60	-
Spear thrower-dart	94	61	-
Spear thrower-dart	104	61	-
Spear thrower-dart	125	62	-
Spear thrower-dart	113	65	-
Spear thrower-light willow dart	49.3	88.6	-
Spear thrower-light willow dart	51.5	88.6	-
Spear thrower-light willow dart	47	84.2	-
Spear thrower-light willow dart	47	86.2	-
Spear thrower-light willow dart	51.5	87	-
Spear thrower-light willow dart	47	87	-
Spear thrower-light willow dart	47	91.2	-
Spear thrower-light willow dart	49.3	89.1	-
Spear thrower-light willow dart	49.3	89.1	-
Spear thrower-light willow dart	49.3	93.1	-
Spear thrower-light willow dart	49.3	93.1	-
Spear thrower-JL medium dart	165	52	-
Spear thrower-JL medium dart	160	48	-
Spear thrower-JL medium dart	159	58	-
Spear thrower-JL medium dart	164	64	-
Spear thrower-JL medium dart	169	56	-
Spear thrower-JL medium dart	162	56	-
Spear thrower-JL medium dart	163	42	-
Spear thrower-JL medium dart	164	51	-
Spear thrower-JL medium dart	165	45	-
Spear thrower-JL medium dart	165	47	-
Spear thrower-dart-biface	279	43	1-1
Spear thrower-dart-biface	279	46	1-2
Spear thrower-dart-biface	279	45	1-3
Spear thrower-dart-biface	279	44	1-4
Spear thrower-dart-biface	279	44	1-5
Spear thrower-dart-biface	259	43	11-1
Spear thrower-dart-biface	261	43	2-1

(Continued)

Table 2.3 Continued.

Delivery Style-Projectile Form	**Weight (g)**	**Velocity (mph)**	**Launch Number**
Spear thrower-dart-biface	261	44	2-2
Spear thrower-dart-biface	261	44	2-3
Spear thrower-dart-biface	261	45	2-4
Spear thrower-dart-biface	245	45	4-1
Spear thrower-dart-biface	245	45	4-2
Spear thrower-dart-composite	230	44	13-1
Spear thrower-dart-composite	230	N/A	13-2
Spear thrower-dart-composite	230	46	13-3
Spear thrower-dart-composite	233	43	22-1
Spear thrower-dart-composite	233	N/A	22-1
Spear thrower-dart-composite	234	43	17-1
Spear thrower-dart-composite	225	44	15-1
Spear thrower-dart-composite	228	41	33-1
Spear thrower-dart-composite	228	44	33-2
Spear thrower-dart-composite	225	45	35-3
Spear thrower-dart-composite	225	43	35-4
Arrow-bow 45lb-biface	64	55	3-1
Arrow-bow 45lb-biface	64	58	3-2
Arrow-bow 45lb-biface	58	62	10-1
Arrow-bow 45lb-biface	66	60	7-1
Arrow-bow 45lb-biface	53	63	5-1
Arrow-bow 45lb-composite	48	65	14-1
Arrow-bow 45lb-composite	48	72	14-2
Arrow-bow 45lb-composite	51	74	23-1
Arrow-bow 45lb-composite	46	73	18-1
Arrow-bow 45lb-composite	46	72	18-2
Arrow-bow 45lb-composite	50	66	21-1
Arrow-bow 45lb-composite	50	69	21-2
Arrow-bow 45lb -unslotted	41	67	31-1
Arrow-bow 45lb -unslotted	41	68	31-2
Arrow-bow 45lb -unslotted	43	68	29-1
Arrow-bow 45lb -unslotted	47	N/A	30-1
Arrow-bow 45lb -unslotted	47	77	30-2

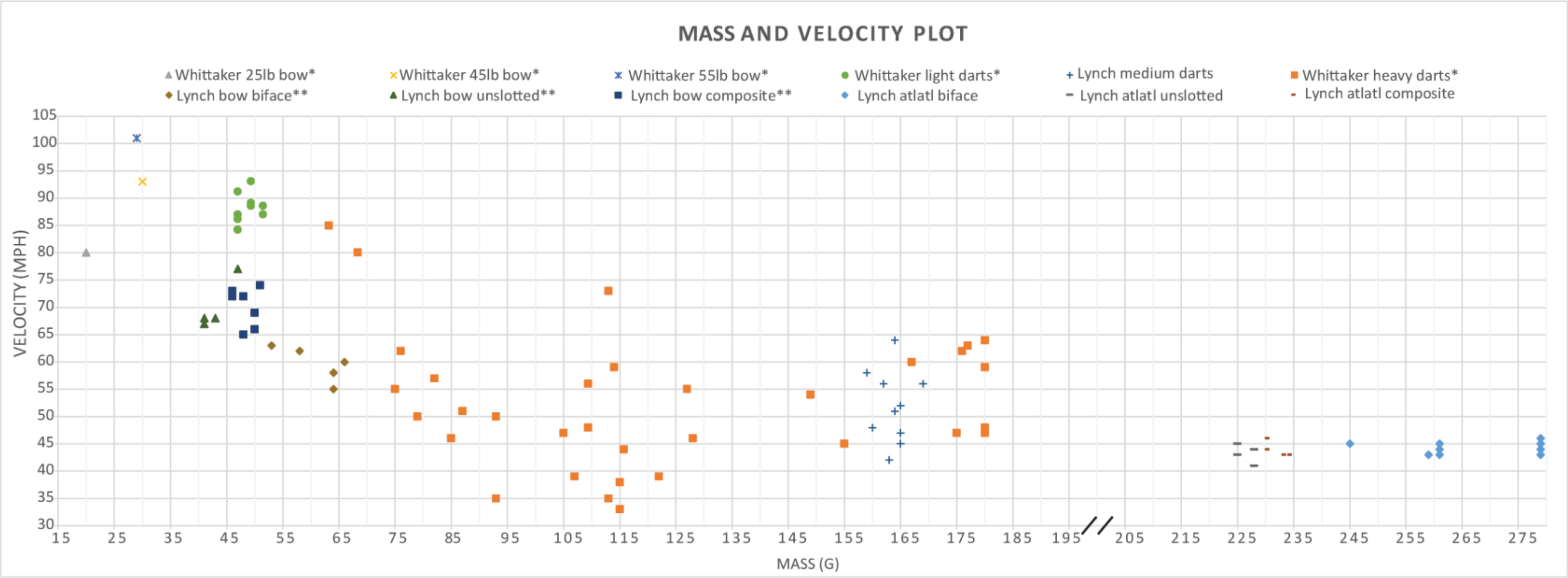

Figure 2.3 Mass and velocity plot for spear thrower and bow and arrow launches measured in the current study or taken from literature.
*** Whittaker et al. (2017) provides a large sample of vetted mass and velocity values from experimental literature.**
**** Recurve bow used in this study had a draw weight of 45 lbs.**

Combining the large Beringian points with hafting and fletching materials resulted in relatively heavy arrows weighing 41-66g. Arrows armed with osseous tips weighed an average of 43.8g, while those armed with lanceolate lithic bifaces averaged 61.0g, a difference of 17.2g almost entirely resulting from the differential weights of the points themselves. This difference in mass greatly altered the velocity at which these arrows traveled down range. Arrows tipped with osseous and composite projectile points produced an average velocity of ~112km per hour, while heavier arrows armed with lithic bifaces averaged a velocity of 96km per hour (Table 2.3, Figure 2.3).

Kinetic-energy and momentum values were calculated for 90% of experimental launches (when velocity was successfully captured) (Table 2.3, Figure 2.4). Our experimental testing documented high momentum for all projectile-point forms in the spear-thrower weapon system. Darts armed with lithic lanceolate points produced a mean momentum of 5.25g m/s, reaching a high of 5.74kg m/s. Heavier projectiles require more energy to reach a given velocity, but this mass and energy also makes these projectiles slow to come to a rest after initial impact, resulting in large wounds with extensive tissue damage. Darts armed with composite-inset projectiles produced a mean momentum of 4.5kg m/s, and osseous points, 4.3kg m/s (Table 2.4; Figure 2.4). Kinetic energy is more heavily influenced by velocity than mass (Whittaker et al. 2017); however, our experimental darts, particularly those armed with lithic bifaces, were so massive that they produced high KE.

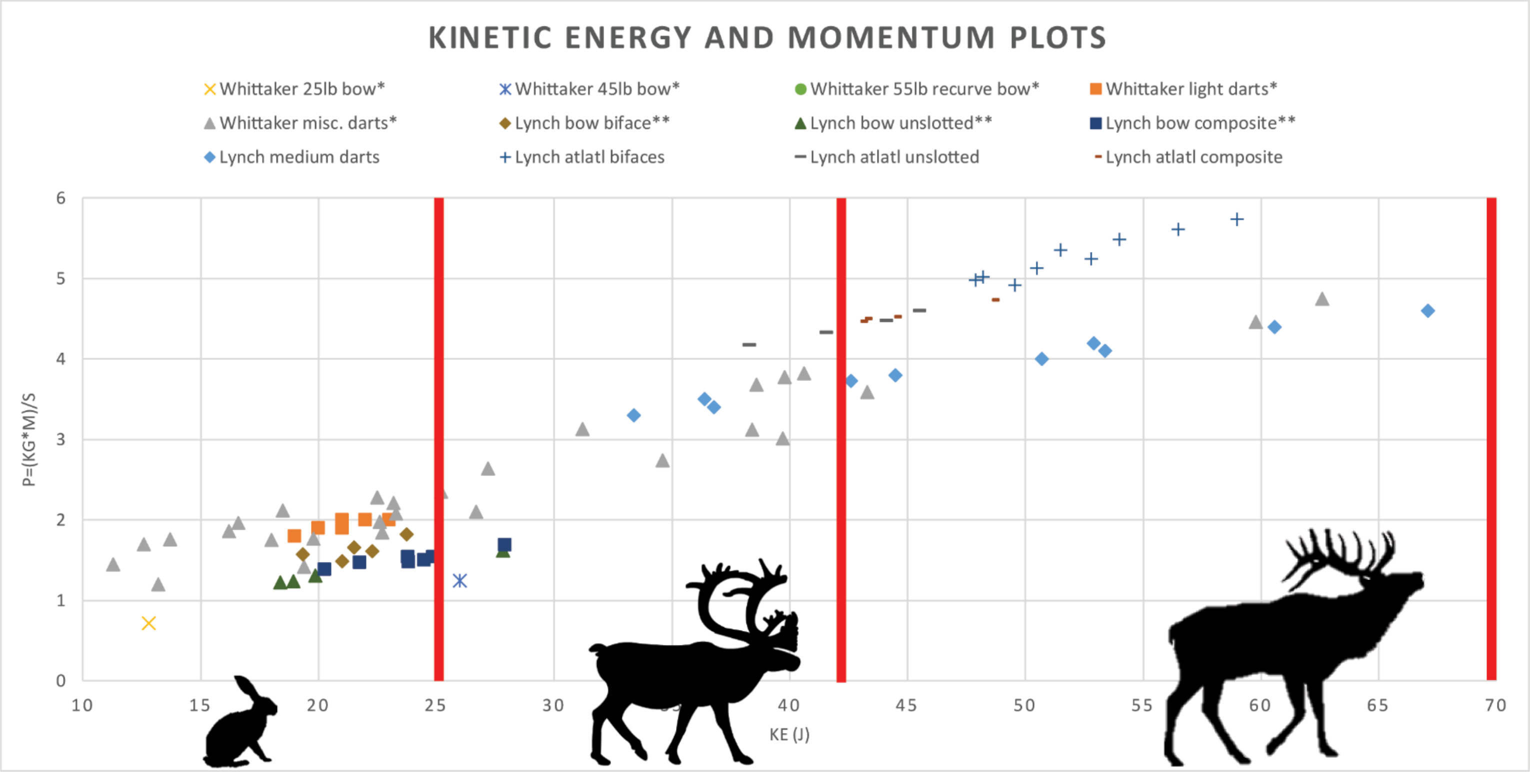

Figure 2.4 Kinetic energy and momentum plot for spear-thrower and bow-and-arrow launches measured in the current study or taken from literature. Recommended kinetic energy and momentum ranges for modern bow hunters by prey size, from Tomka (2013), are shown by vertical red lines. (*Whittaker et al. (2017) provides a large sample of vetted mass and velocity values from experimental literature; ** recurve bow used in this study had a draw weight of 45 lbs.).

The high mass of the lanceolate bifaces hafted to arrows resulted in reduced velocity but slightly increased momentum, generating 1.63kg m/s of momentum compared with only 1.51kg m/s and 1.3kg m/s for arrows tipped with composite and osseous points, respectively (Table 2.3). Tomka (2013) compiled range recommendations for KE by prey size, and by mapping these over our plotted momentum and KE values we can see that spear throwers tipped with large lanceolate points generate enough KE to dispatch large-to-very-large Beringian fauna, such as wapiti and bison, common in faunal assemblages (Figure 2.4) (Graf and Bigelow 2011; Potter 2011; Wygal 2011). Thus, lanceolate bifaces are best suited to enhance the momentum of darts launched by a spear thrower to create lethal wounds, while velocity and osseous point morphologies are important factors in driving penetration of experimental arrow launches.

2.4.2 Penetration Patterns

Our experiment resulted in 59 total launches and thrusts: 15 of thrusting spears, 18 from the bow, and 26 from the spear thrower. Penetration metrics and accuracy results are presented in Table 2.2 and Figure 2.5. Below we report these results by weapon system and point class.

2.4.2.1 Thrusting Spear

Thrusting spears were targeted at vital areas on the carcass to simulate a blow that would quickly dispatch a living target, reducing energy expenditure in recovery of the animal and increasing the safety of the hunter (Torrence 1989) Thrusting spears into the rib cage and vital organ area of the carcass resulted in seven contacts with hard

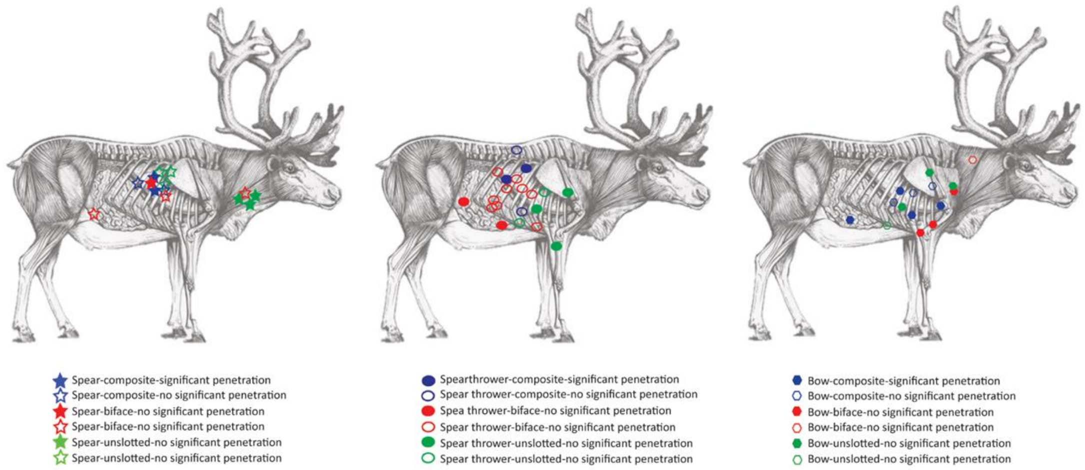

Figure 2.5 Penetration results and accuracy patterns for each point form delivered by thrusting spear, spear thrower, and bow. Penetration greater than 30mm is considered statistically significant

tissues (lungs, muscle, other organs). All point classes experienced increased penetration when contact was made with soft tissue. Lithic bifaces largely failed in their deployments as thrusting spears. A single deep penetration of 50mm was achieved when targeting away from the protective rib cage, and hard-tissue penetration averaged less than 15mm. The minimal penetration achieved by bifaces in our testing is likely the result of the energy required to overcome the resistance to penetration caused by their high tip cross-sectional area (Table 2.1), a level of force that overwhelmed the hafting elements when contact was made with hard tissues. Osseous points achieved moderate penetration in soft tissues and shallow penetration of hard tissues, averaging 56mm deep. Composite points achieved high levels of penetration and proved the most capable of navigating between or through hard tissues, penetrating the thoracic cavity, achieving penetration values averaging 165mm, deeper than other points and sufficient to quickly dispatch medium-to-large bodied game (Doelman 2009; Doelman et al. 2009).

2.4.2.2 Spear Thrower

All point forms penetrated the target in soft and hard tissue contacts when launched from the spear thrower. Lithic bifaces contacting soft tissue areas penetrated deeply, averaging 110mm deep. Many bifacial-point hits to the rib cage rebounded from impact with little penetration or damage to the point, similar to biface rebounding Wood and Fitzhugh (2018) observed. A few of our direct hits to ribs resulted in fractures to the struck bone, though little penetration into the thoracic cavity. Osseous points continued to penetrate soft and hard tissue to moderate depths as seen in other weapon systems, averaging 80mm deep. Composite points produced penetration values between those of osseous and lithic points (averaging 85mm deep), continuing to excel at navigating hard tissues in the rib cage, penetrating vital organs and soft tissues.

2.4.2.3 Bow and Arrows

All bow launches were targeted at vital areas of the carcass and contact was made with both soft and hard tissues surrounding the thorax. All point forms achieved higher penetration values when contact was made with soft tissue. High degrees of accuracy were attained (Figure 2.5); however, despite compensation through increased arrow spine and user targeting, lithic bifaces were the most difficult to place on target. They shallowly penetrated soft tissues in the lower front quadrant of the carcass with an average penetration depth of 58.5mm, but hard-tissue contact mostly resulted in full rebound of the biface with no penetration. Osseous points successfully penetrated soft and hard tissue, but penetrated higher during soft-tissue contact. The consistent and low-tip cross-sectional areas of the osseous points hafted to arrows launched at high velocities, facilitating initial penetration of hide and muscle, but only reaching an average penetration of 78mm. Contact with hard tissue was often sufficient to end the continued penetration of the osseous points into more vital areas. Composite points achieved the highest penetration in soft- and hard-tissue contacts, averaging 84.5mm.

2.4.3 Wound Ballistics

The following section summarizes experimental results concerning aspects of wound ballistics including wound type, total wound area (TWA), and durability.

2.4.3.1 Wound Type

Wounding dynamics observed in this experiment confirm associations between Beringian point classes and specific wound types observed in experimental testing conducted by Wood and Fitzhugh (2018), and expand on their results to incorporate large lanceolate lithic bifaces. Our bifaces produced massive incised wounds that are known to gape open and bleed profusely (Farjo and Miclau 1997). Simple osseous points with narrow tips, small TSCA values, and no cutting edge created puncture wounds through blunt-force trauma (Figure 2.6). These wounds result in bruising and tissue bridging, but minimal wound-channel damage or hemorrhaging (Fackler 1990). Composite points deployed by every weapon system produced laceration wounds of torn, cut, and/or pierced tissue and were typically associated with fragmentation or deformation of the projectile (Figure 2.6).

2.4.3.2 Total Wound Area (TWA)

Calculating TWA of contacts that achieved penetration into the target allowed the severity of each wound to be quantified, providing a method for comparing wound ballistics and evaluating differential lethality potentials of each point class used in each weapon system (Figure 2.6). Lithic lanceolate bifaces launched from spear throwers produced an enormous mean TWA value of 85.3cm^3; however, when they were hafted as arrows and launched from a bow, bifaces produced a mean TWA value of only 41.8cm^3, because of high mass and resistance to penetration. Lithic bifaces performed even more poorly in thrusting spears, producing a mean TWA value of 29.60cm^3.

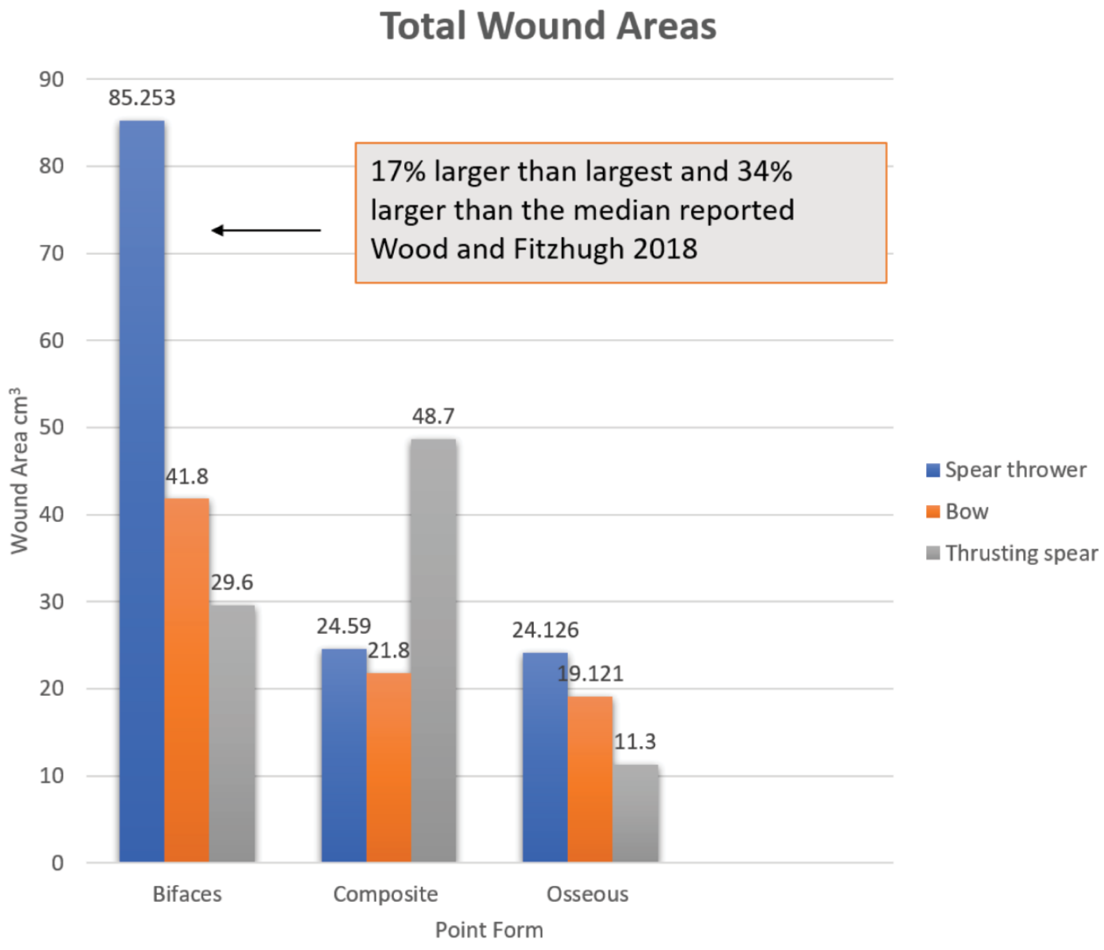

Figure 2.6 Mean total wound area data procured by each point form as components of each weapon system.

Osseous points produced consistent puncture wounds in both hard- and soft-tissue contacts. When launched from a spear thrower, they produced a maximum TWA of $33.1cm^3$ and mean of $24.1cm^3$. When deployed as arrow tips, osseous points produced a mean TWA of $19.1cm^3$, and when deployed on a thrusting spear, $11.3cm^3$. Composite points produced mean TWA values of $24.59cm^3$ when deployed from the spear thrower, $21.8cm^3$ when launched from the bow, and $48.7cm^3$ when used on thrusting spears. These mean TWAs are significantly larger than those for osseous points, particularly when deployed as a thrusting spear, with the increased wound severity relating to the laceration caused by inset microblades.

2.4.3.3 Durability

Across weapon systems, the 'simple' osseous point class proved to be the most durable point form, with each point functioning through ~3.5 deployments. Lithic bifaces across all weapon systems functioned an average of 3.1 contacts, though this number includes rebounding when they contacted with ribs. Additionally, bifaces overwhelmed the hafting elements of our hand-thrust spears 75% of the time. Observable use wear or damage to bifaces following soft-tissue contact was subtle and only documented on 28.5% of impacts. Bifaces failed catastrophically during hard-tissue or off-target contacts much more frequently than either osseous point class. Composite points remained functional for an average of 2.1 deployments, but microblades were displaced 61% of the time. More microblades were displaced inside the target when a point was launched from the spear thrower or shot from the bow, than when deployed on a hand-thrust spear. Both osseous and composite points most often failed between mid-and full-bevel (38% of contacts) resulting in snap and bending fractures with steps and/or hinges characteristic of impact fractures. Failure of the distal tip of osseous points occurred in 12.5% of contacts, resulting in longitudinal splitting, crushing, and/or large flake removals.

2.5 Discussion

The actualistic testing of complete prehistoric weapon systems presented here adds to a growing effort to systematically document the function, performance parameters, and potential application spaces of ancient hunting technologies (e.g. Anderson 2010; Hughes 1998; Letourneux and Petillon 2008; Lipo et al. 2012; Shott 1997; Walde 2014). By evaluating momentum, kinetic energy, lethality, and durability for each point form deployed through three weapon systems, the results of the experiments highlight the trade-offs and range of options available to Beringian hunters.

2.5.1 Experimental Observations

The section below summarizes experimental observations and interpretations concerning Beringian lanceolate bifaces, osseous points, and composite points as aspects of weapons systems.

2.5.1.1 Beringian Lanceolate Bifaces

The large bi-beveled antler rods and lanceolate bifaces interred as grave goods in the terminal Pleistocene double-infant burial at Upward Sun River suggest Beringian foragers employed a robust foreshaft morphology in some application spaces (Potter et al. 2014). Bi-beveled osseous tools have also recognized as elements of the Clovis weapon system in temperate North America, though many functions have been proposed for these artifacts (Sutton 2018). However, in this experiment, lanceolate bifaces deployed as thrusting spears were regularly turned away by hard tissue contacts and dislodged from beveled hafting before significant penetration could be achieved. This surprised us, given the use of wide foreshafts and beveled hafting techniques suggested by these archaeological examples and other experimental studies. The width, TSCA, and high mass of these Denali-style bifaces resulted in their separation from the hafts at contact.

Lanceolate lithic bifaces hafted to robust spear-thrower darts produce incised wounds with massive total areas and deep penetrations in soft tissue contacts. These types of wounds were also produced in hard-tissue contacts, though direct impacts with a rib of the actualistic target resulted in several ‘rebounds’; this was also experienced by Wood and Fitzhugh (2018), who achieved more consistent lithic-point penetration when changing the delivery angle from perpendicular to a “quartering away” angle, creating lethal wounds to vital areas while avoiding the ribcage. Altering the angle delivery and shot placement of the lanceolate bifacial points hafted as spear-thrower dart tips likely would have increased the number of lethal wounds per deployment. Such a behavioral adaptation would be difficult to recognize archaeologically, though projectile approach angle has been interpreted when projectile impacts have been identified on faunal elements (Waters et al. 2011; Pitulko et al. 2016).

Experimental Denali bifaces were unsuited for use as tips of arrows. To start, the ratio of point size to haft width made hafting difficult. Additionally, the weight of the bifaces compromised the accuracy of the arrow launches. Each launch required compensation in aiming to ensure contact with vital areas of the target, compensation not required when launching lighter and narrower osseous projectiles which traveled along flat trajectories. This effect likely would have been minimized or masked in controlled launches over short distances.

2.5.1.2 Osseous Points

Osseous points preformed the most uniformly of the point forms across all weapon-system deliveries. When deployed as the tips of thrusting spears, they achieved low levels of penetration in both hard- and soft-tissue contacts, and they produced puncture wounds of consistent size and shape with low TWA values. Low TSCA values, narrow point widths, and smooth transitions between osseous points, hafts, and foreshafts facilitated increased penetration, but lack of sharp cutting edge along the length of the point reduced the TWA and resulted in wounds with little hemorrhaging. The natural plasticity of osseous material and the strength of the beveled hafting technique, however, allowed these points to maintain their structural integrity while navigating hard and soft tissue contacts. Ethnographically, hand-thrust spears tipped with large osseous points were selected for hunting large game in initial-approach and disadvantageous hunting of solitary, dangerous game and/or herd animals, especially when replacement spears, foreshafts, and points were unavailable to hunters (Churchill 1993; Ellis 1997). On the alternate end of the prey-size spectrum, small osseous projectile points hafted as arrow tips are overwhelmingly selected by hunters for dispatching small-bodied or furbearing game (Ellis 1997; Salem and Churchill 2016).

Osseous points in this experiment produced puncture wounds with moderate mean TWA values when hafted as points on large spear-thrower darts. The plasticity of bone and strength of beveled hafting techniques resulted in overall high durability of these darts and points, but the low mass of these points hafted without the use of heavy, rigid foreshafts failed to provide the front-end weight and rigidity needed to increase the accuracy of spear-thrower darts thrown long distances (VanderHoek 1998).

Osseous points hafted as the tips of arrows preformed with similar consistency. These points were likely to survive soft- and hard-tissue contacts with minimal damage related to impact, though the durability limitations of osseous raw material were apparent in off-target contacts with the ground surface and the wooden support frame (Table 2.1). Osseous point forms produced the lowest TWA of any point form when launched from the bow. The lack of cutting edge and low overall mass of the osseous point and arrow shaft inhibited the penetration achieved by these points and limited the overall total wound areas. Few of the hard- or soft-tissue contacts resulted in wounds considered lethal or efficient in dispatching medium to large Beringian game (Churchill 2008; Whittaker et al. 2017; Wood and Fitzhugh 2018).

Overall, the high durability and reliability factors identified in this experiment should be considered as key design elements in weapon systems tipped with osseous points.

2.5.1.3 Composite Points

Composite points produced on caribou antler and inset with microblades deployed as thrusting spears achieved the deepest penetration into the target and produced the largest TWA of any point form tested. Plasticity of the osseous element facilitated navigation of the point between ribs and increased access to vital organs, while the cutting edge of the inset microblades created large lacerated wounds with high TWA values.

Composite points hafted to robust spear-thrower darts produced lacerated wounds with moderate TWA values and low penetration in soft- and hard-tissue contacts. The composite point and dart combination used in this experiment was affected by the same ballistic issues limiting the efficiency and effectiveness of low-mass osseous points, but the addition of the lithic cutting edge significantly increased TWA values despite generally low penetration values.

Composite points hafted as arrow tips produced only moderately higher penetration and mean TWA values than osseous arrow tips. Despite the modest increase in TWA, composite points launched as arrow tips from bows with ethnographically-appropriate draw weights likely would not have produced lethal wounds in medium- to large-bodied prey. Contact-period Athabaskan bow design incorporated numerous features that increased draw weight (a proxy for higher velocity and hence lethality) significantly beyond what is observed in self bows utilized by most foragers, adapting the technology so that it was suitable for hunting moose (Maschner and Mason 2013). Similar features such as bracing, backing, and recurve limbs could potentially be combined to increase the 'lethality' of composite points and bow weapon systems, but no direct evidence exists for the emergence of these subarctic bow adaptations in Alaska until the late Holocene.

Experimental penetrative patterns serve as a functional proxy for lethality when evaluating 'effectiveness' of lithic and composite point forms (Salem and Churchill 2016; but see Waguespack et al. 2009). This testing confirms the expected effectiveness of lanceolate bifaces hafted as part of a spear-thrower weapon system; additionally, we suggest that composite points perform most effectively arming hand thrust spears, navigating protective hard tissues in the thorax and creating lacerated wounds to vital organs. Simple osseous points preformed with the most consistency across all weapon systems, producing generally shallow penetration and small puncture wounds though is important that we consider plasticity and durability as drivers of selection that were likely as important as the production of large wounds and massive hemorrhaging depending on the task being performed by ancient Beringian hunters.

2.5.2 Application Spaces: Drivers of Projectile Point Selection in Beringia?

The results of our experiment directly contribute to an understanding of application spaces of Beringian point classes and weapon systems, specifically in central Alaska where reported site locations, faunal data, and lithic assemblages provide support for our interpretations of behavioral use context. In a behavioral-ecology framework, weapon systems represent a series of deliberate design decisions made by the users to maximize the efficiency and effectiveness of their hunting toolkits (Torrence 1989). Identifying functional characteristics of these projectile-delivery technologies yields insight into the drivers of tool selection and projectile-point morphology, suggests 'best fit' application spaces for specific combinations of weapon and projectile-point technologies, and measures performance parameters for Beringian hunting toolkits.

The earliest archaeological assemblages in interior Alaska are concentrated in the Nenana and Tanana valleys, where wind-swept floodplains and high terraces harbored lingering steppe environments supporting Pleistocene megafauna including bison and wapiti until the early Holocene (Graf and Bigelow 2011; Guthrie 1983, 2017). During the late Pleistocene, the size of individual animals had yet to experience significant diminution, though mammoth populations crashed prior to the arrival of humans (Guthrie 2017; Potter 2011). Herd size and gregariousness in remaining megafauna populations decreased by the late Pleistocene, increasing search and pursuit time for these species and encouraging the broadening of the diet to include a wide variety of terrestrial and anadromous resources (Potter 2011). Bluff-top and overlook sites likely represent spike camps in an orb-model of landscape settlement, with these sites serving as hunting outlooks and staging areas for launching hunting forays, secondary processing of large mammals, and tool-kit repair associated with more semi-permanent winter base-camp sites in lowland settings (Goebel and Potter 2016; Graf and Bigelow 2011; Guthrie 2017; Potter 2008). The positioning of the spike camps would have allowed foragers to scan valleys for lowland large-game resources like bison and wapiti as well as to access other predictable, seasonally-available lowland and upland resources (Guthrie 2017; Potter 2011; Rasic 2011). Seasonality data from faunal assemblages in both the Tanana and Nenana valleys indicate foragers occupied spike camps in montane zones and bluff-edge locations in lowland areas near their exits of the Alaska Range during the autumn/early winter, when large-game gregariousness was at its peak, the mammals had reached yearly fat-reserve maxima, and they were transitioning from summer upland habitats to wintering grounds in montane zones and lowlands (Guthrie 2017; Wygal 2011, 2018). Foraging groups exhibit a broad-spectrum diet at large spike camps such as Broken Mammoth, Dry Creek, Swan Point, and Mead where a variety of fauna including bison, wapiti, caribou, Dall sheep, and small-game resources including migratory waterfowl and fish have been recovered (Potter 2011). A wide variety of task-specific behaviors also took place at spike camps, and these likely changed seasonally, annually, or even millennially, contributing to inter-site projectile-point variability in the Beringian assemblages (Potter, 2008 2011; Wygal 2011, 2018). Technologically, Rasic (2011) suggests individual elements of a full toolkit may have been manufactured, used, and maintained on independent cycles, and Wygal (2018) identified environmentally mutually exclusive toolkits and independent cycles of microblade and bifacial-point production, with microblade assemblages associated with lowland taiga (< 400 m) and montane zones (400-900 m), and no microblades but common bifacial points in upland settings (> 900 m).

The results of this experiment contribute to an understanding of this differential distribution of late-Pleistocene/early-Holocene hunting technology. Composite antler points inset with lithic microblades were the most effective of the Beringian point classes when deployed as tips of thrusting spears, causing deep penetration and large total wound areas. Lack of corrals, fencing, or drivelines in the north Alaska Range suggests that foragers armed with composite thrusting spears likely seized on naturally-occurring landscape features to create disadvantageous hunting opportunities, for example deep snow drifts in the winter and bodies of water in the late summer/early fall for the procurement of large-to-very-large game including bison. This explains the repeated associations of microblade technology and bison faunal assemblages in lowland and lakeshore settings as well as the strong association of lanceolate bifaces with caribou and Dall sheep in montane and upland zones. Our results suggest that upland application spaces would have been ideally suited for foragers using lithic bifaces and spear throwers practicing approach and ambush hunting in the open and parkland landscapes of the Alaska Range foothills and alpine tundra. Caribou and Dall sheep are particularly vulnerable to ambush hunting with long-range projectile technology, based on their tendencies to reuse favored trails and escape paths, so that they can be ambushed from concealed positions at points along these trails, or alternatively they can be predictably herded along obvious routes into the effective range of waiting hunters (Guthrie 2017). The exploitation of large caribou herds clustered around ice patches in upland settings is widely documented in the Yukon ice patches, and in these situations hunters favored bifacial lithic points and spear-thrower technology for thousands of years before transitioning to bow hunting (Hare et al. 2004). Large TWA values generated by experimental lanceolate bifaces launched from a spear thrower represent a weapon system with design elements tailored to increasing lethality and decreasing search and recovery time for medium-bodied game that can flee upslope into difficult-to-access areas.

2.6 Conclusions

This paper presents the results of an experimental projected aimed at exploring the function and ballistic qualities of lithic bifacial, simple osseous, and composite projectile points observed in the Beringian archaeological record. Further, this experimental project tested investigated the relationships between projectile point forms and three weapon delivery systems: 1) dart points launched with a spear thrower, 2) arrow tips shot from a bow, and 3) spear points arming thrusting spears. Thirty-six Beringian projectile points, twelve of each form, were shot, launched, and thrust at an actualistic target to (1) identifying differences in wound ballistics created by each combination of point form and weapon system; (2) assessing the relative lethality of each point and weapon combination through proxies of penetration, wound type, and total wound area bolstered by the use of an actualistic target; and (3) systematically documenting the function, performance parameters, and potential application spaces of ancient hunting technologies. Experimental testing results indicate that robust lanceolate bifaces were most effective when launched from a spear thrower and created large TWA areas, ideal for dispatching medium-to-large body game. Composite antler points inset with lithic microblades functioned most effectively as arming elements of hand thrust spears navigating between protective skeletal elements and creating lethal laceration wounds. Simple osseous points produced the most consistent penetration and TWA results across all three weapon systems. These points produced less lethal puncture wounds but were highly durable and often survived multiple impacts. Better understanding of the relationships between projectile point forms and specific prehistoric weapon systems have significant implications for interpreting technological organization, hunting toolkits, mobility, and land use patterns in Paleoarctic and Paleoindian populations.

Understanding the nuances of weapon systems and projectile point forms is important for archaeologists studying late Pleistocene and early Holocene foragers in the north with economies significantly tied to the procurement of medium-to-very-large-bodied game. Weapon systems incorporating heavy darts and robust hand thrust spears are necessary for dispatching the largest mammoth steppe fauna which are regularly incorporated into the faunal assemblages of Siberian and Beringian foragers (Frison 1989; Pitulko et al. 2014; Whittaker 2017) and the targeting of these species have consequences in hunting tool kit design decisions. Changing climate and ecological regimes during the Holocene transition resulted in changing fauna on the landscape and we can expect that Paleo forgers would adapt their hunting tool kits to be better suited to pursing smaller, swifter prey (Tomka 2013; Hare et al 2014.). Composite projectile points, and associated microblade technologies, were central components of toolkits employed by Beringian hunters (Dixon 2011; Potter 2011), but our understanding of the adaptive nature of this technology has been influenced by limited experimental assessment of the functional and ballistic qualities of the point form. This study suggests that hypothesized associations between relatively small, inset points recovered in eastern Beringia, microblades technology, and an early manifestation of the bow and arrow is one possible interpretation of these artifacts. But, assessments of function based solely on point morphology can fail to recognize design and construction elements that are adaptive inside larger weapon systems and cultural application spaces.

Beyond Beringia, expanded experimental testing of prehistoric hunting toolkits is an important component of creating a holistic understanding of subsistence patterns and technological organization in paleolithic populations. The effectiveness of a weapon is a complex matter, involving not only the morphological attributes of a point form but also factors such as weapon system of deployment, hafting methodology, user skill, environmental conditions, cultural application spaces, and more. Modern experimental methodologies and more robust theoretical understandings of weapon systems will continue to create broader understandings of the roles of these tools in prehistoric populations.

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3. REEVALUATING THE BLAIR LAKES ARCHAEOLOGICAL DISTRICT: EXPANDING THE HOLOCENE ARCHAEOLOGICAL RECORD OF INTERIOR ALASKA

3.1 Introduction

Interior Alaska continues to play a leading role in our understanding of the peopling of Beringia and the Americas, and it represents one of the longest continuously occupied regions of the American continents (Gómez-Coutouly 2012; Hirasawa and Holmes 2017; Holmes 2011; Lanoë et al. 2018; Potter et al. 2011; Potter et al. 2016; Potter et al. 2017). The Tanana and Nenana River basins are renowned for their deeply stratified aeolian deposits containing exceptional late-Pleistocene archaeology at sites such as Swan Point and Broken Mammoth, as well as Dry Creek, Walker Road, Owl Ridge and Teklanika West, respectively (e.g., Goebel and Buvit 2011; Goebel and Potter 2016; Graf et al. 2010) (Figure **3.**1). However, the archaeological potential of many geographic and ecological subregions in interior Alaska remains untested. The Tanana Flats, a collective designation for a vast lowland area that extends north of the foothills of the Alaska Range, bounded by the modern Tanana River corridor in the north and east and the Nenana River valley to the west, is one such area. Lacking the characteristic bluff-edge settings considered 'high-probability' localities for the preservation of late-Pleistocene archaeology in interior Alaska (Goebel and Potter 2016; Potter 2008a), the potential of the Tanana Flats to contribute to the development of a more comprehensive regional occupation record and a fuller understanding of human adaptions to subarctic

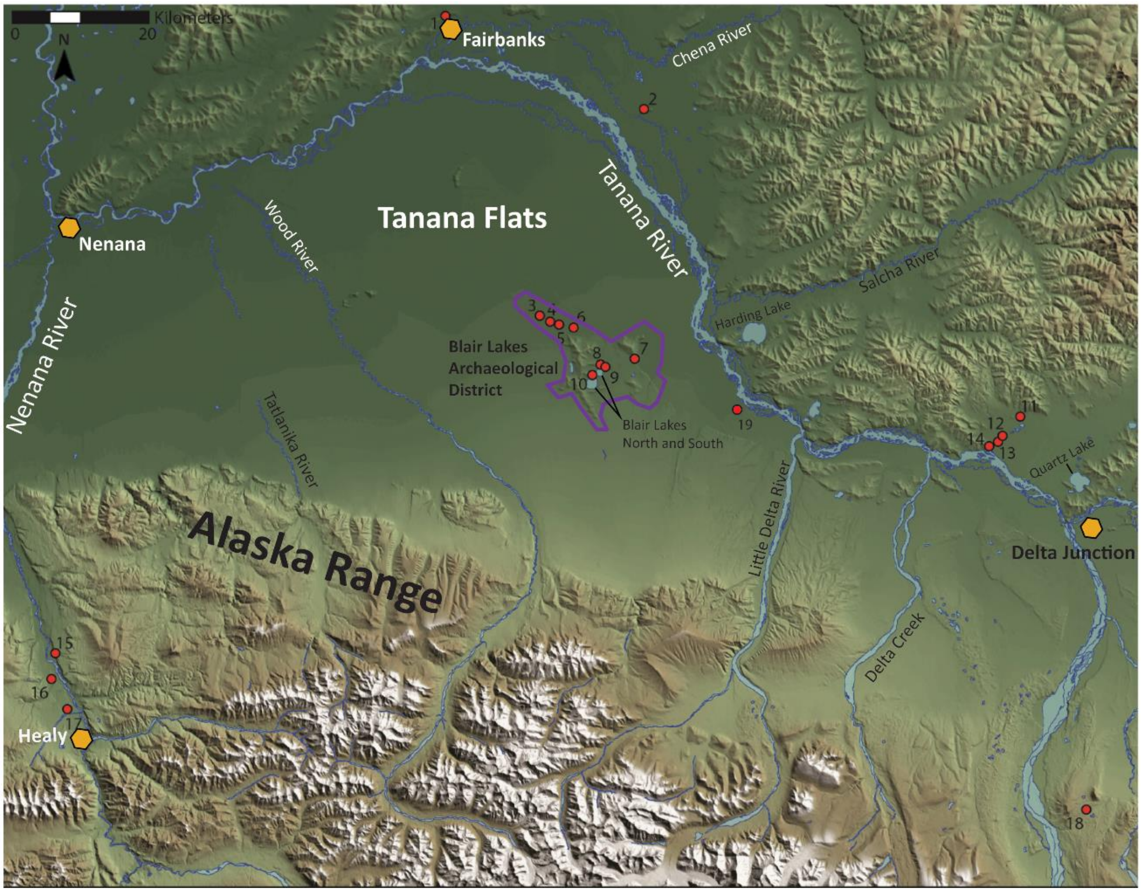

Figure 3.1 Regional overview map of the Tanana Flats, Blair Lakes Archaeological District, and sites mentioned in text: (1) Campus Site; (2) Chugwater; (3) FAI-2060; (4) FAI-2077; (5) FAI-2073; (6) FAI-2047; (7) McDonald Creek (FAI-2034); (8)FAI-2063; (9) FAI-2064); (10) South Blair Lakes-1; (11) Swan Point; (12) Holzman; (13) Mead; (14) Broken Mammoth; (15) Walker Road; (16) Little Panguingue Creek; (17) Dry Creek; (18) Donnelly Ridge; (19) Upward Sun River.

landscapes has been unrealized.

Despite results from early archaeological survey and testing, the Tanana Flats remain understudied, especially in comparison to the middle Tanana River valley and Nenana valley. The area has long been utilized by U.S. Army Alaska (USAGAK) as a training area, resulting in a series of cultural-resource-management surveys and small-scale excavations starting in the 1970s that identified dozens of sites in the region suggesting widespread human use of the area by the early Holocene (Dixon et al. 1980). More recent survey and testing in the area by Colorado State University's Center for the Environmental Management of Military Lands (CEMML) and Texas A&M University (TAMU) have confirmed the presence of archaeological sites in a variety of under-studied ecological settings, such as lake shores, throughout the Holocene (Esdale et al. 2014, 2015, 2016), and has extended the record of human occupation back into the late Pleistocene (Gaines 2009, 2010; Goebel et al. 2017).

Here we report the results of field-based studies carried out in the Blair Lakes area of the southeastern Tanana Flats. While research of the earliest archaeological sites and traditions in central Alaska has been extensive, the most intensively studied sites occur in south-facing overlook settings. Investigations of landscapes set away from the modern paths of the Tanana and Nenana rivers (and the modern highway system) have been less prevalent, including upland settings, dune fields, and lowland basins across Alaska (Krasinski 2018). As a result, significant variability in early, middle, and late Holocene archaeological assemblages, site distributions, mobility strategies, and landscape use has potentially gone unnoticed (Blong 2018; Krasinski 2018; Lanoë et al. 2018; Potter 2008; Wygal 2009, 2018). The Holocene-spanning record of the Blair Lakes Archaeological District (here after, Blair Lakes) represents an ideal data set f or exploring these patterns at a localized scale that can be expanded and incorporated into larger regional interpretations of prehistoric foraging behavior in Alaska since 14,000 calendar years ago (cal BP).

To build on these earlier efforts and to expand the established Holocene archaeological record of the Tanana Flats, in 2013-2015 a team of CEMML and TAMU archaeologists conducted extensive testing and excavations along the northern shore of south Blair Lake as well as archaeological surveys of the ridgeline complexes surrounding the lakes. We had three major objectives: (1) to establish the geomorphological context and occupational history of the northern shore of south Blair Lake; (2) to identify sites within the district that contain archaeological deposits potentially informing on regional prehistoric settlement patterns and land-use strategies; and (3) to evaluate the importance of understudied settings for investigating human adaptation during the Holocene.

3.2 Study Area: The Blair Lakes Archaeological District

The Blair Lakes Archaeological District encompasses more than 38,000 acres of the Tanana Flats, and is made up of more than 86 archaeological sites dating from the late Pleistocene through the historic period (Figures 3.1 and 3.2) (Esdale et al. 2016). The Tanana Flats is ethnographically and archaeologically recognized as part of the traditional seasonal subsistence territories of Tanana and Tanacross Athabaskan groups, including the Salcha, Chena, and Wood River bands (Helm and Sturtevant 1982). The district is contained within the larger Tanana Flats Training Area operated by U.S. Army Alaska. The sites reported in this paper were discovered and/or tested during mitigation projects related to military training activity and development. Together they represent continuous use of the Tanana Flats beginning with the late Pleistocene Nenana archaeological component at the McDonald Creek site dated to as early as 13,850 cal BP

(Goebel et al. 2017), followed by successively younger sites dating to the early, middle, and late Holocene (Dixon et al. 1980; Gaines 2010; Gaines et al. 2009; Goebel et al. 2017; Lynch 2014, 2015, 2018).

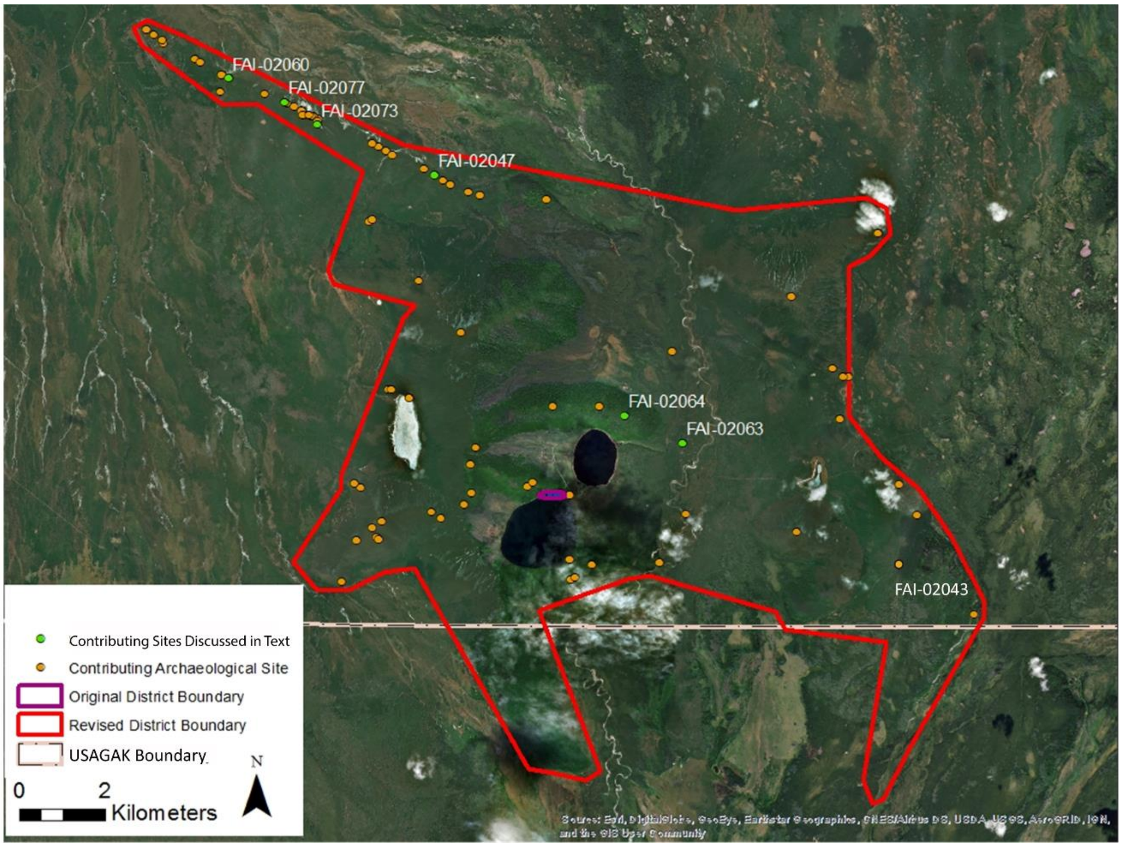

Figure 3.2 Map of original Blair Lakes Archaeological District and revised Blair Lakes Archaeological District boundaries. Green circles represent archaeological sites discussed in text, orange circles represent sites not discussed but still contributing to the redefinition of the district.

3.2.1 Environmental Setting of the Tanana Flats

3.2.1.1 Geology

The Tanana Flats is a collective designation for the lowland area that extends between the northern boundary of the Alaska Range and the modern path of the Tanana River. Soil-probe data show depth to fluvial gravels of the post-glacial Tanana River decreasing trending from south to northeast, indicating the movement of the Tanana River during the late Pleistocene and Holocene away from the Blair Lakes towards its current location (Yeske and Esdale 2014). The Blair Lakes and their associated raised hills and terraces are located in the southeastern portion of the Tanana Flats, and are drained by a small stream named Dry Creek. Even during the height of the Wisconsin glaciation, most of the Tanana Flats, including all of the Blair Lakes study area, remained unglaciated (Coulter et al. 1962). The hills surrounding Blair Lakes are composed of quartz-mica schist, phyllite, and quartzite of the Yukon Crystalline Terrane (Birch Creek schist), dating to the Precambrian or early Paleozoic (Péwé et al. 1966). They are overlain by outwash gravels presumably of Middle Pleistocene (Illinoisan) age. Mantling this are Fairbanks loess deposits varying in thickness based on localized conditions (Carlson et al. 2016; Kline 1980; Pewe et al. 1966; Wilson et al. 2015).

Blair Lakes themselves formed during the late Pleistocene as a result of either rapid aggradation of Dry Creek, tectonic faulting, or a combination of these two forces (Carlson et al. 2016; Wilson et al. 1998). Dixon et al. (1980) documented a series of beach ridges along the eastern shore of north Blair Lake that rise progressively eastward, suggesting at least one, perhaps two, high stands during which the Blair Lakes were connected. On the southern shores of the lakes, similar deposits can be observed truncating older Holocene and/or late-Pleistocene sediments in places (Dixon et al. 1980). This post-glacial rising of Blair Lakes resulted in erosion of a well-developed "swale and ridge" microtopography (Dixon et al. 1980). During the Holocene, colluvial activity, peat formation, and the erosion of the lake outlet led to a drop in the water level and Blair Lakes' eventual division into two bounded bodies of water.

3.2.1.2 Flora

Two major ecosystems dominate the landscape of the Blair Lakes area: (1) lowland spruce-hardwood forest isolated on raised geologic features and (2) low-brush muskeg bogs covering most of the low flats (Dixon et al. 1980; Esdale et al. 2015; Lynch 2015, 2016, 2018). The lowland spruce-hardwood forests are made up of black and white spruce (*Picea mariana* and *P. glauca*, respectively), birch (*Betula papyfera*), aspen (*Populus tremuloides*), poplar (*Populus balsamifera*), and rare tamarack (*Larix laricina*) (Dixon et al. 1980; Joint Federal-State Land Use Planning Commission for Alaska 1973). The bogs of low-brush muskeg are dominated by willow (*Salix* spp.), dwarf birch (*Betula* spp.), a suite of berry-producing plants including low-bush cranberry (*Vaccinium oxycoccos*), blueberry (*V. caespitosum*), crowberry (*Empetrum nigrum*), and bearberry (*Arctostaphylos uva-ursi*), as well as various ground-covering ferns, lichens, and mosses (Dixon et al. 1980; Joint Federal-State Land Use Planning Commission for Alaska 1973). These vegetation communities are distributed largely based on elevation, drainage, soil conditions, and proximity to existing bodies of water. Parts of the study area situated around 600 m in elevation are dominated by coniferous trees, while deciduous trees thrive in the higher hills surrounding the lakes. Most of the Tanana Flats lying below 500 m is characterized by tall and low-growth shrubs, occasional deciduous trees following the paths of rivers and streams, and herbaceous plant communities (Dixon et al. 1980).

3.2.1.3 Fauna

The fauna present in the Tanana Flats represents a fair sample of species from across interior Alaska. Several smaller "eco-zones" within the flats provide sufficient habitat variability to support a variety of large- and medium-bodied mammals including moose (*Alces alces*), wolf (*Canis lupus pambasileous*), and both black and brown bear (*Ursus americanus* and *U. arctos*). The northern flank of the Alaska Range lies roughly 40 km south of the study area and supports large numbers of Dall sheep (*Ovis dalli*) and caribou (*Rangifer tarandus*). The lowland areas of the Tanana Flats are home to a multitude of bird species including a significant number of migratory waterfowl in the spring, summer, and fall. Blair Lakes, and other small lakes scattered across the Tanana Flats, are inhabited by arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), and northern pike (*Esox lucius*). Several species of salmon (*Onchorhynchus* spp.) are also seasonally present in rivers and streams throughout the Tanana Flats, and recent archaeological findings have demonstrated the importance of anadromous-fish exploitation in interior Alaska since the late Pleistocene (Choy et al. 2016; Halffman et al. 2016).

3.2.2 Cultural Setting of the Tanana Flats

Yubestu microblade technology in the Tanana Valley at Swan Point CZ4, dating to 14,150 cal BP, provides a technological link between the earliest occupants of interior Alaska and the late-Upper-Paleolithic Diuktai technologies of eastern Siberia (Gómez-

Coutouly 2012, 2018; Hirasawa and Holmes 2017; Holmes 2011; Holmes et al. 1996; Lanoë et al. 2017; Potter et al. 2011). Following this oldest assemblage, variability in the Alaskan archaeological record increases dramatically during the Allerød interstadial. Sites characterized as part of the Nenana complex, defined largely by their lack of microblade and burin technologies and the appearance of small triangular or teardrop-shaped projectile points, are found in the Nenana and Tanana River basins dating to about 13,800-13,000 cal BP, starting nearly a millennium before the onset of the Younger Dryas cooling event (Goebel et al. 1991; Gore and Graf 2017; Graf and Bigelow 2011). Between 13,000 and 11,000 cal BP, microblade technology reappears in association with burin technology, lanceolate bifaces, and other bifacial and unifacial tool types, in assemblages of the Denali complex, which are found throughout the interior at sites such as Dry Creek, Owl Ridge, Panguingue Creek, Broken Mammoth, Gerstle River Quarry, Chugwater, Phipps, and Whitmore Ridge (Goebel and Potter 2016; Gore and Graf 2017; Graf and Bigelow 2011; Graf and Goebel 2010; Hoffecker et al. 1996; Potter 2008b; Powers et al. 2018; West 1996). During the Allerød, Alaskan hunter-gatherers occupied lowland landscapes along major river drainages while establishing "spike camps" in the foothills of the Alaska Range to procure upland resources (Guthrie 2017). Limited faunal evidence suggests humans in the lowlands were using a broad variety of resources including birds, as well as medium to large game like bison in the foothills (Graf and Bigelow 2011). During the Younger Dryas, a transition to a more highly-mobile land-use system with expanded occupations of upland areas occurred in central Alaska, and while foragers maintained a broad-based economy including the procurement of fish as well as large-game species such as bison and wapiti in lowland settings, an increased presence of bison and Dall sheep at sites in the foothills supports seasonal exploitation of medium and large game (Blong 2018; Holmes 2011). The Nenana component at the McDonald Creek site yielded lithic artifacts in association with hare, goose, and bison faunal elements, suggesting foragers in the Tanana Flats were also engaged in a broad-based subsistence strategy (Goebel et al. 2017).

After 10,000 cal BP the boreal forest spread throughout interior Alaska, coincident with a re-organization of tool kits, site locations, mobility strategies, and raw-material selection, all associated with the emergence of the Northern Archaic tradition of the middle Holocene (Cook 1969; Esdale 2008 Holmes 1986; Potter 20008b; Wilson and Slobodina 2007). Northern Archaic hunter-gatherers utilized a broad toolkit to minimize risk on a landscape with fewer, more homogeneously-dispersed, terrestrial resources (Esdale 2009). Their sites exhibit at least three distinct projectile-point forms including osseous points slotted and inset with lithic microblades, notched lithic projectile points, and straight-based lanceolate lithic points (Esdale 2008). The accompanying tool kit reflects significant variability in lithic-tool production and is comprised of burins, microblades, bifacial knives, side and end scrapers produced on flakes, and notched pebbles (Cook and Gillispie 1986; Esdale 2008, 2009; Esdale et al. 2015; Potter 2008b). Northern Archaic subsistence focused on the exploitation of seasonally available resources such as caribou, moose, small-game animals, birds, and fish (Esdale 2008, 2009, 2015; Potter 2008b), although larger game such as bison were dispatched when available (Potter et al. 2018). These populations likely operated within a mobility system that emphasized semi-permanent residential basecamp sites supported by increased logistical subsistence forays into upland and lakeshore settings and greater reliance on seasonally-abundant resources. Site location seems to have driven assemblage variability, with smaller, less technologically diverse task-specific locations occurring in overlook/upland settings and lower-elevations sites, particularly those situated on lakeshores, being characterized by increased raw-material and tool-type diversity, a higher prevalence of microblade production, and more diverse faunal assemblages (Cook 1969; Esdale 2009; Holmes 1986; Lynch 2015, 2016; Potter 2008b).

Another major shift in Holocene forager lifeways and technological organization has been documented approximately 1200 cal BP, when the Athabaskan tradition became archaeologically visible in interior Alaska (Dixon 1985; Lynch et al. 2018; Potter 2008; Shinkwin 1979). The transition to the Athabaskan tradition is not well understood; however, recent linguistic research supports an early development of the Dene language possibly dating to between 12,000 and 4000 cal BP, implying a long, possibly in situ, development of this archaeological tradition (Ives 2010; Kari and Potter 2010). While the geographic and temporal origin of the Athabaskan tradition is unclear, it represents a distinct technological reorganization, with site assemblages being characterized by a heavier reliance on bone, antler, and native copper for tool production, intensive use of birch bark, and an absence of microblade and burin technology (Clark 1981; Dixon 1985; Shinkwin 1977, 1979). In addition to straight and barbed osseous projectile points, straight-based lithic lanceolate projectile points became prevalent, and the introduction of the bow and arrow into the region has been documented in alpine ice patches of nearby Yukon, Canada (Hare et al. 2004, 2012). Sites of the Athabaskan tradition are often made up of large house features and associated cache-pits, both of which reflect reduced residential mobility, and they were often positioned near lakes and marshes to facilitate exploitation of seasonally-abundant game such as caribou, fish, and waterfowl (Dixon 1985; Potter 2008; Shinkwin 1975, 1979).

Despite the clear importance of low-elevation and lakeshore landscapes in the adaptations of Holocene foragers documented at sites such as Healy Lake Village, Quartz Lake, and Lake Minchumina (Cook 1969; Holmes 1986; Potter 2008a; Younie and Gillispie 2016), archaeological investigations of low-elevation and lakeshore localities in interior Alaska remain rare. Excavations at the South Blair Lake -1 site, presented here, serve to expand this limited record. By expanding our focus to include such poorly investigated landscapes as well as later time periods (e.g., the middle and late Archaic), this study in particular adds significantly to our understanding of human adaptive and culture change through the Holocene.

3.2.3 Early Research in the Blair Lakes Archaeological District

The original Blair Lakes Archaeological District was comprised of six prehistoric, historic, and multi-component sites situated within an approximately 200x100-m area on a low terrace along the north shore of southern Blair Lake (Dixon et al. 1980). Below we present brief summaries of the prehistoric sites originally reported by Dixon et al. (1980), based on their 1979 field work (Figure 3.3). Sites FAI-0046 and FAI-0054 relate to historic features along the lakeshore associated with Walt “Tex”

Blair, and they consisted of cabins, outbuildings, and other structures as well as machine equipment and refuse accumulations. These historic sites are not discussed here.

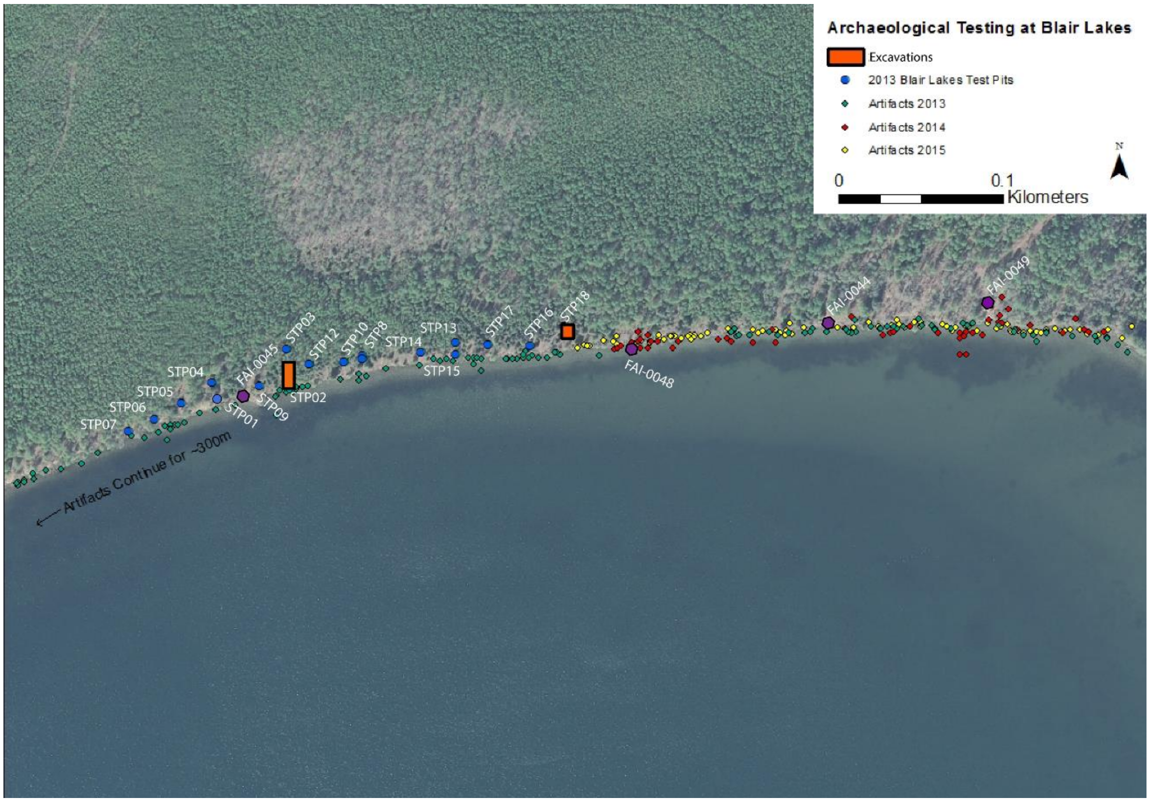

Figure 3.3 Map of 2013-2015 archaeological sites, distribution of submerged artifacts, and excavations along the northern shore of south Blair Lake.

FAI-00044 is located 3 m from the present shoreline in an eroding cut bank along the northern shore of south Blair Lake. Dixon et al. (1980) noted that significant disturbance related to military activity surrounded the site area. During initial testing, eight 30x30-cm test pits were excavated, five of which were positive for cultural material and yielded an assemblage of 274 collected specimens, much of them were heavily fragmented faunal material. Phase II testing through four 1x1-m excavation units revealed a multi-component occupational history dominated by microblade-production technology. In the unit that yielded most of the lithic material, Dixon et al. (1980) identified an artifact zone between 0-26 cm below the ground surface. Within this, his team recovered 107 “waste flakes”, 25 microblades and microblade fragments, two microblade cores, two microblade-core tablets, and three burin spalls (one retouched). The lithic assemblage was manufactured on a variety of raw materials including chert, chalcedony, quartz, and a single flake produced on obsidian. The two microblade cores and 22 of the microblades were produced on rhyolite, while three microblades were on chert (two on gray chert and one on black chert). No radiocarbon dates were generated; however, the microblades, microblade cores, and burin spalls indicated to Dixon et al. (1980) that this occupation likely represented a “late Denali complex” occupation presumably dating to the late Holocene.

FAI-00045 was located 6 m north and 4 m above the modern lake shore along an erosional cut bank on the northern shore of south Blair Lake. Ten 30x30-cm test units were excavated at this locality, five of which produced cultural materials, including a possible core tablet, a long, unmodified blade-like flake, obsidian flake, scraper/possible adze, and base of a lanceolate projectile point produced on red chert. Additionally, “waste flake” debitage, fire-cracked rock, and mammal long bones (likely moose) were identified. The remains of a historic log structure rests on the surface of this locality, and a single rim-fire .22-caliber cartridge was recovered from a near-surface context. Targeted excavation of eight 1x1-m units in 1979 revealed two, or possibly three, prehistoric occupations (Dixon et al. 1980). First was a possible Denali-complex occupation based on the presence of rhyolite flakes in deeply buried portions of the site area, a material Dixon et al. (1980) interpreted as a “preferred material type” of Denali tool makers in the production of microblade technology. Second was a Northern Archaic component defined by several lanceolate projectile points and bases. Third was a late prehistoric Athabaskan occupation based on a radiocarbon age of 1790 ± 130 14C BP and a grooved hammerstone/adze. Much of the faunal material was heavily burned and/or fragmented, which may indicate the extraction of marrow and production of bone grease. Distal limb bones that occur in the assemblage may have resulted from off-site initial butchering, with intensive processing happening along the lakeshore (Dixon et al. 1980).

FAI-00048 was located approximately 4 m north and 3 m above the northern shoreline in an eroding cut bank (Figure 3.3). All cultural material identified was recovered in an area of active erosion. A few lithic “waste flakes”, one retouched flake, and faunal material (long bones from a medium-to-large-bodied mammal, some with charring) were collected from this location. Fire-cracked rock and cobbles were reported, too, but were left in situ by investigators. A single 1x1-m test unit placed on the terrace surface above the cut bank produced no artifacts.

FAI-00049 was located approximately 2 m north and 4 m above the northern shoreline, along an eroding cut bank. No test units were excavated, but three chert flakes were recovered from a reddish soil horizon directly below surface-level organics.

Dixon’s first systematic testing along the northern shore of south Blair Lake produced substantial results, including the identification of five prehistoric archaeological sites and numerous historic sites, features, structures, and artifacts. Dixon et al. (1980) interpreted these combined results as an extensive Denali occupation focused on microblade production, overlain by a Northern Archaic occupation, with a third Athabaskan occupation in near-surface contexts, all in close proximity to the modern lakeshore. The collective significance of these archaeological resources led to the creation of the original Blair Lakes Archaeological District. Dixon et al. (1980) interpreted the abundance of cultural materials, relatively high raw-material variability, and re-use of the shoreline through time as representative of possible early- and middle-Holocene base camps as well as a potential late-prehistoric Athabaskan village site.

Thus, while previous investigations demonstrated high potential for the preservation of multi-component lakeshore occupations along the northern shore of south Blair Lake, additional testing and systematic excavation efforts were necessary to establish an occupation chronology and define the extents of the sites.

3.3 Field and Laboratory Methodology

Our team's investigation of the archaeology of the northern shore of south Blair Lake occurred during a series of short, intensive, consecutive efforts in the 2013-2015 field seasons. Systematic archaeological testing in 2013 focused on relocating and determining site boundaries for sites FAI-00044, FAI-00045, FAI-00048, and FAI-00049, earlier described by Dixon et al. (1980), assessing stratigraphic contexts preserved along the lakeshore, and collecting artifacts in exposed, submerged contexts within the lake. Provenience of submerged artifacts was recorded with recreation-grade Garmin GPS units, with "lots" being collected together when more than one artifact was recovered within the accuracy range of the GPS unit (~1 m). The 2013 results were used to determine the location of block excavations conducted in 2014 and 2015.

To establish discrete site boundaries along the northern shore of south Blair Lake in 2013, a series of 18 shovel test pits (STPs), 30-40 cm in diameter, were placed at 20-m intervals within 5-10 m of the modern shore of the lake. The tested area encompassed the four prehistoric sites originally recorded by Dixon et al. (1980) (Figure 3**.**3). These excavations were conducted using shovels following arbitrary 10-cm levels until the basal, culturally-sterile, bedded sands were reached. In these excavations, all removed sediments were passed through 1/8th-inch screen. Lithic artifacts, faunal remains, and organic materials suitable for radiocarbon dating encountered were collected for full analysis**.**

Additionally, in 2013 a 6-m geomorphological test trench was excavated to document the generalized stratigraphy of the lakeshore deposits. This locus was designated South Blair Lake-2. The trench was composed of adjoining 1x1-m units running north to south perpendicular to within 1 m of the modern lakeshore, expanding on the original STP-8 (Figure **3.**3). The trench was excavated using trowels following natural strata and arbitrary 5-cm levels within these strata to capture fine changes in the general lakeshore stratigraphic sequence. Provenience data of all encountered cultural materials were recorded and mapped.

The results of the 2013 testing project were used to guide expanded block excavations that took place in 2014 and 2015. Ten 1x1-m excavation units were placed in an area incorporating previously excavated STP-18, where a concentration of microblades and associated debitage was encountered. A 2x2-m excavation block was established, then expanded by one 1x1-m excavation block to the north to identify the boundary of the buried microblade concentration. Three 2x1-m excavation blocks were placed 1 m to the east, south, and west of the main excavation block. A 1-m balk was left between each of these 2x1-m units and the 2x2-m unit. This locus was designated South Blair Lake-1, and these 1x1-m units were excavated using trowels following natural strata, and arbitrary 5-cm levels within these strata. Provenience data of all encountered cultural materials were recorded using a Sokkia total station to facilitate detailed mapping of the cultural components at the site.

Lithic debitage recovered during all phases of the testing and excavations was analyzed using a standard set of metric and nonmetric variables established in Andrefsky (2005). Variables included assessments of debitage class/type and an assessment of raw-material type and color, condition, platform category, and presence of cortex. Tools were designated as produced on flakes, blades, microblades, or bifaces, and assessed using metric attributes and measures of retouch including form, face, and invasiveness. Metric data taken on all tools included length, width, thickness, and weight. Tool-type assignments followed established descriptions of tool types from interior Alaska (e.g. Goebel et al. 1991). Several examples of fire-cracked rock were recovered from the block excavation at South Blair Lake-1 but were not subjected to further analysis.

All collected materials from the project will be permanently curated at the University of Alaska Museum of the North.

Geochemical characterizations of obsidian artifacts were conducted by Jeffrey Rasic using a Bruker Tracer III-SD at the University of Alaska Museum of the North, Fairbanks, Alaska, and results were compared to known and unknown source data in an attempt to define provenance, following Reuther et al. (2011).

Samples of organic materials (charcoal) were submitted to Beta Analytic, Inc., for standard AMS radiocarbon analysis (Table 3.1).

A small number of fragmentary faunal remains were recovered during the 2014-2015 excavations but were in a heavily degraded and calcined condition that prevented species and element identifications.

3.4 Results

3.4.1 Lakeshore Survey 2013-2015

Following Dixon and colleagues' (1980) description of a large number of artifacts recovered in a submerged, near-shore context along the northern shore of south Blair Lake, we conducted a series of underwater transects, collecting artifacts along a ~500-m stretch of the shore in 2013, 2014, and 2015 (Figure 3.3). The eastern, western, and southern lake margins were also surveyed in 2013 but produced only rare artifacts. Along the northern shore, numerous projectile points, bifaces, flake tools, microblade cores, and large flakes were recovered during each lakeshore survey (Figure 3.4). These artifacts lacked secure context, but their overwhelming number and diversity, the high variability of raw materials utilized in their production, and the recovery of multiple projectile points and projectile-point fragments with diagnostic morphologies (including small triangular points and straight-based lanceolate points) suggests the northern shore of south Blair Lake saw intensive occupation, perhaps as a residential site, during the late Holocene. Moreover, the presence of so many cultural remains submerged in the lake Moreover, the presence of so many cultural remains submerged in the lake indicates significant coastal erosion since these occupations.

3.4.2 2013 Boundary Testing Along the Northern Shore of South Blair Lake

Using the locations of artifacts recovered from eroded contexts and previously identified sites as reported by Dixon et al. (1980), in 2013 we began a systematic testing of the northern shore of south Blair Lake. Eighteen shovel tests were excavated along the first terrace above the modern shoreline of the lake, at 20-m intervals. These shovel tests were generally set within 5-10 m of the edge of the shoreline terrace, but one shovel test (STP-3) was set ~20 m from the lakeshore to comprehensively capture the geomorphological character of the landform. The results of the shovel testing confirmed that the northern shore of south Blair Lake was extensively used throughout much of the Holocene. Despite testing nearly 300 m along the lakeshore, no clear locus boundaries could be established, with 15 of the 18 shovel tests yielding cultural materials (Table 3.2) At no point were consecutive shovel tests negative, and no lateral break in cultural material more than 20 m was identified. In addition, eight of the shovel tests (44%) encountered multiple buried components, with their ages being established through stratigraphy and radiocarbon dating. While much debitage was recovered, few tools were encountered. STP-3 yielded a small assemblage from a late-Holocene context (30-50 cm below the surface), including two obsidian flake fragments geochemically identified as possible Unknown Group B and a small obsidian retouch chip from Batza Tena. STP

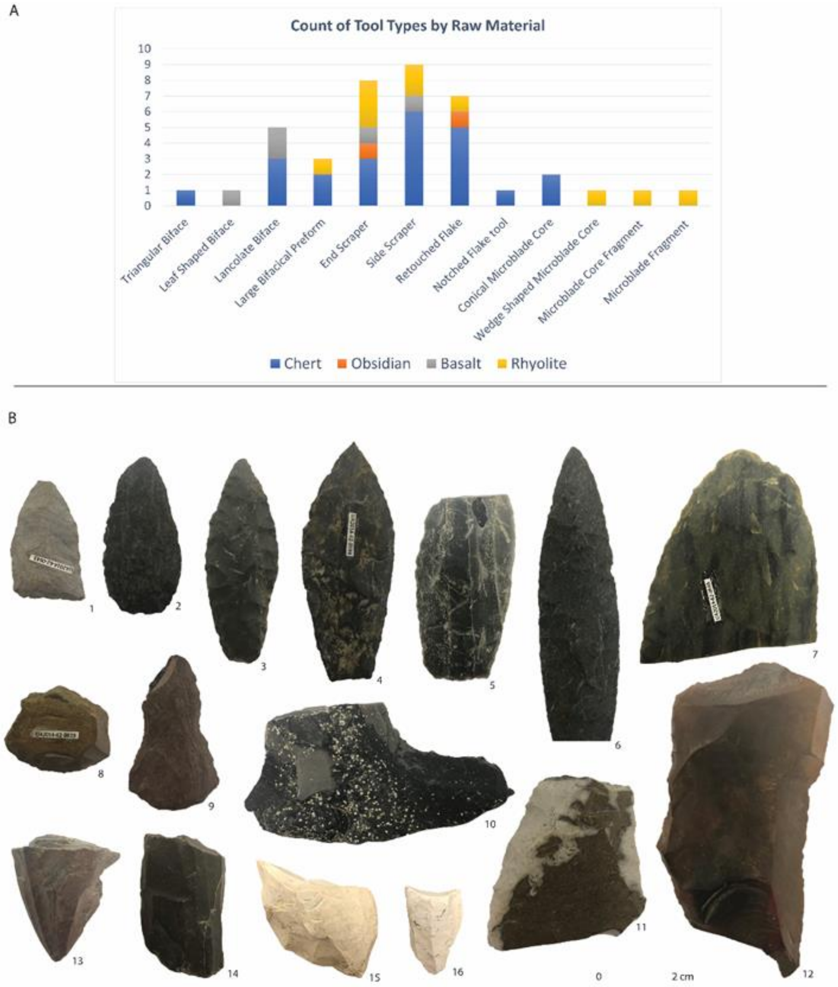

Figure 3.4 A: Frequencies of artifacts recovered from submerged context under south Blair Lake in 2014-2015; B: representative artifacts recovered from the submerged context: (1) triangular biface, (2) leaf shaped biface (3, 4, 5, 6 lanceolate bifaces, (7) large bifacial preform fragment, (8, 9) end scrapers, (10) notched flake tool, (11, 12) side scrapers, (13, 14) conical microblade cores, (15) wedge- shaped microblade core, (16) microblade core fragment.

Table 3.1 Radiocarbon (AMS) dates from test and block excavations in the Blair Lakes Archaeological District.

Excavation Context	Site	Lab Number	Material	^{14}C Age	Calendar Age[2]	Stratigraphic Context	Cultural Component Association
2013 Geologic Trench							
	SBL-2	UCIAMS-135108	Charcoal[1]	855 ± 15	732-788	O/A-horizon	Upper Cultural Component
	SBL-2	UCIAMS-135109	Charcoal[1]	8220 ± 25	9088-9284	Paleosol	Lowest Cultural Component
	SBL-2	Beta-364086	Charcoal[1]	862 0± 40	9529-9673	Paleosol	Lowest Cultural Component
	SBL-2	UCIAMS-135107	Charcoal[1]	8720 ± 30	9552-9787	Paleosol	Lowest Cultural Component
2014 and 2015 Block Excavations							
	SBL-1	Beta-404891	Charcoal[1]	158.9 ± 0.4 BP	modern	Subject to stratigraphic compression and disturbance	Not archaeological
	SBL-1	Beta-404985	Charcoal[1]	3280 ± 30 BP	3447-3577	B horizon, C Horizon and Ab_2 contact	Lower limiting date for Component 3
	SBL-1	Beta-404892	Charcoal	7840 ± 30 BP	8544-8652	Paleosol	Component 2
	SBL-1	Beta-405223	Charcoal[1]	7830 ± 30 BP	8544-8652	Ab_1 and Lower Loess contact	Lower limiting date for Component 2
	SBL-1	Beta-405453	Charcoal[1]	9040 ± 40 BP	10173-10249	Lower Loess	Component 1

(Continued)

Table 3.1 Continued.

Excavation Context	Site	Lab Number	Material	^{14}C Age	Calendar Age[2]	Stratigraphic Context	Cultural Component Association
Other Tested Sites in the District							
	FAI-02047[3]	Beta-283428	Charcoal[1]	1430 ± 40 BP	1288-1391	A-horizon	Component 2
	FAI-02060[3]	Beta-283429	Charcoal[1]	8130 ± 40 BP	8996-9139	Paleosol	Component 1
	FAI-02064[3]	Beta-283435	Charcoal[1]	2170 ± 40 BP	2056-2312	Basal Silt	Component 1
	FAI-02077[3]	Beta-283435	Charcoal[1]	10,130 ± 50 BP	11598-12023	Buried B-horizon	Associated with Component 1
	FAI-02043[4]	Beta-281235	Charcoal[1]	10,730 ± 50 BP	12671-12759	Lowest Loess	Upper Component
	FAI-02043[4]	Beta-283430	Charcoal[1]	11,600 ± 50 BP	13547-13584	Upper Sands	Lower Component

1. These charcoal samples represent dispersed pieces (i.e., not from recognizable archaeological features).
2. Radiocarbon dates were calibrated using CALIB7.1.0, following Stuiver and Reimer (1993).
3. From Esdale et al. 2016
4. From Gaines et al. 2009

Table 3.2 Artifact assemblages from 2013 shovel testing along the north shore of the southern Blair Lake.

Shovel Test Designation	**Context**	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
STP-1	*Late Holocene Component*								
		Flake shatter	1						1
		Core-reduction flake	1						1
		Retouch chip fragment	1					4	5
		Retouch chip						2	2
		Biface-thinning flake	1					1	2
		Total	4					7	11
	Middle Holocene Component								
		Flake shatter	26					11	37
		Core-reduction flake	7					1	8
		Secondary cortical Spall	1						1
		Retouch chip fragment	59					35	94
		Retouch chip	18					8	26

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
		Biface-thinning flake	14					10	24
		Total	125					65	190
	Early Holocene Component								
		Flake shatter	3					3	6
		Core-reduction flake Flake	1						1
		Cortical spall fragment	2						2
		Retouch chip fragment	5					5	10
		Retouch chip						1	1
		Biface-thinning flake	3					1	4
		Angular shatter		2					2
		Total	14	2				10	26
STP-2	*Middle Holocene Component*								
		Flake shatter	2						2
		Retouch chip fragment	2						2
		Retouch chip	1						1
		Total	5						5

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
	Early Holocene Component								
		Flake shatter	5					1	6
		Biface-thinning flake	5						5
		Total	10					1	11
STP-3	*Late Holocene Component*								
		Flake shatter	4	2				2	8
		Retouch chip	2	1				2	5
		Biface-thinning flake	2					1	3
		Total	8	3				5	16
STP-5	*Middle Holocene Component*								
		Core-reduction flake	2						2
		Retouch chip fragment	4						4
		Retouch chip	3					1	4
		Biface-thinning flake	1						1
		Total	10					1	11
	Early Holocene Component								
		Flake shatter	1						1
		Total	1						1

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
STP-6	*Late Holocene Component*								
		Flake shatter	14				7		21
		Core-reduction flake Flake Shatter	13		1		2		16
		Blade-like flake	1						1
		Cortical spall fragment	1						1
		Secondary cortical spall fragment			1				1
		Retouch chip fragment	7				1		8
		Retouch chip	2						2
		Angular shatter	1				13		14
		Medial microblade fragment	1						1
		Total	40		2		23		65
	Middle Holocene Component								
		Angular shatter					1		1
		Total					1		1
	Early Holocene Component								
		Flake shatter	1						1
		Total	1						1

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
STP-7	*Late Holocene Component*								
		Retouch chip	1						1
		Total	1						1
STP-8* (Triangular point)	*Early Holocene Component*								
		Microblade fragment	1						1
		Proximal microblade Fragment	1						1
		Triangular biface	1						1
		Total	3						3
STP-9	*Middle Holocene Component*								
		Flake shatter	1						1
		Retouch chip fragment	1						1
		Total	2						2
STP-10	*Late Holocene Component*								
		Flake Shatter	1						

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
STP-10		Retouch chip fragment	1						
		Biface-thinning flake	2						
		Total	4						4
	Middle Holocene Component								
		Retouch chip fragment	4						4
		Total	4						4
	Early Holocene Component								
		Flake shatter	6						6
		Core-reduction flake	4						4
		Cortical spall fragment	1						1
		Retouch chip fragment	54						54
		Retouch chip	12						12
		Biface-thinning flake	15						15
		Flake shatter	6						6
		Total	92						92

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
STP-11	*Late Holocene Component*								
		Flake shatter	3					1	4
		Biface-thinning flake	2					1	3
		Total	5					2	7
	Middle Holocene Component								
		Flake shatter	6						6
		Core-reduction flake	1					1	2
		Retouch chip fragment	6					1	7
		Retouch chip	1					1	2
		Biface-thinning flake	3						3
		Flake shatter	6						6
		Total	17					3	20
	Early Holocene Component								
		Flake shatter	2						2
		Total	2						2

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
STP-13	*Middle Holocene Component*								
		Core-reduction flake						1	1
		Total						1	1
STP-14	*Early Holocene Component*								
		Flake shatter	2						2
		Total	2						2
STP-15	*Late Holocene Component*								
		Flake shatter		7				2	
		Core-reduction flake		4					
		Cortical spall fragment		1					
		Biface-thinning flake	1	2					
		Flake shatter		7				2	
		Total	1	14				2	17
	Middle Holocene Component								
		Core-reduction flake	1						1
		Total	1						1

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
	Early Holocene Component								
		Core reduction Flake	1			1			2
		Total	1			1			2
STP-16	*Early Holocene Component*								
		Flake shatter	1						1
		Total	1						1
STP-18	*Late Holocene Component*								
		Flake shatter	1					10	11
		Core-reduction flake						5	5
		Blade-like flake	1						1
		Retouch chip fragment						1	1
		Retouch chip						1	1
		Biface-thinning flake	1						7
		Flake shatter	1					10	11
		Angular shatter	1						1
		Total	4					23	27

(Continued)

Table 3.2 Continued.

Shovel Test Designation	***Context***	**Artifact Category**	**Raw Material**						
			CCS	Obsidian	Basalt	Rhyolite	Quartz	Chalcedony	Total
	Middle Holocene Component								
		End scraper	1						1
		Total	1						1
	Early Holocene Component								
		Core-reduction flake						1	
		Retouch chip fragment						2	
		Retouch chip						1	
		Biface-thinning flake						4	
		Microblades	1					35	
		Flake shatter						13	
		Angular shatter						1	
		Core fragment						1	

(Continued)

yielded a small triangular bifacial point and two chert microblade fragments in a Holocene stratigraphic context. This shovel test was incorporated into the geologic test trench described below. STP-15 yielded the largest concentration of obsidian debitage (n = 14), from a late-Holocene context. Four flakes and seven flake fragments were recovered from 0-30 cm below the surface and geochemically assigned to Unknown Group N (4), Batza Tena (6), and Unknown Group K or M (1). STP-18 yielded debitage assemblages in early-, middle-, and late-Holocene contexts. From the middle-Holocene component came 33 microblades (1 complete and 16 proximal, 9 medial, and 7 distal fragments), all produced on chalcedony, as well as a microblade fragment and an end scraper produced on chert. TP-18 became the locus of block excavations undertaken in 2014-2015, described below**.**

3.4.3 2013 Stratigraphic Trench at SBL-2

Early in the 2013 testing, we excavated a 6x1-m trench, oriented perpendicular (north-south) to the lakeshore, to record the geomorphological profile of the first terrace, where all archaeological loci had so far been documented (Dixon et al. 1980; Gaines et al 2009, 2010). Three of the six contiguous 1x1-m test units produced cultural materials. We designated this locus as South Blair Lake-2 (SBL-2).

About 7 m from the lakeshore, the modern surface of the terrace exhibits a barely noticeable slope toward the lake, but this increases dramatically to more than 30° near the bluff edge, which is a nearly vertical 2-m-high erosional face at the lakeshore (Figures 3.3, 3.5). Buried sediments follow a similar slope toward the lakeshore, with several discontinuous silt layers evident in the profile. The northernmost unit

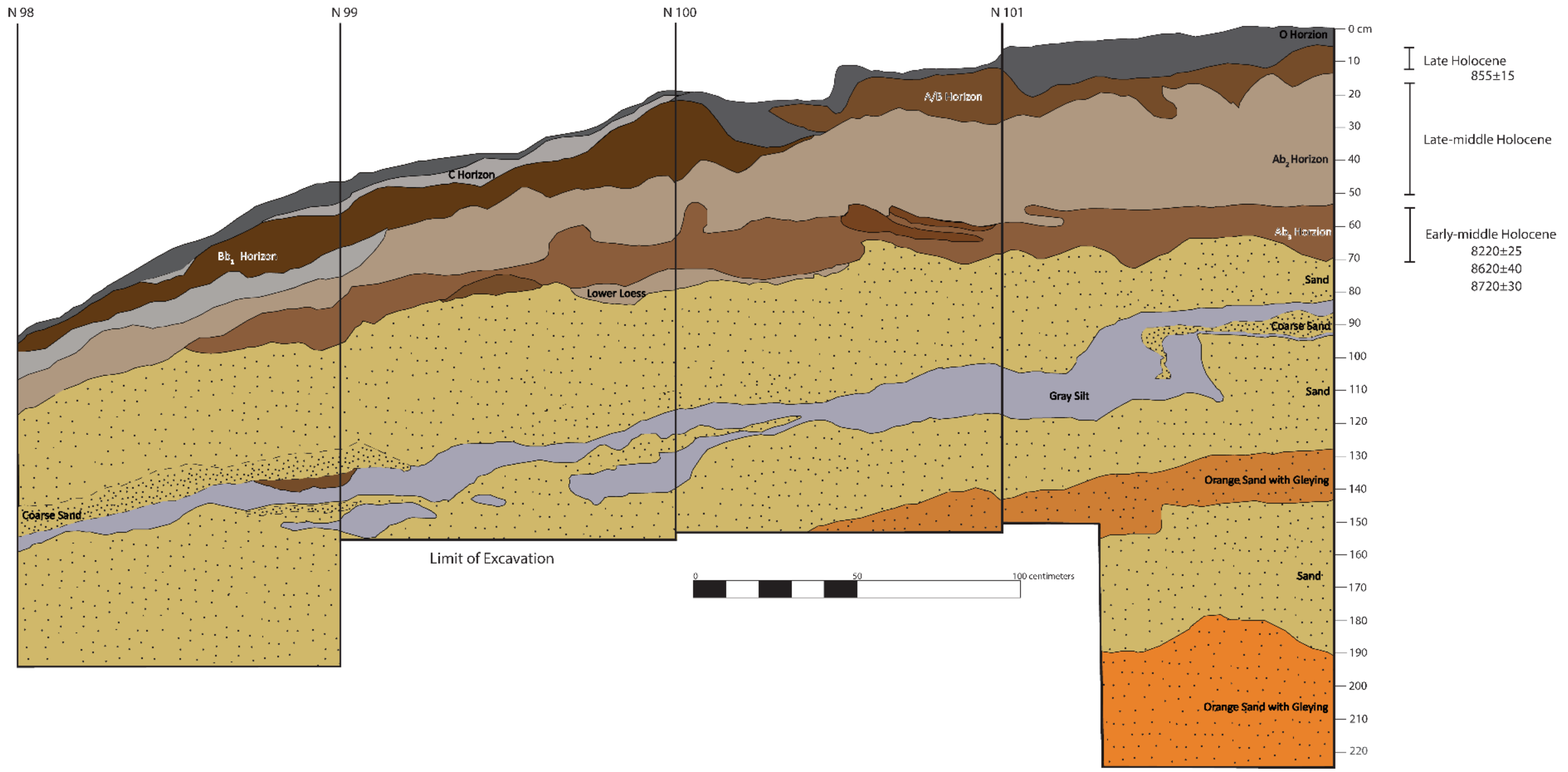

Figure 3.5 Stratigraphic profile of the west wall of the geological test trench at South Blair Lake-2

Figure 3.6 Artifacts from South Blair Lake-1. A, Component 3: (1) core fragment, (2) combination tool, (3) knife, (4) convergent scraper, (5) lanceolate biface, (6) notched point midsegment; B, Component 2: (1) knife, (2) wedge shaped microcore, (3) wedge-shaped microcore and core tab refit, (4) sample of microblades; C, Component 1: (1) knife, (2) end scraper, (3) triangular point.

(N101E102), yielded a profile that is representative of the stratigraphy encountered during the shovel testing of the terrace. Modern A/B horizons underlie this organic-rich layer in units N101E102 and the northern half of N100E102. A small amount of cultural material was recovered in this context, as well as dispersed charcoal that yielded a radiocarbon age of 855 ± 15 ^{14}C BP. Underlying the O horizon in units N98 and N99E102 as well as the southern half of N100E102 is a thin, discontinuous C horizon of lightly weathered gray silt. This in turn caps a distinctive reddish silt, a buried B horizon (Bb1) reaching 20 cm thick. The absence of modern A/B horizons in the sloping southern units is notable, likely due to the instability of the steeper slope, which would have been less heavily vegetated through time. A continuous buried A horizon (Ab2) is present below these deposits, across the entire trench profile. The Ab2 horizon masks a 35-cm thick loess deposit observable across the profile, closely following the increasing dip of the slope towards the lakeshore. The thickness of this loess deposit decreases to less than 10 cm in unit N98E102. An assemblage of lithic artifacts including a small triangular biface (Figure 3.6 C3) and dispersed charcoal was recovered from this context. This loess horizon rests on another paleosol (Ab3), also following the southward slope toward the lake, but it narrows and eventually pinches out in unit N98E102. A few artifacts and associated dispersed charcoal were recovered from this paleosol, yielding radiocarbon ages of 8220 ± 25, 8620 ± 40, and 8720 ± 30 ^{14}C BP (Figure 3.5; Table 3.1). In the northern portion of the test trench, this paleosol rests directly on top of a series of alternating sand, coarse sand, and silt deposits. The contact between the upper silt (loesses with paleosols) and lower sand deposits is very abrupt and wavy, potentially an unconformity, with the upper-lying silts dating to no earlier than the early-middle Holocene, and the lower-lying sands, presumably to the late Pleistocene. The sands are likely related to high winds during the late Pleistocene, as documented elsewhere across interior Alaska (Dilley 1998; Reuther et al. 2016). The lack of soil development within them indicates that the landscape along the lakeshore was not fully stabilized and sparsely vegetated during and soon after deposition. At this locality, the alternating basal sand deposits were excavated to a depth of more than 2 m below the surface and proved to be culturally sterile.

3.4.4 2014 and 2015 Block Excavations at SBL-1

The discovery of more than 30 microblades in a middle-Holocene context in STP-18 on the northern shore of south Blair Lake guided the placement of a block excavation, a locality we referred to as South Blair Lake-1 (SBL-1). A grid of ten 1x1-m excavation units was established along a north-south axis to increase the sample of archaeological materials and to document their stratigraphic context and age (Figure 3.6). The excavation yielded artifacts from four stratigraphically separated components.

The stratigraphic profiles described and mapped for the block excavation generally follow the profile at SBL-2 described above (Figure 3.7). Upper deposits follow the natural slope of the terrace, progressing from nearly flat in the north to a slope of nearly 10° to the south, where there is an abrupt 2-m drop to the water line. Most of the excavation was conducted on the relatively flat area of the terrace surface; however, in the southern portions of the excavation the increased surface slope was reflected in subsurface deposits. The farthest south 2x1-m excavation (N93E99, E100) was positioned closest to the terrace edge, resulting in significant disturbances to the upper portion of the profile likely from solifluction and erosion.

The stratigraphic profile of the west wall of the excavation (units N96 and N97E99) is representative for SBL-1 (Figure **3.**7). The O horizon across the site was

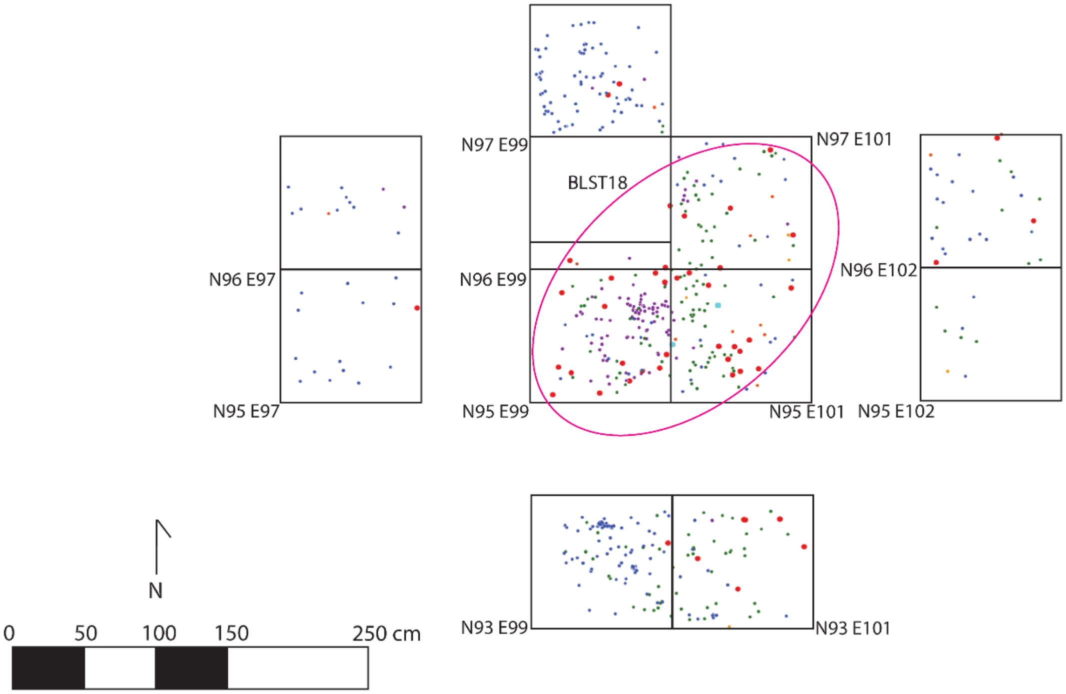

Figure 3.7 Site map and distribution of cultural material recovered in block excavations at South Blair Lake-1, with the concentration of microblade production circled in red (blue dots, Component 4; green dots, Component 3; purple dots, Component 2; orange dots, Component 1)

relatively thin (< 5 cm) and underlain by a modern A horizon, approximately 5-8 cm thick. The youngest cultural layer (Component 4) at this locality was identified in this context, with a small number of flakes, debitage, angular shatter, and fire-cracked rock

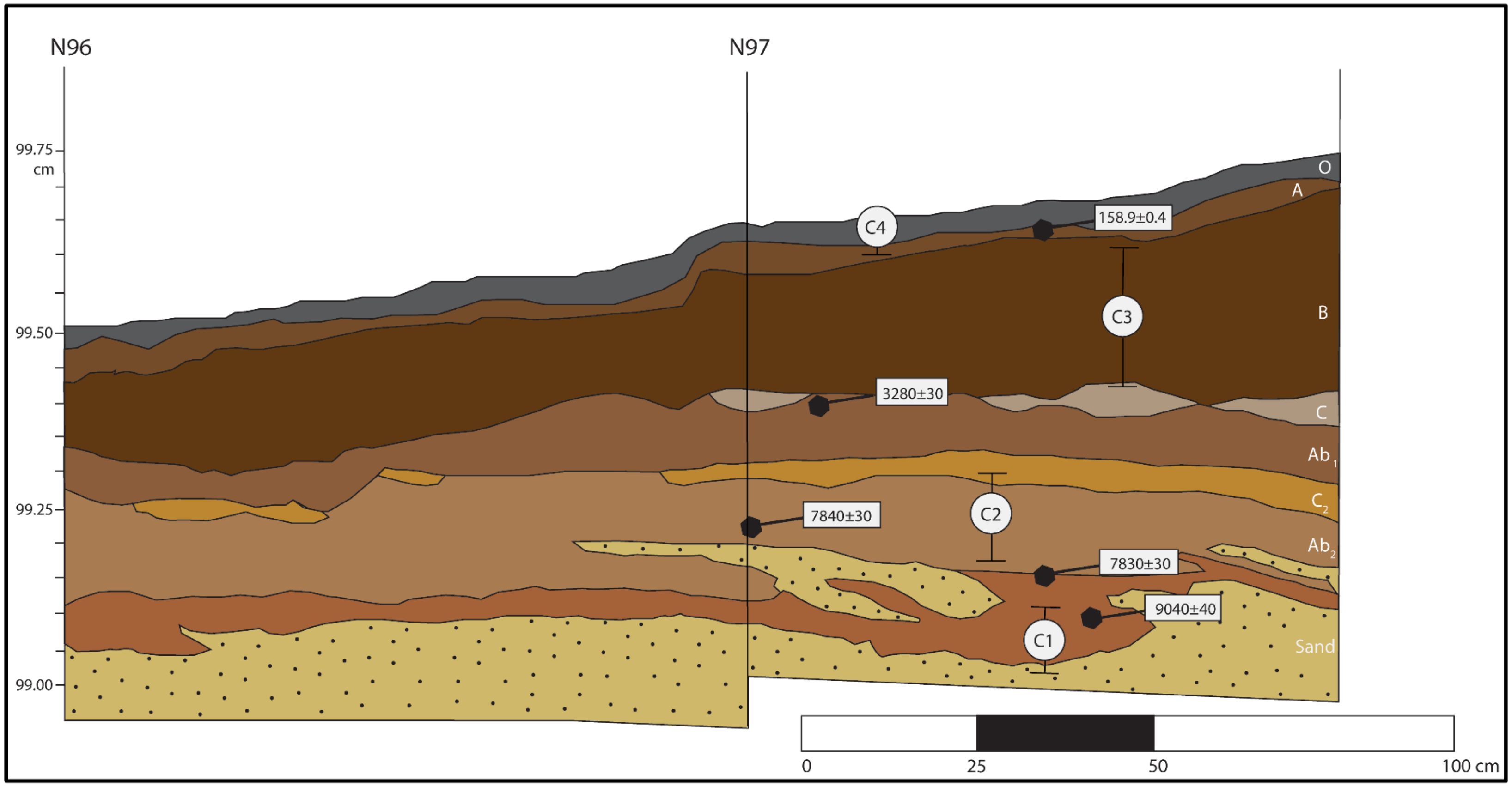

Figure 3.8 Stratigraphic profile of west wall of excavation units N97E99 and N96E99 at South Blair Lake-1.

recovered at the contact of the O and A horizons. A small amount of dispersed charcoal was recovered in this context and yielded a modern radiocarbon age, not surprising given its stratigraphic context and an association with modern bullet casings and fragmented plastic pieces, the result of historic and modern military use of the northern shore of the lake. Underlying the modern A horizon is a silt deposit/B horizon more than 25 cm thick in the northern portion of the profile. This B horizon is highly weathered with a distinct red color. Distributed throughout this horizon is a dense cultural component (labelled Component 3) with large flakes and flake tools, as well as a fragment of a notched bifacial point on chert and a lanceolate bifacial point on obsidian. Component 3 also yielded a large assemblage of debitage, fire-affected rock, and unidentifiable calcined bone. This thick B horizon rests on a discontinuous light gray silt (or C1 horizon) that often pinches out completely in southern units. Underlying this C horizon, or directly under the modern B horizon where it is missing, is a paleosol (Ab1) horizon of lightly weathered loess, which is present across the site and is approximately 7-12 cm thick. This Ab1 is relatively unaffected by the sloping dip of the upper stratigraphic horizons. Dispersed charcoal collected in an area that exhibited some compression of the base of the modern B horizon, discontinuous pockets of C1 horizon, and the top of the Ab1 horizon, yielded a radiocarbon date of 3280 ± 30 14C BP, providing a lower-limiting age for Component 3. A discontinuous silt (buried C2 horizon) underlies Ab1, though it is present mostly in pockets and often entirely absent from the profiles of more southern units. In N97E99, where the C2 horizon is most recognizable, it is culturally sterile. It caps a weathered lower loess (Ab2) horizon identifiable in all excavation units, more than 20 cm thick in places. The early-middle Holocene microblade cluster encountered during initial testing was identified in this context, and during the block excavation it yielded a large microblade assemblage (Component 2) including two wedge-shaped cores and a core tablet. A sample of dispersed charcoal and a second sample collected from a charcoal concentration associated with the microblade assemblage yielded ages of 7840 ± 30 and 7830 ± 30 ^{14}C BP, respectively. Underlying the Ab2 paleosol is a thin a band of unweathered silt (about 5 cm thick in some places), called C3, which was heavily soliflucted and contained the oldest cultural component at SBL-1. Component-1 artifacts were recovered from near the contact of this lowest silt deposit and the underlying bedded sands (which were excavated to 2.2 m at SBL-2). Dispersed charcoal collected in association with a basalt unifacial knife yielded an age of 9040 ± 40 ^{14}C BP. Our excavation into the Pleistocene sands continued to a depth of about 20 cm across the excavation. No artifacts were recovered from this unit.

Artifact assemblages for each component are described below.

3.4.4.1 Component 4

The uppermost cultural layer, Component 4, produced a small assemblage of lithic artifacts and a single fragment of fire-cracked rock, in a near-surface context mixed with fragments of plastic, glass, and rifle-shell casings. The majority of the debitage assemblage recovered in the component was flake fragments produced on chert (4), obsidian (1), and rhyolite (1), as well as proximal flakes produced on chalcedony (3). Two biface-thinning flakes produced on obsidian (1) and chalcedony (1) were recovered as well, along with a single blade-like flake produced from obsidian and two pieces of angular shatter manufactured on chert and chalcedony. A single microblade produced on quartzite was recovered from this context, though the excavation of shell casings (2) and multiple fragments of glass and opaque plastic recovered up to 6 cm below surface indicate that the lithic material may have been displaced from another context. This component yielded no identifiable features, and no faunal material.

3.4.4.2 Component 3

A total of 240 debitage pieces were recovered from Component 3. Lithic reduction in this context is best characterized as reflecting late-stage flake-core reduction as well as biface reduction (Table **3.**3). Chert and rhyolite are the primary raw materials, representing 54% (129 and 18% (43) of the assemblage, respectively. Core-reduction flakes are primarily chert (65%) and obsidian (13%), while biface-thinning flakes are disproportionately less on chert (52%) and greater on chalcedony (18%) and rhyolite (15%). A small number of retouch chips (n = 11; 73% on chert and 27% on rhyolite) likely represent limited tool finishing or resharpening. A chert core tablet, chert core fragment, and a small amount of chert angular shatter (n = 5) reflect the core-and-flake reduction strategy that dominates the Component 3 lithic debitage assemblage. Five blade-like flakes produced on chert (1), obsidian (1), rhyolite (2), and chalcedony (1) have crushed platforms and irregular lateral margins, suggesting they were not produced through some uniform blade technology. Six microblades were recovered at the base of the component, three produced on dark gray chert, two on light gray chalcedony, and one on obsidian, the same raw materials that dominate the much larger microblade

Table 3.2 South Blair Lake’s Component 3 debitage assemblage.

Debitage Type	**Raw Material**							
	CCS	Obsidian	Basalt	Rhyolite	Quartzite	Chalcedony	Other	Total
Core-reduction Flake	44	9		7	1	7		68
Blade-like Flake	1	1		2		1		5
Secondary cortical spall	2							2
Retouch chip	8			3				11
Biface-thinning flake	17	3	2	5		6		33
Microblade	3	1				2		6
Flake shatter	47	16	2	21	3	11		100
Angular shatter	5			5		1	1	12
Unworked cobble							1	1
Core fragment	1							1
Core tablet	1							1
Total	129	30	4	43	4	28	2	240

assemblage of Component 2. We suspect they may relate to that lower component and were secondarily introduced into Component 3. No microblades were found higher in the B horizon where most of the Component 3 assemblage originated. This component yielded no identifiable features and no faunal material.

The Component-3 tool assemblage includes a notched-point fragment produced on dark gray chert (Figure **3.**8 A6), a lanceolate obsidian biface (Figure **3.**8 A5), a large rhyolite core fragment (Figure **3.**8 A1), and a series of very large flake tools, including a side scraper produced on a large rhyolite flake, a combination tool (Figure **3.**8 A2) a convergent scraper on a cortical spall (Figure 3.8 A4), and a heavily retouched knife produced on chert (Figure 3.8 A3).

3.4.4.3 Component 2

Analysis of debitage indicates Component 2 represents primarily a microblade-production area; however, flake-core reduction and late-stage-biface reduction also occurred. A total of 219 debitage pieces were recovered (Table 3.4). These were produced on several raw materials including chert, obsidian, basalt, rhyolite, and

Table 3.3 South Blair Lake -1’s Component 2 debitage assemblage.

Debitage	**Raw Material**					
	CCS	Obsidian	Basalt	Rhyolite	Chalcedon	Total
Core-reduction flake	16	22	1	2	3	44
Blade-like flake	3	1		2	1	7
Secondary cortical spall	1					1
Retouch chip fragment		4				4
Retouch chip	1	18				19
Biface-thinning flake	5	7				12
Microblade	7	3		16	38	64
Flake shatter	34	11	6	5	3	59
Angular shatter	2	1	2			5
Core fragment	1					1
Core tablet			1			1
Microblade core			1	1		2
Total	70	67	11	26	45	219

chalcedony. Chert is the most prevalent raw material, making up 32% of the total assemblage, with seven distinct varieties of chert identified visually. Most are core-reduction flakes (23% of the chert assemblage) and one is a cortical spall (1%), but biface-thinning flakes (7%) also occur, together indicating primary and secondary reduction of this raw material. Obsidian, which constitutes 31% of the debitage assemblage, is associated with core-reduction flakes (33% of the obsidian assemblage) indicative of primary core reduction, as well as tiny retouch chips and their fragments (33% of the obsidian assemblage) as well as biface-thinning flakes (10% of the obsidian assemblage) indicative of biface reduction and tool resharpening. Rhyolite and chalcedony core-reduction flakes and blade-like flakes together make up only 4% of the debitage assemblage, but these are more heavily represented in the microblade-production assemblage described below. The basalt pieces were identified near the base of the component and may be displaced from Component 1.

Besides the debitage described above, 64 microblades, two microblade cores, and one microblade-core tablet with thin blade-like removals (found within 5 cm horizontally and less than 1 cm vertically from one of the cores and refits) were recovered from Component 2 (Table 3.5). Both microblade cores are wedge-shaped cores, one produced on rhyolite (Figure 3.8 B2), the other on gray chert (Figure 3.8 B3). The rhyolite microblade core is relatively small, measuring 43.8 mm in length and 20 mm in width from keel to striking platform, with only four irregular blade removals present on the front and significant damage evident, seemingly originating from flaws in the raw-material nodule. The initial striking platform from which the present blade scars originated was removed by detaching a core tablet that resulted in the removal of a significant portion of the top of the core. The counter-front of the rhyolite core was worked bifacially to form a keel that extends to its base. The second microblade core was produced on a high-quality gray chert that allowed for the successful removal of long, thin, regular microblades, with five blade-removal scars present on the front of the core, and one larger, more irregular blade removal along one of its lateral margins. This core was abandoned following the failed removal of a core tablet (recovered nearby and re-articulated in Figure **3.**8 B3), which ultimately removed nearly 50% of the front of the core. The counter-front and base of this core were bifacially shaped into a keel. Thirty-eight microblades from this component were produced on chalcedony, sixteen on

Table 3.4 South Blair Lake-1’s Component 1 debitage assemblage.

Debitage Type	**Raw Material**			
	CCS	Basalt	Rhyolite	Total
Core-reduction flake	28	56	3	87
Blade-like flake	3	4	1	8
Retouch chip fragment	1	1	1	3
Retouch chip	1			1
Biface-thinning flake		2		2
Flake shatter	32	72	9	113
Angular shatter	1	2		3
Core fragment		1		1
Total	66	138	14	218

rhyolite, seven on gray chert, and three on obsidian (Figure **3.**8 B4). A majority of the microblades are proximal (45%) and medial (32%) fragments. Given the lack of primary-reduction debitage among the rhyolite and chalcedony sub-assemblages, the microblade cores were prepared away from the excavated area at SBL-1.

The tool assemblage recovered from Component 2 was small but expressive. A rhyolite flake tool with minimal retouch along one lateral margin measuring 19.88 mm long, 5.6 mm wide, and 1.62 mm thickness and a similarly retouched bladelet measuring 11.79 mm long, 5.95 mm in width, and 1.43 mm in thickness produced on rhyolite were recovered. Additionally, a bilaterally retouched knife measuring 40.62 mm in length, 27.8 mm in width, and 5.74 in thickness on a large gray chert flake was recovered in this context (Figure 3.8 B1).

3.4.4.4 Component 1

A total of 218 pieces of debitage were recovered from Component 1, the second-largest debitage assemblage recovered (Table **3.**5). It is dominated by 138 pieces of fine-grained basalt debitage (63%) of moderate quality for knapping, a material that was likely procured locally but transported to the site well into the lithic-reduction sequence. The basalt debitage is overwhelmingly representative of later-stage core-and-flake reduction, given the preponderance of core-reduction flakes and blade-like flakes (44%) produced on this material. Chert is well-represented in the debitage assemblage, too, with 27 flake fragments produced on a brown chert not encountered in any other component. Three other chert varieties also occur, and together the chert sub-assemblage is characterized chiefly by core-reduction flakes and blade-like flakes (47%), also clear signs of later-stage core-and-flake reduction. Significantly, no cortical spalls were recovered from this component. Obsidian is also absent. The small amount of rhyolite debitage (6%) is almost certainly related to the microblade production area documented in Component 2, as it was generally recovered from portions of the excavation where there was little to no stratigraphic separation between the components. A small fragment of a flake core produced on basalt was also recovered in this context. This component yielded no identifiable features, and no faunal material.

A unifacial backed knife (Figure **3.**8**,** C1) produced on the prevalent basalt was recovered resting horizontally at the contact of the base of the lowest silt and the top of the culturally-sterile basal sand. It bears a unifacially-worked lateral margin opposing a natural steep back along the opposite edge. In addition, there is a very steeply-retouched end scraper produced on basalt (Figure 3.8, C2). Both of these tools appear to have been made on blades.

3.4.5 Other Holocene Archaeological Sites Within the Blair Lakes Archaeological District

SBL-1 is one of the largest, most extensively investigated archaeological sites within the Blair Lakes Archaeological District; however, there are 85 other sites that have contributed to re-defining the district in 2017 (Figure **3.**2). Many of these have only been preliminarily tested but have the potential to significantly contribute to our understanding of the prehistoric occupation of the Tanana Flats and Interior Alaska. Seven of these sites in particular, FAI-02043, FAI-02047, FAI-02060, FAI-02063, FAI-02064, FAI-02073, and FAI-02077 (Figures 3.9 - 3.14) have yielded archaeological

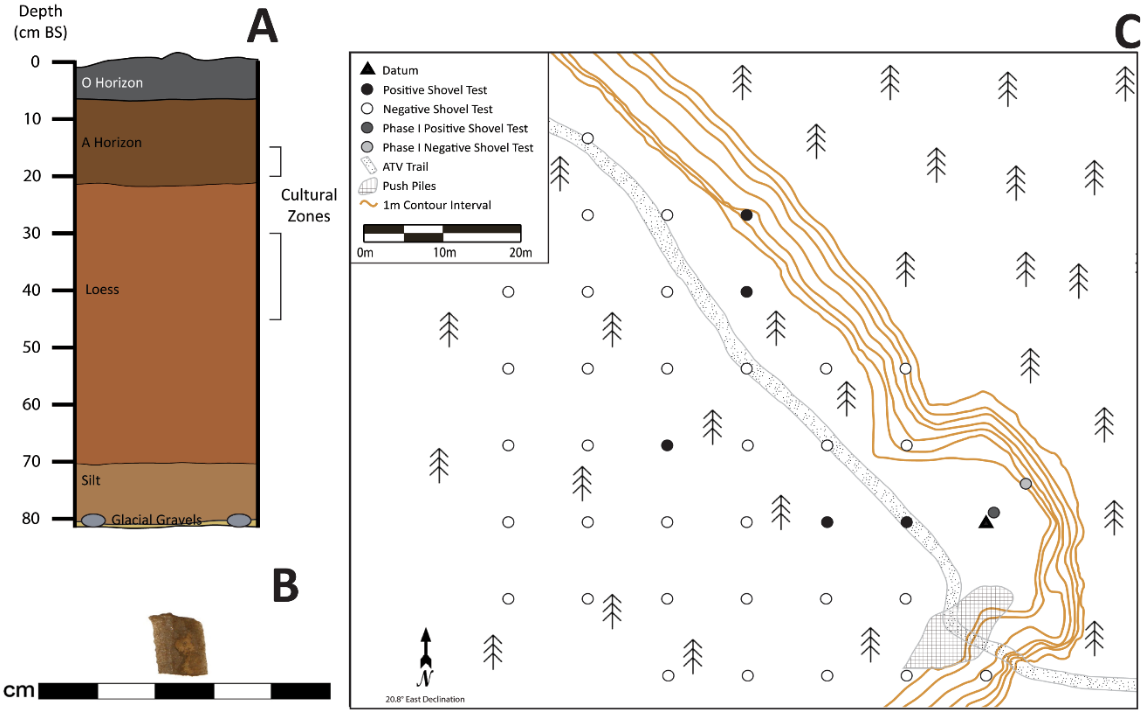

Figure 3.9 A stratigraphic profile of STP 0N 20W; B, medial microblade fragment; C, site map.

assemblages in secure stratigraphic contexts with diagnostic lithic artifacts or radiocarbon dates, suggesting specific Holocene ages based on our understanding of the geomorphological and depositional characteristics of the terrace complex and hills that surround the Blair Lakes. These sites were discovered during archaeological survey and testing conducted by CEMML archaeologists between 2009 and 2017, and they have been determined eligible for the National Register of Historic Places and presented in reports to the State Historic Preservation Office, Alaska (Esdale et al. 2014, 2015, 2016).

Details on these sites can be found in Table 3.6. At FAI-02043 (McDonald Creek) Goebel et al. (2017) have identified a well-preserved cultural component dated to 11,900-11,500 14C BP. The assemblage includes thousands of undiagnostic debitage

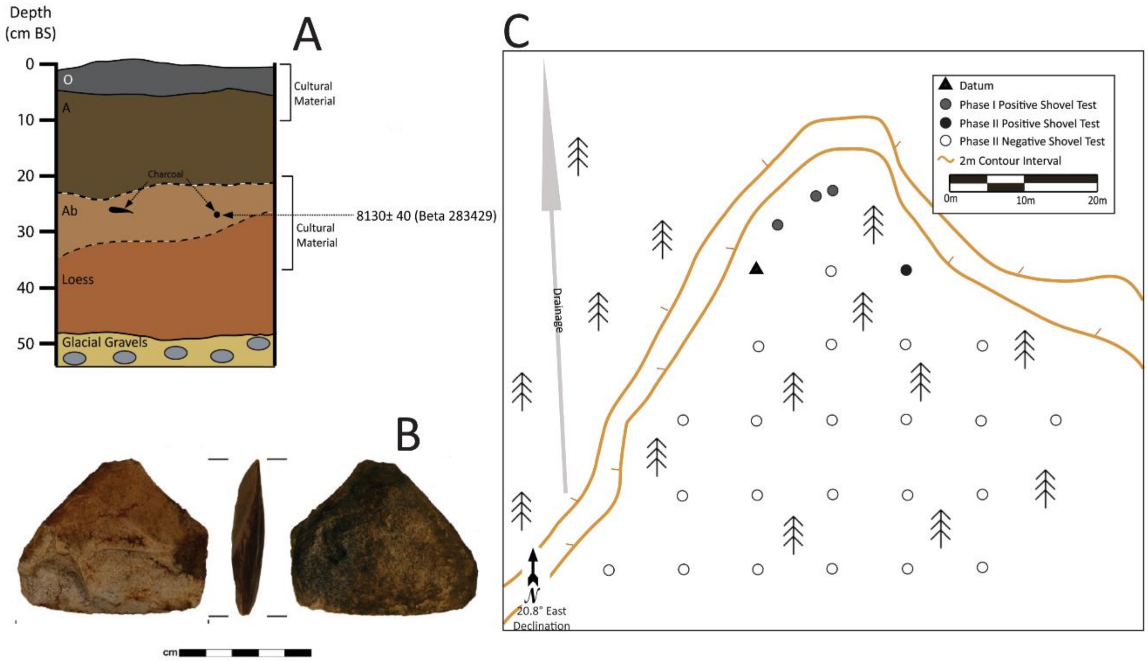

Figure 3.11 FAI-02060: A stratigraphic profile of STP A-10-21; B, retouched flake from surface context; C, site map.

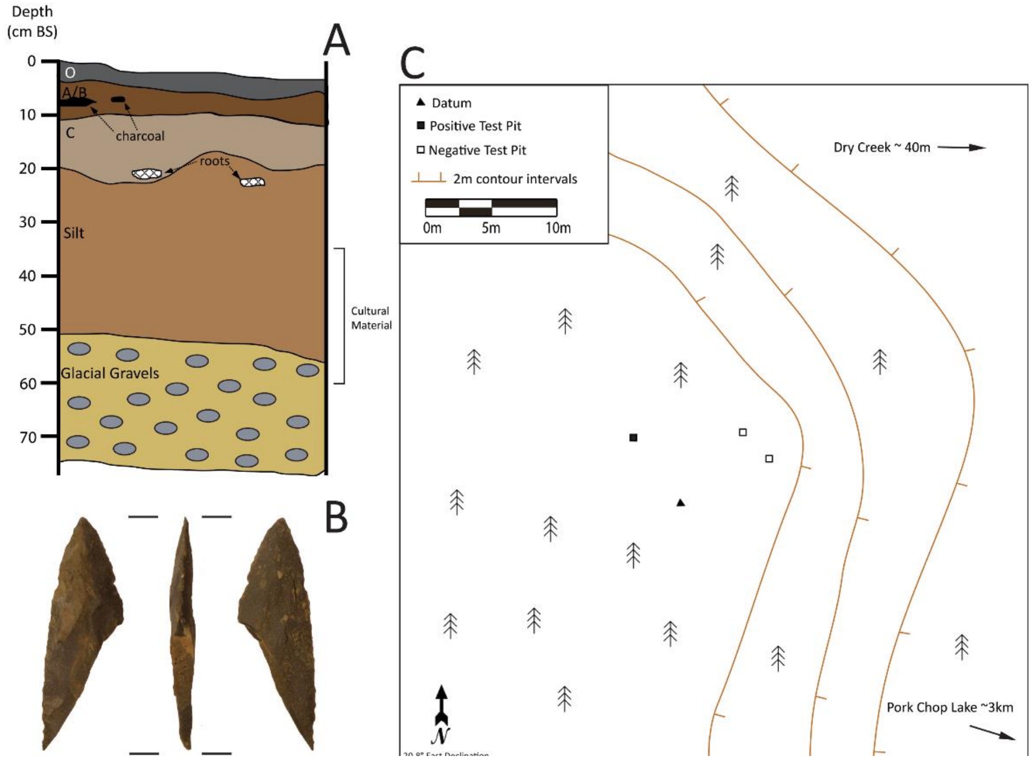

Figure 3.10 FAI-02063: A, stratigraphic profile of STP B-10-02; B, chert biface fragment; C, site map

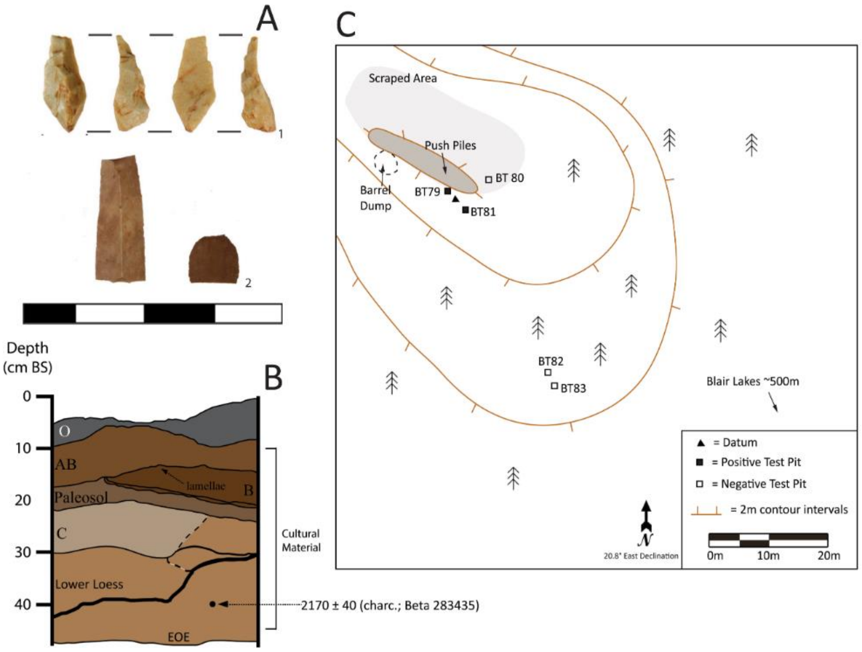

Figure 3.13 FAI-02064: A, (1) rhyolite flake fragment, (2) microblade fragments; B, stratigraphic profile of STP B-10-03; C, site map.

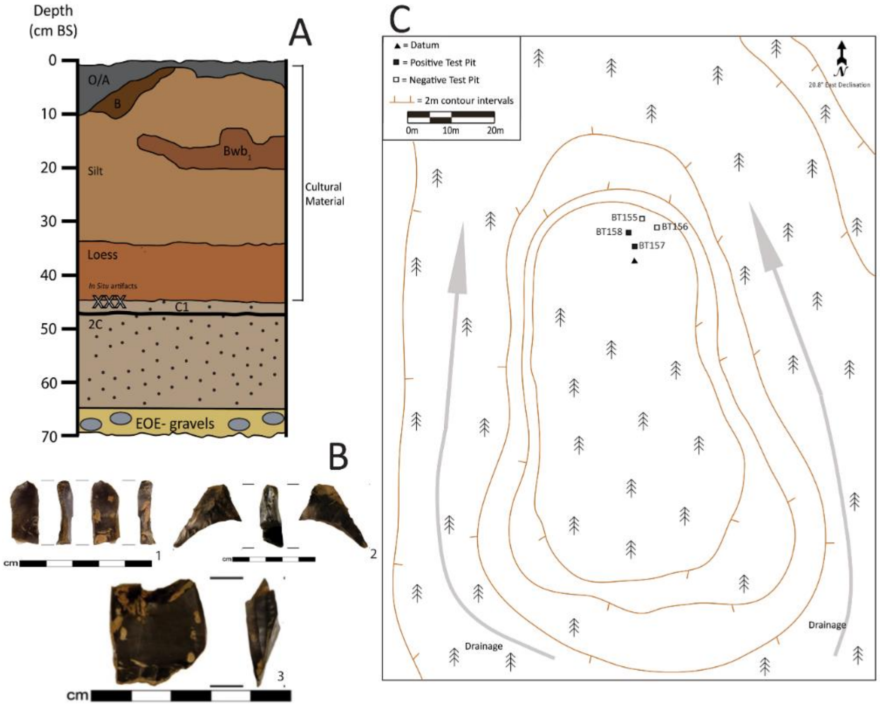

Figure 3.12 FAI-02073: A, stratigraphic profile of B-10-13; B, (1) core fragment, (2) core tablet, (3) wedge-shaped microblade core; C, site map.

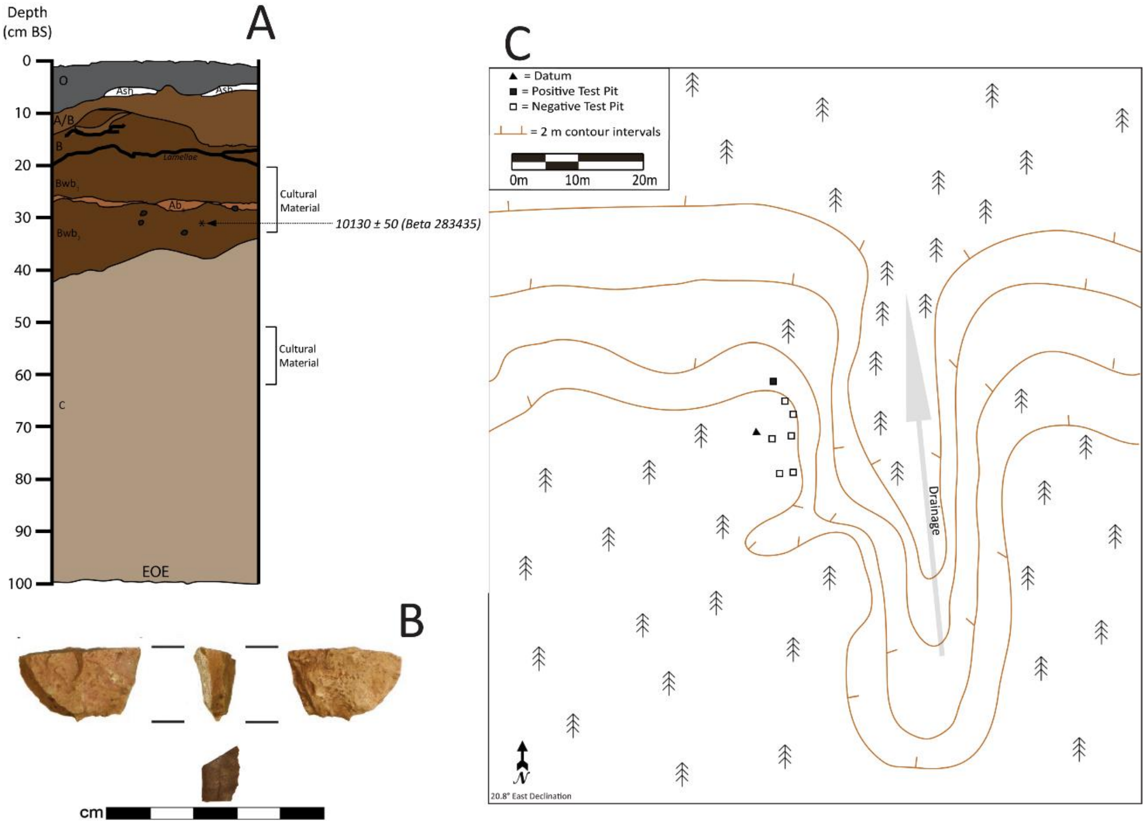

Figure 3.14 FAI-02077: A, stratigraphic profile of B-10-17; B, (1) rhyolite biface fragment, (2) microblade fragment; C, site map.

Table 3.5 Other Holocene Archaeological Sites Within the Blair Lakes Archaeological District.

Site	Landscape Location	Stratigraphy	Cultural Components	Radiocarbon or Relative Date Range
FAI-02047 (Figure 8)	On a 10-12-m high terrace that formed over glacial outwash and overlooks a substantial drainage to the west and the Tanana River valley to the south and southeast.	The site is capped by a roughly 8-cm thick organic (O) horizon, which is underlain by a 10-15-cm stratigraphic unit of dark brown silt (A horizon). This silt contains the upper archaeological component. A distinct color change signals a loess deposit reaching 50 cm thick. Within this large, uniform silt deposit a second cultural component was encountered that ranged in depth from 30 to 45 cm below the surface (bs). The loess stratigraphic unit rests on a 10-cm layer of lightly weathered yellowish-brown silt, which was deposited directly over glacially deposited gravels.	Upper Component: 11 rhyolite flakes and 4 calcined bone fragments Lower Component: 1 rhyolite flake, four biface thinning flake, 1 blade-like flake, and one retouched flake produced on gray chert.	Upper Component - 1430 ± 40 ^{14}C BP (BETA-283428) - charcoal
FAI-02060 (Figure 9)	~12 km northeast of the northern shore of Blair Lakes South, on a north-facing terrace edge (10-12-m high) overlooking a large north-south drainage to the west and the Tanana Flats to the north.	A 7-cm thick O horizon is underlain by a light olive brown silt (A horizon) 8 to 20 cm in thickness. The upper cultural component at the site is contained within the O horizon and the upper 5 cm of the A horizon. A 10-cm thick paleosol of dark brown silt lies under this upper loess and contains the lower cultural component. It rests on a thick layer of light brown loess that yielded cultural materials in its upper 5 cm that were attributed to the lower component. This buried loess rests on glacial gravel deposits.	Upper Component: 4 flake fragments, basalt (1), chert (2), rhyolite (1). Lower Component: 4 flakes produced on chert, 24 flake fragments, chert (15) and rhyolite (9).	Lower Component - 8130 ± 40 ^{14}C BP (Beta-283429) - dispersed charcoal
FAI-02063 (Figure 10)	1.5 km east-northeast of Blair Lake North. The site rests on an east-facing bluff of a terrace with prominent views of the adjacent Dry Creek drainage and Pork Chop Lake, 2 km east.	A 6-cm thick O horizon caps a series of loesses, including a 5-cm thick weathered sandy silt layer, which in turn rests on a dark yellowish-brown silt layer that extends from 10 to 20 cm bs. A basal yellowish-brown silt layer underlies this and reaches more than 30 cm thick. It rests on glacial gravel deposits. The recovered artifact assemblage is contained within the basal silt layer.	Cultural Component: 11 flakes and 1 large lanceolate projectile point fragment all produced on gray chert	No datable, organic material was recovered during testing at FAI-02063; however, the context of the archaeological assemblage suggests an early-Holocene occupation based on dated components in similar contexts in the Blair Lakes area.
FAI-02064 (Figure 11)	On the crest of a bedrock knoll 500 m northwest of Blair Lakes North at an elevation of about 350 m. The site offers a commanding 360° view of the surrounding landscape including Blair Lake North.	A 3-cm thick O horizon overlies a 15-cm thick A horizon. Underlying this is a dark brown Ab horizon reaching 5 cm thick. This paleosol rests on a 14-cm thick stratum of lightly weathered yellowish-brown silt that contains a series of lamellae in its upper 5 cm. Lithic artifacts were recovered throughout the loess underlying the O horizon. It caps an angular, decaying regolith produced by the underlying schist bedrock.	An assemblage of 71 lithic artifacts was recovered throughout the loess portion of the profile: 2 rhyolite flakes and 1 chert microblade fragment were recovered from the modern A horizon, 21 flakes on chert (7) and rhyolite (14) were …	Disbursed charcoal was collected in association with artifacts near the base of the profile (40 cm bs) during testing and produced a radiocarbon date of 2170 ± 40 ^{14}C BP (Beta-283435).

(Continued)

Table 3.5 Continued.

Site	Landscape Location	Stratigraphy	Cultural Components	Radiocarbon or Relative Date Range
FAI-02064 (Figure 11) Continued			association with the paleosol, 1 proximal flake produced on chalcedony, 1 obsidian flake fragment, 9 chert flake fragments, and 19 rhyolite flake fragments	
FAI-02073 (Figure 12)	11 km northeast of the northern shore of Blair Lake South, along the edge of a north-facing alluvial terrace rising 15 m above the surrounding landscape, offering a 270-degree viewshed. Two unnamed drainages converge 20 m north of the site and form a moderate-sized drainage flowing to the northeast across the Tanana Flats.	A thin O horizon rests on three distinct silt layers, capping a sandy gravel base. The O/A horizons cap the site from 0-10 cm bs. Underlying this is a discontinuous but strong brown B horizon in a 30-cm thick yellowish-brown silt stratum. This rests on a 10-cm thick unweathered, light gray silt, which in turn is underlain by an olive sandy-silt stratum 14-24 cm thick. It contains a single, well-defined lamella at 48 cm bs. The sandy-silt stratum rests on glacial gravel deposits.	Forty-one pieces of lithic debitage were recovered throughout the profile, from 0 to 45 cm bs. The debitage assemblage includes 21 flakes and flake fragments produced on black chert, three flake fragments on dark gray chert, three flake fragments on light gray chert with dark gray bands, and two flake fragments on brown rhyolite. Two microblades produced on chert (one black and one very dark gray), one microblade core tablet (dark gray chert), and a possible burin (dark gray chert) were recovered during the excavation, but their stratigraphic positions are difficult to isolate. One microblade core produced from dark gray chert was recovered in situ at 45 cm bs.	No datable material was recovered during testing at FAI-02073; however, context of the archaeological assemblage suggests a possible late Pleistocene/early Holocene age based on the character of the lithic assemblage and context in comparison to archaeological components and strata along the same terrace system in the Tanana Flats (i.e., FAI-2043, FAI-02063, FAI-02077)
FAI-02077 (Figure 13)	8 km northeast of the northern shore of Blair Lake South on a north-facing, 15-m high terrace.	A moderately thick O horizon reaches from 0 to 10 cm bs and overlies an A horizon approximately 5 cm-10 cm thick and a B horizon that extends from 15 to 28 cm bs. This rests on a thin, weakly developed Bb horizon encountered between 28-30 cm bs. Directly underlying this buried B horizon is a buried A horizon approximately 1-3 cm thick at approximately 30 cm bs. Underlying this is a second weakly developed buried B horizon that extends from ~30-42 cm bs. This rests on a C horizon of loess that reaches from 42 cm bs to the termination of excavation at 140 cm bs.	Cultural material at FAI-2077 is limited and encountered between 20-30 cm bs, but the nature of shovel testing makes it difficult to assign this material to an exact stratigraphic position within an arbitrary 10-cm excavation level. lithic artifacts including a single microblade and biface fragment between 20-30 cm bs. In the northern-most shovel test, one large gray chert flake fragment, one gray chert microblade, and one rhyolite biface fragment were recovered between 20-30 cm bs.	Dispersed charcoal suitable for radiocarbon dating associated with lithic artifacts was collected in situ at 31cm bs. This sample produced a date of 10,130 ± 50 ^{14}C BP (Beta-283435)

pieces, a few retouched tools, and numerous remains of a variety of fauna (see also Gaines 2009, 2010). At FAI-02077 a radiocarbon age of 10,130 ± 50 14C BP is associated with a small assemblage of lithic materials including microblades and biface fragments. Similarly, at FAI-02063 and FAI-02073 (not directly dated but encountered in lower loess units similar to FAI-02077), microblades and lanceolate biface fragments were recovered. Together these sites indicate that the terraces and hills in the Blair Lakes vicinity have been utilized by humans since the end of the Pleistocene. Continued Holocene occupation of the district's terraces and hilltops is further demonstrated by the multicomponent sites FAI-02043, FAI-02047, FAI-02060, and FAI-02064, all of which produced small lithic assemblages reflective of short-term hunting outlooks. Radiocarbon ages associated with these occupations span the Holocene, from 8130 ± 40 to 1430 ± 40 ^{14}C BP (Table **3.**1). These findings, although preliminary and based solely on the excavation of restricted STPs, complement the culture history developed by our more extensive excavations along the northern shore of south Blair Lake.

3.5 Discussion

Our multiyear testing and excavation program in the Blair Lakes Archaeological District has had three major objectives: (1) to establish the geomorphological context and occupational history of the northern shore of south Blair Lake; (2) to identify sites within the district that contain archaeological deposits potentially informing on regional prehistoric settlement patterns and land-use strategies; and (3) to evaluate the potential of specific areas in the district, outside of traditional "high-probability" bluff-edge settings, for investigating human adaptation during the late Pleistocene and Holocene.

Specifically, we hoped to identify archaeological sites and cultural components that could expand our understanding of early hunter-gatherer occupations of lakeshores, hilltops, and other traditionally under-investigated settings.

3.5.1 Geomorphological Context and History of the Northern Shore of South Blair Lake

Early testing on the northern shore of the south Blair Lake by Dixon et al. (1980) identified five prehistoric archaeological sites that together suggested the presence of a Denali occupation focused on microblade production, a Northern Archaic occupation, and an Athabaskan occupation, all in close proximity to the modern lakeshore. Based on reconnaissance survey, Dixon et al. (1980) interpreted the large amount of cultural material, high raw-material diversity, and re-use of the shoreline through time as representative of early- and middle-Holocene base camps, as well as a potential late-prehistoric Athabaskan village site. The Blair Lakes Archaeological District, with its original boundaries, was established based on these results. Our testing efforts in 2013 and block excavations in 2014-2015 expand on these early results, providing a better understanding of the geomorphological context of the archaeological record preserved in the terrace adjacent to the northern shore of south Blair Lake, clarifying the geochronology of the preserved cultural occupations, and characterizing technological activities and settlement organization of the lakeshore’s early inhabitants.

First, our 6-m geologic test trench at SBL-2 revealed the stratigraphy of the terrace adjacent to the lakeshore and confirmed it to be a valuable context for recovering stratified archaeological materials dating to the early, middle, and late Holocene (Figure

3.5). The series of Holocene aeolian deposits reaching up to 75 cm in thickness, within which multiple paleosols and cultural components were encountered, represents a prime source of information for reconstructing Holocene archaeology in an understudied lowland lakeside context. Alternating deposits of silt, sand, and coarse sand generally characterize the basal (Pleistocene) stratigraphy of the intensively occupied terrace. Radiocarbon dates of 8220 ± 25, 8620 ± 40, and 8720 ± 30 ^{14}C BP provide important geochronological information regarding the development of a major early-Holocene paleosol along south Blair Lake's shoreline.

Second, the results of our shovel testing confirmed that the northern shore of the lake was intensively utilized by humans throughout much of the Holocene. Testing nearly 300 m along the shore of the lake yielded no clear locus boundaries due to a high density of cultural materials. Fifteen of 18 shovel tests yielded lithic artifacts, and no horizontal break in cultural material larger than 20 m was identified. Eight of the shovel tests (44%) encountered multiple buried components. Analyses of the stratigraphic profiles of each shovel test replicated much of the stratigraphy described in the test trench at SBL-2, and radiocarbon dates from various strata and shovel tests aided in developing a geochronology for the site's loesses, paleosols, and associated cultural components, which span the early, middle, and late Holocene. In addition to recovered debitage assemblages, the testing project (the trench and STPs) also yielded a small number of lithic tools including a small triangular-shaped bifacial point on a gray chert flake from an early-Holocene context, as well as numerous microblades in a middle-Holocene context. The resulting 'vertical record' (i.e., stratigraphy and chronology) corresponds well with the results of Dixon et al. (1980), but the extensive horizontal nature of the archaeological record suggests that the individual sites originally recorded by Dixon et al. should be merged into a single recorded site.

Third, the block excavation at locality SBL-1, where debitage and microblades indicating a microblade-production area were recovered during the testing program, led to identification of four stratigraphically distinct cultural components. Anthropogenic disturbances to the upper portion of the profile obscure the nature of the late prehistoric, near-surface Component 4. However, cultural material was encountered near the contact of the O and modern A horizons in STP 1, 3, 6, 7, 10, 11, and 15, and a radiocarbon date from this context in the test trench at SBL-2 yielded a radiocarbon date of 855 ± 15 ^{14}C BP, suggesting the late-Holocene Athabaskan occupation of the lakeshore was extensive and could be better preserved elsewhere along the northern shore. Component 3 represents the largest assemblage of debitage and tools encountered at SBL-1. These include scrapers manufactured on cortical spalls, large flake tools, and notched and lanceolate points characteristic of Northern Archaic archaeological assemblages (Esdale 2009). The best approximation of the age of this component is 3280 ± 30 ^{14}C BP; however, stratigraphically this is a lower-limiting age for the Northern Archaic occupation. The density and variability of tools in the relatively small excavation area at SBL-1, relatively high diversity of raw materials, presence of fragmented and calcined faunal remains (likely the result of intensive processing of large-mammal bone for grease extraction), and the small amount of fire-cracked rock are together indicative of a long-term, residential occupation (sensu Binford 1980; Potter 2008b) of the Northern

Archaic tradition. More extensive excavations may eventually yield preserved features consistent with this interpretation. Component 2 is dominated by lithic materials reflective of microblade production from wedge-shaped microblade cores made on non-local raw materials and is technologically distinct from other cultural components at the locality. Disbursed charcoal associated with this component at SBL-1 yielded dates of 7840 ± 30 and 7830 ± 30 ^{14}C BP, confirming Dixon and colleagues' (1980) previous identification of a microblade-focused Denali occupation along the lakeshore. In a survey of middle-to-late-Holocene intersite variability across Interior Alaska (Potter 2008), microblade industries have been identified at 73% of Holocene lakeshore sites dated older than 1000 cal BP, but in only 25% of non-lakeshore components (Potter 2008). The drivers of the association of microblade technology and lowland lakeshore landscapes are not well understood, but the pattern is observable in tested lakeshore sites like those at Healy Lake, Lake Minchumina, and now south Blair Lake (Cook 1969; Holmes 1986; Potter 2008). Component 1 was dominated by debitage produced on basalt and visually distinctive chert varieties not observed in upper components. The character of the debitage assemblage suggests secondary and late-state reduction of flake tools and cores transported to the site subsequent to primary reduction elsewhere. Only two flake tools, a unifacial knife produced on basalt and a small end scraper produced on a chert flake, were recovered in this context. Dispersed charcoal collected in association with these materials yielded a radiocarbon age of 9040 ± 40 ^{14}C BP, pushing the known occupation history of the northern shore of south Blair Lake back to the early Holocene. The triangular projectile point produced on a chert flake recovered from a similar stratigraphic context at the test trench (SBL-2) was associated with radiocarbon dates of 8720 to 8220 ^{14}C BP and may be temporally intermediate in age with the Component I and Component 2 assemblages at SBL-1.

The stratigraphic context of the earliest cultural component is also of note. Identified at the contact of the lowest loess and the top of the basal sands, its position indicates that foragers in the Tanana Flats were exploiting Blair Lakes very soon after the stabilization of the first terrace's surface adjacent to the lakeshore (Dixon et al. 1980). Interestingly, the lack of obsidian in Component 1 suggests different raw-material exploitation strategies of the earliest occupants of SBL-1 than those of later occupants. The character of Component 1 follows a pattern of local, lower-quality raw-material utilization, following the prediction of Krasinski (2018) that, when lacking exotic raw materials, early occupants of new landscapes practicing high residential mobility would have exploited low-quality local tool stone while establishing cognitive maps of local landscapes and resources.

3.5.2 Regional Prehistoric Settlement Patterns and Land Use in the Holocene

The extensive collection of lithic tools and cores recovered from under the surface of south Blair Lake, in front of the northern shore, reflects a significant amount of diversity in technological and subsistence activities. The subsurface artifact assemblage included numerous microblade cores, lanceolate bifaces, large biface preforms, notched points, end scrapers, and massive retouched cobble tools produced on various cherts, chalcedony, rhyolite, and obsidian (Figure **3.**4 A, B). The variability in diagnostic tool types and high level of raw-material diversity suggests the presence of multiple residential base camps during the middle and late Holocene, potentially even extending back to the early Holocene. This subsurface assemblage, considered with the extensive archaeological materials encountered in buried context on the lakeside terrace, suggests that south Blair Lake represents a significant landscape feature for the prehistoric inhabitants of the Tanana Flats, from the early Holocene to late prehistoric times. Combined results of surveys, testing, and excavations suggest that occupations of south Blair Lake likely represented a repeatedly-occupied base camp through much of this time, and possibly even a village by the late Holocene.

Moreover, extensive survey projects in the Blair Lakes Archaeological District conducted by CEMML crews have identified 86 archaeological sites in the district, and this paper briefly presents the results of testing at six of these, where cultural materials have been directly dated through dispersed charcoal associated with buried cultural components or indirectly dated based on our understanding of stratigraphic sequences of loess and paleosol stratigraphy (Esdale et al. 2016; Table 3.6, Figure 3.15). Microblade technology (though often lacking cores or other evidence of on-site reduction) and lanceolate-biface fragments are observed in assemblages dated from 10,130 ± 50 to 2140 ± 40 14C BP in elevated terrace and hillside sites in the district. These sites yielded generally small lithic assemblages that lack the raw-material diversity, tool-type variety, highly-processed faunal materials, and site structure, characteristics observed in the

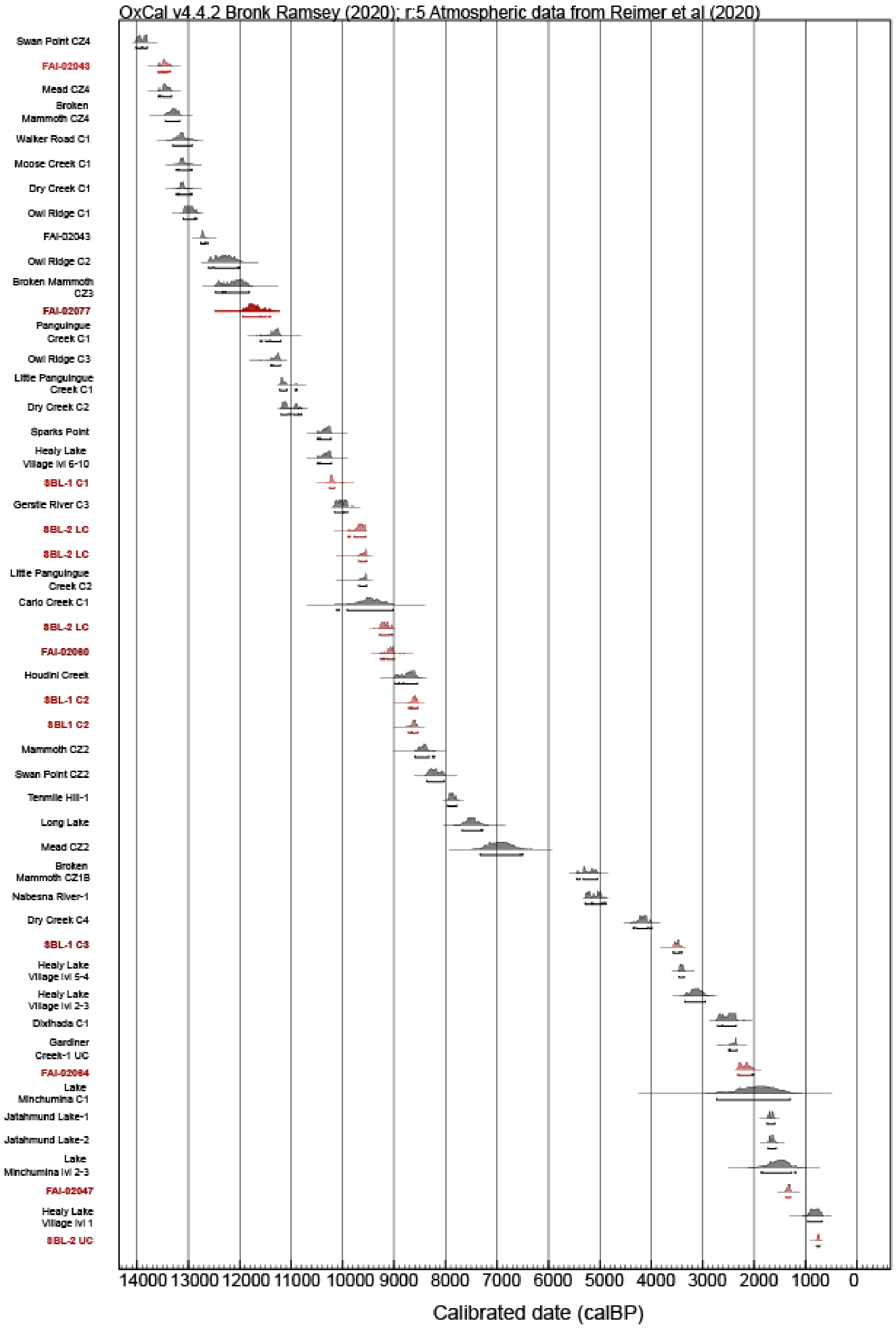

Figure 3.15 Calibrated radiocarbon dates from cultural occupations in the Blair Lakes Archaeological District compared to other sites in interior Alaska. References: (1) this paper, (2) Cook 1996, (3) Esdale et al. 2016, (4) Holmes 1986, (5) Lynch et al. 2018, (6) Shinkwin 1979, (7) Powers et al. 2017, (8) Gore and Graf 2017 (9) Holmes 1996, (10) Dilley 1998, (11) Reger and Bacon 1996, (12) Bowers et al. 1995, (12/3) Bowers 1980, (134) Gómez Coutouly et al. 2019, (15) Gaines et al. 2011, (16) Pearson 1999, (17) Goebel et al. 1996. Radiocarbon dates were calibrated using CALIB7.1.0, following Stuiver and Reimer (1993).

more residentially-oriented assemblages encountered in components 2 and 3 at SBL-1. Taken together, the FAI-02043, FAI-02047, FAI-02060, FAI-02063, FAI-02064, FAI-02073, and FAI-02077 sites present a record of use of elevated locations within the Tanana Flats, hunting overlooks and localities of secondary lithic production or tool maintenance, throughout the Holocene, consistent with interpretations of technological and behavioral continuity in Interior Alaska and southwest Yukon during the mid to late Holocene (Bowers 1999; Easton et al. 2011; Holmes 1986; Holmes and Bacon 1982; Holmes et al. 1996; Potter 2008; Workman 1978). These sites likely represent ephemeral use of elevated topographic features as resource-extraction and hunting-lookout locations associated with relatively long-term residential occupations in lowland lakeside or marsh-side settings as at SBL-1.

Potter (2008) suggests that following the collapse of Beringia's open steppe-tundra biomes at the end of the Pleistocene, forager populations in interior Alaska slowly re-organized from systems of high residential mobility to more logistically-oriented seasonal mobility, as population density and shifting ecological conditions favored semi-sedentary strategies (see also Graf and Bigelow 2011). Aggregation of family groups into larger bands at fishing villages in the summer and dispersion into smaller family units to offset limited resource availability in the winter is documented for pre-contact and early-contact Athabaskan groups in Interior Alaska (see Younie and Gillispie 2016). These patterns are proposed to have emerged in the early-middle Holocene, though comparisons between ethnographic and prehistoric periods is difficult (Potter 2008a). This patterning is clearly reflected in the archaeological assemblages encountered along the northern shore of south Blair Lake and elsewhere in the archaeological district. The laterally extensive evidence of human occupation along the shoreline of the lake, as well as the diversity of lithic raw materials and tools in the excavated assemblages and collected assemblage from under the lake's waters, clearly indicate that this was a focal point on the landscape for Holocene foragers. We hypothesize that they were drawn to the lakes to take advantage of seasonally abundant fish, waterfowl, and ungulates of the boreal forest during much of the Holocene. From this base, the hunting-and-gathering occupants were logistically connected to the numerous extraction sites dispersed across the district. Our combination of survey and block excavation strategies provides an important landscape perspective on the variability of hunter-gatherer technological, subsistence, and settlement organization.

3.5.3 Evaluating the Potential of Specific Areas in the District Outside of Traditional "High Probability" Bluff-edge Settings for Investigating Human Adaptation During the Holocene

While the lakeside terrace preserved along the northern shore of south Blair Lake does not seem to represent a location with high potential for the preservation of late-Pleistocene archaeology, the two cultural components encountered on a high bluff edge approximately 7 km northeast of Blair Lakes at the McDonald Creek site (FAI-02043) dating between 11,950 ± 50 and 10,615 ± 60 14C BP, and deep aeolian deposits encountered in the hill and terrace complexes that yielded microblade fragments and a radiocarbon age of 10,130 ± 50 14C BP at nearby FAI-02077 (overlying even more deeply buried but undated cultural materials) in the Blair Lakes Archaeological District indicate that the Tanana Flats were occupied during the early waves of colonization of interior Alaska (Goebel et al. 2017; Goebel and Potter 2016; Figure **3.**15). Thus, the district represents a prime source for identifying early-period archaeology in an understudied context that was potentially economically remote to late-Pleistocene/early-Holocene foragers (Krasinski 2018).

The potential for recovery of Holocene-aged archaeological materials along the terrace and hill complexes in the district is extraordinary. While not always positioned on traditional 'high-potential' bluff-edge localities associated with glacial river and alluvial terrace landscapes that served as initial travel corridors in eastern Beringia (Goebel and Potter 2016; Hoffecker and Elias 2007; Potter 2008b), the positive landforms in the Blair Lakes Archaeological District provide the only overlook settings in a vast lowland (Esdale 2016). Today, these raised topographic features also represent the most passable areas in the Tanana Flats which are otherwise composed of low-elevation wetlands or thick boreal forests that inhibit easy travel and wayfinding (Krasinski 2018).The profiles at FAI-02047, FAI-02060, FAI-02063, FAI-02064, FAI-02073, and FAI-02077 demonstrate alternating periods of aeolian deposition and stable soil development ideal for preserving archaeological deposits in primary depositional context. Continued testing of terrace and hill "upland" areas and along the shorelines of lakes and marshes in the district will undoubtedly produce additional cultural materials and archaeological sites in dateable contexts, particularly in identified areas of deep loess deposits (similar to the localized conditions at FAI-02077) and terraces associated with modern lakeshores.

3.6 Conclusions

Despite the significant contributions of the Alaskan archaeological record to our understanding of the peopling of the Americas and Holocene occupations of subarctic landscapes, the archaeological potential of many geographic and ecological subregions in interior Alaska remains largely untested. The Tanana Flats is one such region with potential to contribute to the development of more comprehensive regional occupation records and a fuller understanding of human adaptations to subarctic landscapes through time. Building on promising results of extensive CRM surveys and testing, excavations on the northern shore of south Blair Lake and associated topographic features within the Blair Lakes Archaeological District have identified dozens of prehistoric archaeological sites spanning from the late Pleistocene through the late Holocene, including sites positioned on relic terrace edges and multiple multicomponent occupations in lakeshore settings. Positioned in an expansive lowland north of the Alaska Range between the Nenana and middle Tanana valleys, the Blair Lakes Archaeological District represents an ideal place for exploring assemblage variability, site distributions, mobility strategies, and landscape-use patterns in a 'marginal' landscape that must be incorporated into the larger regional record to establish a more holistic understanding of prehistoric forager behavior in interior Alaska since 14,000 cal BP.

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4. APPROACHES TO OSSEOUS AND COMPOSITE PROJECTILE TECHNOLOGY IN THE UPPER PALEOLITHIC OF SIBERIA AND BERINGIA

4.1 Introduction

Throughout the Upper Paleolithic and Mesolithic periods, modern humans in Siberia and Beringia produced a stunning array of projectile weaponry manufactured on osseous materials including bone, antler, ivory, and horn (e.g., Abramova and Grechkina 1985; Goebel 2002; Graf 2013; Pitulko et al. 2004, 2015). These highly variable osseous projectile points represent diversity in technical solutions to the capture of vital nutritional and raw-material resources needed to survive in arctic and subarctic environments. The adaptive roles and implications of variable osseous projectile-point morphologies in the archaeological record, however, is not well understood. Additionally, the relationships between complex osseous projectile-point technologies and the dispersal of modern humans across Siberia and into Beringia has yet to be fully explored. Preservation shortcomings, even in the cold northern sediments of Siberia and Beringia, have severely limited the recovery of these artifacts, and the extensive geography of the Eurasian and North American far north, not to mention the disparate research traditions that have developed during the last century in these areas, have severely constrained our understanding of this important tool class. Sadly, robust understanding of the variability in projectile design evident in the late Upper Paleolithic and Mesolithic to these questions remains elusive because of a lack of integration of data sets of osseous projectile-points from across the region, during the late Pleistocene and the early Holocene.

This paper presents the results of a comparative analysis exploring the morphological and functional variability of osseous projectile weapons recovered from eleven Siberian and Beringian archaeological sites (Figure 4.1). Specifically, I investigate the relationships between raw material, manufacturing technique, morphology, and non-utilitarian modification of middle and late Upper Paleolithic and Mesolithic osseous artifacts, and I infer specific functions of these tools. This study is among the first attempts to create a pan-Siberian/Beringian perspective on early osseous projectile technology and use (e.g., Ackerman 2011; Dixon 2011; Pitulko et al. 2015). Questions addressed include: What is the range of morphological variability in middle Upper Paleolithic, late Upper Paleolithic, and Mesolithic osseous projectile-point assemblages? Did these morphologies change over time? Is morphological variation tied to raw-material selection? Are certain morphologies more likely to have served in specific functions (i.e., as hand-thrust spear points vs. tips of spear-thrower darts vs. alternate, non-weapon functions)? Is assemblage variability tied to site function? Are cultural application spaces recognizable through osseous assemblages? The comparative use-wear and use-damage approach provides an avenue for (1) identifying patterns in the raw-material selection and manufacturing techniques of osseous tools; (2) systematically documenting morphological variability in osseous points from Siberia and Beringia through time; and (3) inferring the functions of organic artifacts.

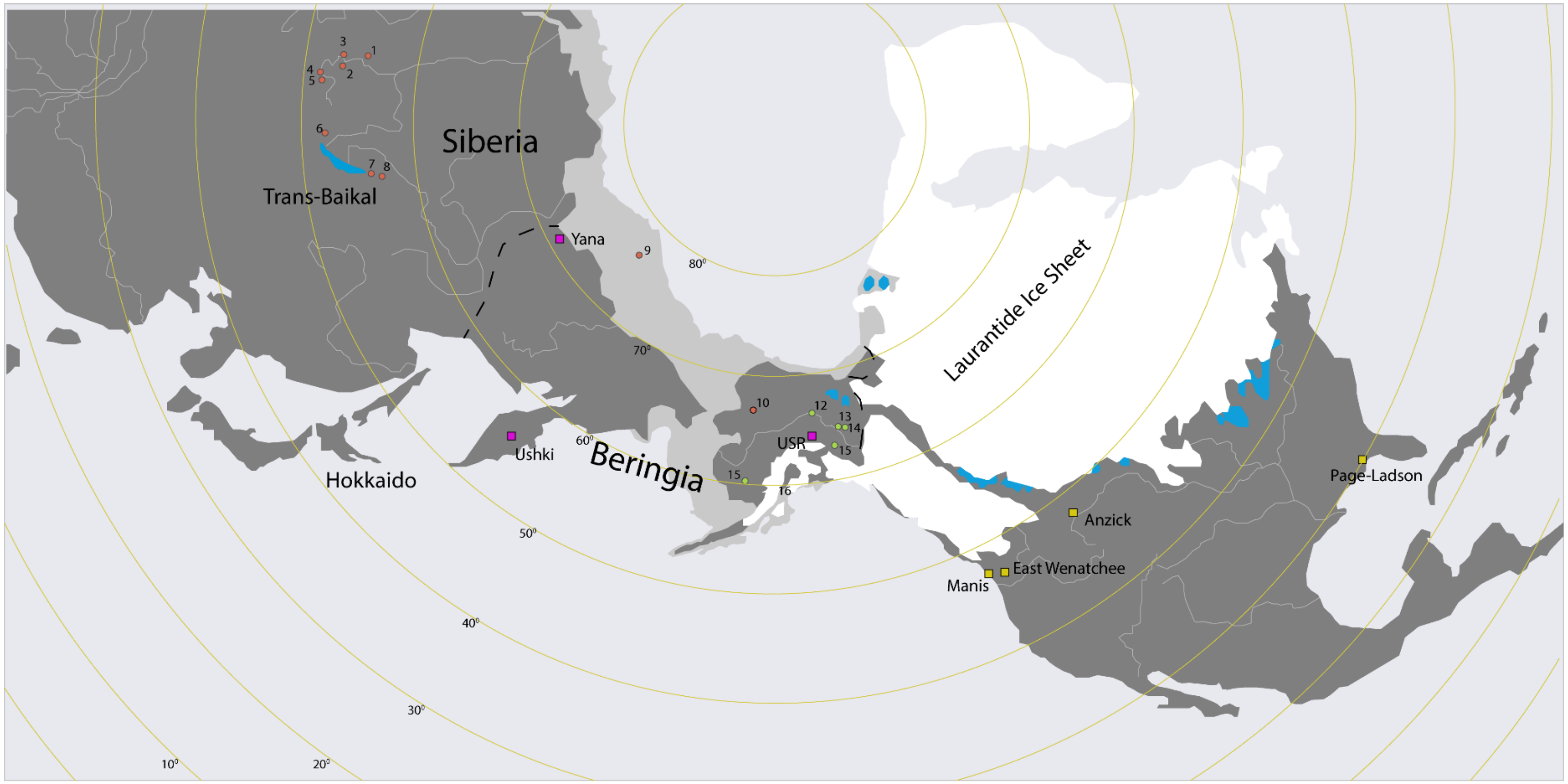

Figure 4.1 Middle Upper Paleolithic, late Upper Paleolithic, and Mesolithic Siberian and Beringian sites mentioned in text (red circles: 1, Afontova Gora-II; 2, Novoselovo-13; 3, Kokorevo group (Kokorevo-I and Kokorevo-II); 4, Maina; 5, Ui-II; 6, Mal'ta; 7, Kurla III; 8, Bol'shoi Iakor; 9, Zhokov; 10, Trail Creek Cave 2); Beringian sites mentioned in text (purple squares); Paleoarctic sites mentioned in text (green circles: 12, Fairbanks Muck Deposits; 13, Swan Point; 14, Broken Mammoth; 15, Ilnuk; 16, Gerstle River Quarry); Paleoindian sites mentioned in text (gold squares).

4.2 Background

Across the Siberian Arctic and Subarctic, late-Pleistocene populations utilized a combination of lithic, osseous, and composite point technologies from the early Upper Paleolithic (beginning ~45,000 cal BP) through the Mesolithic (ending ~9000 cal BP) (Dixon 2011; Goebel 1999, 2004; Gómez Coutouly and Ponkratova 2016; Pitul'ko et al. 2016; Zenin et al. 2006).

During the early Upper Paleolithic (EUP), ~50,000 to 33,000 cal BP, the original modern-human dispersal into Siberia occurred, from the Ob' River to the Transbaikal and north into the Lena River basin (Goebel 1999, 2004; Graf 2013). EUP foragers armed projectiles with unifacial stone points produced on elongated blades and they also manufactured points from antler and used bone and ivory for making retouchers and sewing implements (Goebel 1993, 2004). This tradition of using both stone and osseous materials to produce projectiles appears to have continued through the middle Upper Paleolithic (MUP), 34-24,000 cal BP, leading up to the last glacial maximum (e.g., Goebel 1999; Graf 2009, 2010). Composite points (i.e., slotted osseous points with microblade insets) were added to forager toolkits by the onset of the late Upper Paleolithic (LUP), from about 21,000 to 13,000 cal BP (Goebel 2002, 2004; Graf 2009, 2010; Pitul'ko et al. 2016, 2017) and possibly earlier (Kuzmin 2008). Lithic bifacial points are identified rarely in the MUP and also occur in the LUP, especially in eastern Siberia among Diuktai and Ustinovka assemblages, as well as sites in the upper Yenisei valley (Akimova et al. 2003; Dikov 1979; Larichev and Kholushkin 1992; Mochanov 1977; Pratt et al. 2020). Use of such variable projectile technologies continued into the

Holocene, especially in the far north at Mesolithic sites such as Zhokhov, Uptar, and Tytyl'vaam (Goebel and Slobodin 1999; King and Slobodin 1996; Pitulko 2011; Slobodin 1999). In eastern Beringia, the late-glacial Swan Point assemblage (14,200 cal BP) contains ungrooved preforms of osseous points and microblades, while sites that date more firmly to the Allerød interstadial (~14,000-13,000 cal BP) seemingly contain only ungrooved osseous points and/or bifacial lithic points (e.g., Broken Mammoth CZ4, Mead CZ4; Dry Creek C1, Moose Creek C1, Owl Ridge C1, Walker Road C1) (Graf and Bigelow 2011; Gore and Graf 2018; Graf and Buvit 2017; Holmes 1996, 2011; Holmes et al. 1996; Pearson 1999; Potter et al. 2017; Wygal et al. 2018). During the Younger Dryas and subsequent early Holocene, slotted osseous projectile forms occur in Alaskan assemblages, for example at Trail Creek Cave 2, Lime Hills Cave, and Ilnuk (Ackerman 1996; Graf and Bigelow 2011; Larsen 1968; Lee and Goebel 2016; Potter et al. 2014).

Organic hunting toolkits throughout the Paleolithic and Mesolithic were produced on bone, antler, horn, and ivory. Each of these raw materials represents a durable and widely available resource on a northern late-Pleistocene landscape where access to lithic raw material and wood at times may have been extremely limited (Goebel 2002; Nikolskiy and Pitulko 2013). The mammoth steppe was relatively treeless, limiting access to wood, and snow and ice would have made it difficult to penetrate into the ground surface to collect lithic raw materials for much of the year (Goebel 2002; Guthrie 2001). Thus paleontological 'cemeteries' and large natural accumulations of faunal material like those documented at Berelekh and Yana, as well as the active harvest of large steppe-adapted mammals including rhinoceros, red deer, and mammoth would have provided important raw-material byproducts necessary in the production of full toolkits (Pitulko 2011; Pitulko et al. 2014). While all osseous raw materials are composites of more brittle mineral elements (calcium hydroxyapatite crystal) and fibrous protein (collagen), the character of antler, bone, horn, and ivory depends on specific ratios of mineral content to collagen as well as structural features including osteon size and number, cement lines, and the presence of haversian canals (Guthrie 1983; Katz 1980). Thus, among users of bone, ivory, and antler for the manufacture of tools, there were variable qualities leading to their selection for use in different tasks, as documented for lithic materials (e.g., Beck and Jones 1990). Each organic raw material may also require specialized sequences of treatment in the early stages of point production. For example, antler blanks become significantly more pliable when soaked or boiled, a step in the manufacturing process that can be necessary for obtaining long, straight cortical beam segments. Bone is less reactive to soaking or boiling, but straight, usable lengths can be procured through wedging and splitting of long bones. Understanding these qualities is an important first step for distinguishing the evolution of osseous tool use among Upper Paleolithic humans.

4.2.1 Osseous Toolkits of the MUP in Siberia and Beringia

Across western Eurasia, Upper Paleolithic sites dating between ~34,000-24,000 cal BP and containing elaborate burials, Venus figurines, and small bladelet and organic tools are referred to as Gravettian (Dobrovolskaya et al. 2012; Hoffecker 2002; Roebroeks et al. 2000; Svoboda 2007); however, in Siberia, this phase is designated the middle Upper Paleolithic (Derevianko 1998; Goebel 1999; Graf 2013; Vasil’ev 1992, 2000). MUP sites are distributed in a west-to-east ‘belt’ across southern Siberia, and several sites, for example Ust’-Kova and Alekseevsk, suggest a northward expansion beyond the range of humans during the EUP, with the Yana site, situated 1200 km to the north along the lower Yana River at 71° N (Goebel 2004; Pitulko et al. 2004; Pitulko et al. 2014), being another possible example of this phenomenon. Many MUP sites, including Mal’ta and Ui-I, produced dates suggesting occupation during the marine-isotope-stage (MIS)-3 and MIS-2 transition, a time of increased cooling associated with the onset of the last glacial maximum (Goebel et al. 2000; Graf 2013; Medvedev et al. 1996). Patterns of land use, site distribution, and site structure suggest that MUP foragers were logistically mobile, possibly revisiting large residential bases like Buret’, Mal’ta, and Yana seasonally while extracting site-specific faunal resources at associated spike camps (Graf 2013).

MUP lithic toolkits are characterized by parallel and subprismatic core and blade technologies, as well as core and flake technologies (Goebel and Buvit 2011; Graf 2010, 2014; Larichev et al. 1988; Larichev et al. 1992). Blade cores range from flat-faced to sub-prismatic in shape and vary in size, depending on original package size and degree of reduction (Graf 2010). MUP core-and-blade production is generally considered distinct from microblade production observed later in the LUP (Graf 2010, 2013; Vasil’ev 2003). The use of osseous technology is ubiquitous in MUP sites. Residential sites Malt’a, Buret’, and Yana demonstrate production of utilitarian and non-utilitarian organic artifacts including variable points and ‘rods’ manufactured on antler, bone, horn, and ivory, as well as personal adornments and mobiliary art; while task-specific sites such as Ui-I, Novoselovo-13, and Kashtanka-I yielded less diverse organic assemblages presumably more directly related to the site-specific exploitation of targeted faunal resources (Graf 2013; Hoffecker and Elias 2007; Pitulko et al. 2012, 2014). Projectile-point assemblages are dominated by organic points with morphologies generally guided by raw material of manufacture. For example, mammoth-ivory and mammoth-bone points are generally larger than those produced on cervid bone or antler (Pitulko et al. 2014). Most significantly, the production of organic-weapon-system components including projectile points, foreshafts, and full-length 'darts' and spears on mammoth ivory is a prominent development from more generic bone-tool manufacturing documented in MUP assemblages (Pitulko et al. 2015). On a steppe-tundra landscape largely devoid of wood suitable for weapon-system construction, ivory provided a suitable substitute, especially in MUP sites in arctic Siberia (Pitulko et al. 2015). The mammoth assemblage from Yana contains bones with embedded mammoth-ivory weapon fragments as well as the tip of a stone point with associated fragments of an ivory hafting element embedded in a mammoth scapula (Pitulko et al. 2013). In other treeless landscapes of the far north, ethnographic examples of full-sized throwing spears manufactured entirely from narwhal ivory have been documented (Malaurie 1989). Thus, some archaeologists suggest that full-length spears produced from mammoth ivory such as those recovered at Yana and Sungir' near Moscow in European Russia may represent hunting equipment manufactured for everyday use rather than as "ritual" items (Pitulko et al. 2013). Similar full-length spears, as well as point preforms and mammoth tusk-ivory core technologies, have been identified in several Yana-Indigirka lowland site assemblages dating to the second half of MIS 3 (Nikolskiy and Pitulko 2013). In southern Siberia, where trees were more common, wood likely would have been used in the production of full-length spears designed to be deployed without additional stone or bone points, as experimental testing suggests that such ‘simple’ points could be nearly as effective as their stone-tipped counter parts (Waguespack et al. 2009).

4.2.2 Osseous Toolkits of the LUP in Siberia and Beringia

Signaling a re-occupation of Siberia and Beringia following the last glacial maximum, hundreds of LUP sites are documented across Siberia from the Ob’ River to the Pacific Ocean, including in previously uninhabited regions of Siberia, the Russian Far East, and western Beringia east of the Yana River (Goebel 1999; Graf 2013; Hoffecker and Elias 2007). Dates of 22,200-20,500 cal BP at Studenoe-2 indicate early occupations of the Transbaikal soon after the LGM (Buvit and Terry 2011; Graf 2013). Most well-dated LUP sites in good geologic context postdate these earliest sites. By 20,000-19,000 cal BP LUP settlement reached beyond 56° N, and LUP humans clearly occupied the Aldan River valley by 16,000 cal BP (Graf 2010, 2014). Spikes in dated occupations suggest increases in population density during climatic warm intervals, and reductions in site frequencies indicate population dips during the intervening cold periods (Goebel 2002; Graf 2009). Faunal data from LUP sites indicate an economic system organized around the procurement of site-specific large-game taxa. This combined with a lack of substantial dwellings suggests a high level of mobility among LUP forager populations (Goebel 2002; Graf 2013). Assemblage data from LUP sites in the Yenisei further demonstrate the provisioning of individuals moving frequently between residential bases (Graf 2009, 2010).

LUP lithic assemblages are characterized by flake-based, microblade-based, and blade-based technologies. LUP lithic toolkits include side scrapers, end scrapers, retouched flakes and blades, gravers, burins, and bifaces, some obviously representing knives and others potentially projectiles (Abramova et al. 1991; Lisitsyn 2000; Terry et al. 2009). Osseous tool kits in LUP assemblages include bone, antler, and ivory projectile points, as well as awls, needles, and other utilitarian tools such as shaft straighteners and billets (Abramova 1979a, 1979b; Abramova et al. 1991; Derev'anko 1998). While unmodified 'simple' osseous projectile points continue to appear in LUP assemblages, for example at Berelekh (Mochanov 1977; Pitulko 2011), composite slotted projectile points emerge at this time and are considered a hallmark technology of the microblade-equipped LUP foragers who expanded into the High Arctic and Beringia during the late glacial. Composite projectile points in the LUP are slotted along their lateral margins, with the grooves likely being cut with associated lithic burins or gravers (Graf 2013; Guthrie 1983; this paper). These slots were created for the insertion of microblade midsegments, combining the plasticity and durability of organic points with a sharp lithic cutting edge, resulting in efficient and lethal composite projectile points (Elston and Brantingham 2002; Goebel and Buvit 2011). Composite points from Chernoozer'e and Listvenka, in southern Siberia, and Bol'shoi Iakor in the Baikal area were recovered with inset microblades in place (Akimova et al. 2005; Gening and Petrin 1985), and at Lugovskoe and Kokorevo-I microblades or composite-point fragments have been found embedded in mammoth and bison bones (Abramova 1979b; Zenin et al.

2006). These truly were effective hunting weapons.

4.2.3 Osseous Toolkits of Northern Siberia and Beringia in the Mesolithic

Widespread human occupation of western and eastern Beringia began during the late-glacial Allerød interstadial (15,000-13,000 cal BP) (Goebel and Buvit 2011). Sites in the Tanana basin of central Alaska represent the earliest firmly dated occupations of eastern Beringia during this interval, while the sites of Urez-22, Nikita Lake, and Berelekh in northwestern Beringia likely date to this interval as well (Pitulko et al. 2014). Major climatic and ecological shifts occur across Beringia during this time (Hoffecker and Elias 2007; Meiri et al. 2014). Rising summer and winter temperatures and increased moisture led to the expansion of the more mesic Birch Zone flora, with dwarf birch *(Betula nana*) and willow (*Salix* spp.), and the reduction of steppe-tundra plant communities that supported the large-mammal fauna of the LGM (Guthrie 2003, 2006). Late-glacial archaeological sites in Beringia dating to before ~13,000 cal BP have yielded relatively small lithic and faunal assemblages and lack clear dwelling structures or prepared hearth features (Potter 2011; West 1996). Lithic assemblages of the earliest late-glacial (e.g., Urez-22 and Swan Point CZ4) are characterized as similar to those documented at Diuktai Cave in the Aldan basin and include wedge-shaped microblade cores and microblades produced using the Yubetsu technique, transverse and dihedral burins, and bifacial knives (Goebel and Potter 2016; Mochanov 1977), while later sites between 14,000 and 13,000 cal BP lack microblades and instead contain small teardrop- and triangular-shaped bifacial-stone points (Goebel et al. 1991). Economies in the late-glacial take on a distinctly post-glacial character with procurement of a variety of resources such as wapiti, caribou, sheep, fish, and migratory waterfowl (e.g., Goebel and Potter 2016; Yesner 2007). Osseous tool kits of the eastern Beringian Allerød interstadial are limited to a few examples of wapiti and caribou antler, mammoth ivory, and bone tools (Holmes 1996, 2001; Potter 2011; Potter et al. 2014; Yesner 2001). Osseous tool kits are poorly preserved but include ungrooved and grooved projectile-point preforms made on bone and ivory. The use of ivory is largely confined to scavenged tusk fragments (Holmes 1996; Wygal 2018), though mammoth remained on the landscape at low population densities (Guthrie 2006). Two ivory points have been identified at the Broken Mammoth site (CZ4), an ivory point tip is reported from the oldest cultural occupation of the Mead site and worked ivory tusk fragments have been recovered from the Swan Point and Holzman sites (Lanoë and Holmes 2016; Wygal 2018). Later sites dating to the Younger Dryas (~12,800-11,700 cal BP) with preserved osseous tools, such as Broken Mammoth CZ3, contain only ungrooved osseous point forms, while other sites (e.g., Dry Creek C2, Owl Ridge C2, Moose Creek C2, and Phipps) contain bifacial lithic points and lithic microblades, but not preserved osseous points (Graf and Bigelow 2011; Gore and Graf 2018; Holmes 1996, 2011; Holmes et al. 1996; Potter et al. 2017).

By ~12,000 cal BP, rising sea levels had inundated lowland areas of central Beringia (Elias et al. 1997). Increased available moisture over what was left of the landmass accelerated the transition from steppe-tundra to more mesic tundra and coniferous forest (Bigelow and Powers 2001; Hoffecker and Elias 2007). Detachment of eastern and western Beringia, along with increased population density in the Siberian and Alaskan subarctic forest and along ameliorated coastlines, led to increased regionalization and divergent technological traditions, in both former western Beringia (northeast Siberia) and eastern Beringia (Alaska).

The early-Holocene spread of the boreal forest regime in northeastern Siberia is associated with the emergence and spread of the Sumnagin culture ~12,000 cal BP (Mochanov 1989). Sumnagin site assemblages are notably smaller and less diverse than the boreal-associated Kunda sites of European Russia, possibly the result of preservation bias and the lack of spectacular bog finds in the Siberian record (Hoffecker 2005). Sumnagin lithic assemblages are dominated by tools produced on small blades detached from thin, cylindrical *karandashevid'nii* (pencil-shaped) cores (Hoffecker 2005). Lithic projectile points made on these points are typically unifacially worked but have bifacial stems (Goebel and Slobodin 1999; Mochanov 1977). Associated economies in Siberia were primarily focused on the procurement of large mammals, predominantly moose but also roe deer, reindeer, and brown bear (Hoffecker 2005; Mochanov 1989). Despite the location of many Sumnagin sites along river margins, faunal evidence supporting the exploitation of fish and waterfowl is rare (Mochanov 1989). By ~10,000 cal BP Sumnagin occupations are found across the Siberian Arctic. Zhokhov Island at 76° N was occupied by 9500-9000 cal BP, and the assemblage recovered at the Zhokhov site is remarkably similar to the Sumnagin lithic tool kit, with the notable proliferation of well-preserved non-lithic artifacts (Pitulko et al. 2013). Osseous artifacts recovered in the Zhokhov excavations include slotted and unslotted points on antler and ivory, as well as antler and ivory mattocks, and a bone handle for hafting cutting tools (Pitulko et al.

2013; Pitulko et al. 2015). A few wooden artifacts (made from seaborne drift wood) were recovered from this excavation as well, including a large shovel or scoop, sledge-runner fragments, and, most significantly to this study, arrow shafts indicating the use of a novel weapon system in the early Holocene (Pitulko et al. 2015). Interestingly, foragers at Zhokhov primarily exploited terrestrial resources including polar bear and reindeer (Pitulko et al. 2015), an indication of a terrestrial hunting economy that would not refocus on rich arctic-coastal resources until later in the Holocene (Hoffecker 2005).

Continued amelioration following the Holocene Thermal Maximum (~11,000 cal BP) resulted in the spread of boreal forests to modern ranges across the region (Graf and Bigelow 2011). Early Holocene foragers in northwestern and interior Alaska continued to produce a remarkably stable lithic tool kit. Denali-complex (or Paleoarctic-tradition) assemblages date between ~12,500-7500 cal BP and are characterized by the production of wedge-shaped microblade cores (typically manufactured using the Campus technique), burins, bifacial knives, and lanceolate bifacial projectile points (Goebel 2011; Hoffecker 2005; Potter and Goebel 2016; West 1996). Denali foragers employed a broad economic strategy procuring seasonally available resources including bison, wapiti, caribou, sheep, and moose as well as small game, fish, and waterfowl (Holmes 2011; Yesner 2001, 2007). Settlement strategies were highly mobile with expanded use of upland areas in central Alaska (Blong 2018). Few examples of Denali-aged non-lithic technology have been identified. Four antler rods were recently recovered as grave goods associated with the burial of two infants at the Upward Sun River site dated to ~11,500 cal BP (Potter et al. 2014). These rods were produced on wapiti antler and bibeveled on the same axis, and three of the four rods are decorated with cross-hatched scoring on one face of the rods (Potter et al. 2014). Proximity and position of these rods in relation to recovered Denali-complex lanceolate bifaces suggest that these organic tools served as foreshafts designed to be integrated into darts as part of an atlatl weapon system (Potter et al. 2014). The largest assemblage of Denali-aged organic projectile points was recovered from the Trail Creek Cave 2 site on the Seward Peninsula in northwestern Alaska (Larson 1968; Lee and Goebel 2016). Seven bi-slotted antler points with beveled bases were recovered from excavations there, and they have been directly dated, producing three concordant radiocarbon ages with a range of 11,350 to 11,260 cal BP. A fourth point dated to about 10,335 cal BP suggesting that the site area was occupied in multiple events and that bi-slotted projectile-point technology persisted through the earliest Holocene in northwest Alaska. Two ungrooved organic points manufactured from large-mammal metapodials were identified from the frozen loess deposits at Goldstream Pit 1-G with little specific context but were directly dated to ~9500 cal BP. Two antler artifact fragments were recovered at the Lime Hills Cave 1 site in the Kuskokwim valley of interior southwest Alaska, one triangular antler point or knife base with heavy scoring on its face and edges, as well as a basal fragment of a side-slotted ‘arrowhead’ produced on antler or bone (Ackerman 1996, 2011). A small (< 2 cm) isolated midsegment of a slotted point was also recovered at the nearby Ilnuk site associated with a lithic toolkit characterized as Denali, though this component lacks a radiocarbon age (Hoffecker and Elias 2007; West 1996). An unslotted mammoth-ivory artifact, interpreted as a point or rod, with a near circular cross section approximately 25 cm long 1 cm in cross section with flattening near the base was recovered in excavations at the Gerstle River Quarry site. It was associated with a hearth feature dating to 8860 ± 70 (Potter 2005). As noted above for Upward Sun River, these osseous artifacts are repeatedly associated with Denali/Paleoarctic lithic industries, often including lanceolate bifacial points.

Numerous organic projectile points have been recovered from later Holocene contexts in eastern Beringia. Ice-patch surveys in southeast Alaska and southwest Yukon have identified dozens of organic projectile points and weapon-system components dating from approximately 9000 cal BP to historic times, among other things suggesting a regional replacement of atlatl weapon systems by bows and arrows around 1200 cal BP (Hare et al. 2004; Hare et al. 2012). Additionally, Arctic Small Tool tradition site assemblages from northwest Alaska dating to the mid-Holocene (approximately 4500 cal BP to 2700 cal BP) contain variable toggling and non-toggling organic harpoons specialized for the harvest of marine mammals (Tremayne and Brown 2017). These assemblages are largely associated with the middle to late Holocene and therefore not included in this project analysis.

4.3 Materials and Methods

For this project, I viewed and analyzed 163 MUP, LUP, and Mesolithic projectile points and organic tools. For the MUP, these included organic artifacts from the Mal’ta (n = 11) and Novoselovo-13 (3) sites. For the LUP, these included organic artifacts from Afontova Gora-2 (11), Bol’shoi Iakor (5), Kokorevo-I (22), Kokorevo-II (40), Kurla-III (15), Maina (34), and Ui-II (5). For the early-Holocene Beringian sites, I examined artifacts from Zhokhov (10) and Trail Creek Cave 2 (7). This required travel to the archaeological laboratories at the Russian Academy of Sciences, St. Petersburgh, Kunstkamera, and Hermitage in St. Petersburg, Irkutsk State University in Irkutsk, Chita Pedagogical Institute in Chita, and the National Museum of Denmark in Copenhagen. These assemblages were selected based on their availability for analysis in the fall of 2019. Organic assemblages from Siberian sites Kantegir I, Golubaia I, Studenoe, Chernoozere II, Ui-I, Afontova Gora 3, Denisova Peshchera, Malaia Syia were not available for analysis, and the organic artifact assemblages from the Alaskan sites Swan Point and Broken Mammoth were unavailable to the author as they were part of other active research projects or being transferred to new curation facilities, respectively. However, the author was also able to view many artifacts from the Yana sites with V. Pitul'ko.

A combination of macroscopic and microscopic analytical approaches was used to document production techniques, morphological variability, variability in hafting techniques and basal designs, and functions of MUP, LUP, and Mesolithic osseous and composite projectile points. Following Villa and D'Errico (2001), Knecht (1993), Olsen (1984), Campana (1989), and Petillon et al. (2016), all osseous artifacts were examined to determine their raw material of manufacture and deliberate manufacture by humans. Macroscopic morphologies of all point margins and faces were examined for evidence of percussion, abrasion, and other expressions of manufacturing or damage during use. Low-power microscopy was used to determine differences in manufacturing technique and anthropogenic damage along functional working edges and tool faces, following

Villa and D’Errico (2001) and Lyman (1994). Striations, grooves, tool marks, and marginal flaking attributes were fully documented. Certain fracture patterns derived from analysis of stone and organic projectiles, bolstered by experimental testing conducted by the author, are considered diagnostic of impact (Fisher et al. 1984; Ho Ho Committee 1979; Lynch n.d.). The most recognizable fractures related to impact are step-terminating bending fractures. These result from longitudinal pressure from the distal and proximal ends of the objects and bending fractures that result from pressure perpendicular to the dorsal and ventral sides of the objects result in small spin-off fractures on only one broad side. Spin-off fractures can have considerable dimensions, and long spin-off fractures can occur on one, or even both, sides of a projectile point (Fisher et al. 1984). Additionally, impact burination is considered a diagnostic signal of impact. Sometimes difficult to distinguish from intentional burination, impact burinations usually lack the negative bulb of percussion at the burin initiation or the Hertzian features associated with intentional removals (Fisher et al. 1984; Lomard et al. 2004). Lastly, crushing, although not diagnostic by itself, may also occur on the tip or proximal base of an organic tool used during hunting (Lynch n.d.; Petillon et al. 2011). Crushing was identified by multiple, small, uneven overlapping step-like fractures, visible as tiny chips and removals along the proximal and distal ends of points (Fisher et al. 1984). Low-power (10x-220x) use-wear analysis and raw-material determinations were conducted using an AM7915MZT Dino-Lite Edge microscope. Digital calipers, a goniometer, and digital scales were used to collect metric data, including longitudinal length, width at most proximal end (base), width at midpoint, width at most distal end, thickness at most proximal end, thickness at midpoint, thickness at most distal end (tip), weight, number of slots/grooves, length of slot(s)/groove(s), depth of slots/grooves, and width of slots/grooves. In the rare occurrence that microblades remained inset in an osseous point, these microblades were examined for use wear and edge damage, standard metric measurements were taken (including number of microblades in place, lengths of microblades, and widths and thicknesses of exposed portions of microblades. All artifacts analyzed were photographed using a Nikon D3400 digital camera.

When combined, low-power microscopic and macroscopic analyses are the most cost- and time-effective techniques for documenting dominant tool motion or activity (Odell 2004). High-power magnification was not used, because such microscopes are not easily transported and they are more suited to determining polish and striations potentially identifying materials that tools were used against (Odell 2004), not a focus of this project. Together the morphometric and use-wear analyses were designed to identify formal variations and discontinuities in point assemblages, as well as to establish ranges of morphological variability.

4.4 Results

The following section details results of both MUP and LUP osseous assemblages by site, beginning chronologically with the MUP.

4.4.1 MUP Osseous Assemblages

Figure 4.2. Morphological variability in the Mal'ta organic assemblage: (a-b) rods; (c) triangular bone point distal fragment; (d-e) ungrooved ivory point fragments; (f) rhinoceros horn 'dagger'.

4.4.1.1 Mal'ta

Eleven organic points and tools from Mal'ta were available for analysis, all from M. M. Gerasimov's early excavations (Gerasimov 1964) (Figure 4.2a-f; Tables 4.1-4.2). Six of the points in the assemblage were produced on ivory, one distal fragment was produced on intermediate raw material (either ivory/antler), one midsegment was produced on bone, two point fragments were produced on indeterminate raw material (either antler or bone), and one large ‘dagger’ was produced on rhinoceros horn (*Coelodonta antiquitatis*).

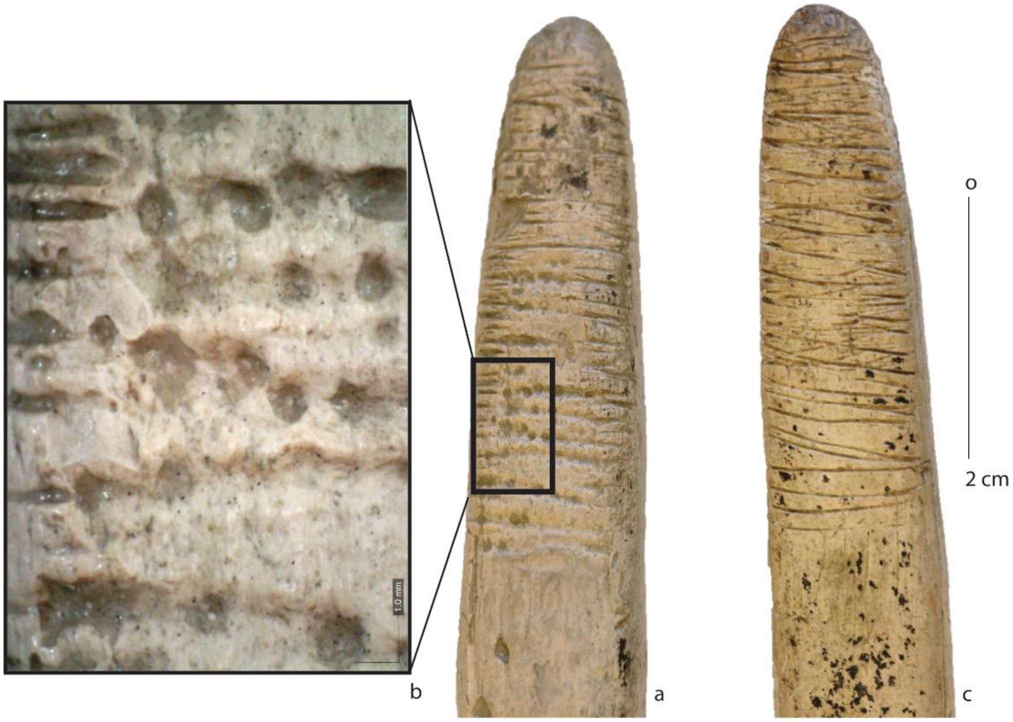

Figure 4.3 MUP Mal’ta rod decoration: (a) rod 370/669/135 with parallel and crossing incisions with circular pocking on the rounded base; (b) rod 370/669/135 decorations at 30x magnification; (c) rod 370/670/136 with parallel and crossing incisions on rounded base.

The two rods were complete or nearly complete (370/669/135, 370/669/134), four of the artifacts were midsegments of points (370/670/136, 370/663/138 (811-7-138), 370/656/433, 1573-5), and four artifacts were distal fragments of points (9-3-137, 1573-

Table 4.1. Mal’ta Osseous Artifact Morphometrics.

Artifact Number	Point Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
370/669/135	distal	219.48	16.12	18.99	12.21	13.32	ivory	yes	no
370/669/134	distal	242.89	12.48	17.66	9.33	12.45	ivory	yes	no
370/670/136	midsegment	174.44	11.72	16.04	14.39	10.43	Ivory	yes	no
370/666	complete	297.43	19.81	17.72	6.51	12.96	horn	yes	no
370/663/138 (811-7-138)	midsegment	155.02	5.96	6.27	2.84	5.32	bone	yes	no
9-3-137	distal	107.12	6.96	6.34	3.9	5.85	ivory	yes	no
370/656/433	midsegment	48.18	5.61	6.52	5.51	4.11	ivory	yes	no
1573-1	distal	80.65	6.51	5.78	3	2.6	ivory?/antler?	yes	no
1573-3	distal	105.06	6.95	13.04	6.76	5.18	ivory	yes	no
1573-4	distal	86.89	11.94	13.13	5.84	5.37	antler?/bone?	yes	no
1573-5	midsegment	73.58	12.83	11.34	8.43	8.55	ivory	yes	no

Table 4.2 Mal’ta Osseous Point Modifications

Artifact Number	Number Grooves	Indication of Use	Comments
370/669/135	0	yes	long, stepped flake removal along one face originating from removed proximal end; scoring on distal end on both faces of point; rounded base; pocking superimposed on the proximal scoring
370/669/134	0	yes	proximal tip removed in a snap; scored along distal end; refit from 3 pieces
370/670/136	0	yes	step-fracture removals from distal end of point; heavy of scoring along longitudinal axis through distal break; scoring on proximal end
370/666		yes	heavily degraded; rhino horn dagger
370/663/138 (811-7-138)	0	yes	cylindrical point; distal end broken-not likely related to impact; no trace of beveling or tapering up to distal break
9-3-137	0	yes	thin narrow distal end of point; scored in straight line and cross hatched
370/656/433	0	yes	small midsegment; refit from 3 pieces; no scoring, beveling, or grooving

(Continued)

Table 4.2. Continued

Artifact Number	Number Grooves	Comments
1573-1	0	cylindrical point fragment; no scoring or beveling; rounded proximal tip
1573-3	0	tapered distal fragment
1573-4	0	tapered distal end of antler/bone point
1573-5	0	wide, rounded midsegment; one long axis of point abraded then incised with parallel scoring; heavy and dark staining

1, 1573-3, 1573-4). Artifact 370/663/138 is a midsegment fragment of a cylindrical point, circular in cross section, with no trace of beveling or tapering toward the break and no additional decoration (Figure 4.2b). Artifact 370/669/135 is a rod beveled on the proximal end with a long, stepped flake removal along one face. The distal end of the rod is scored on both faces with a series of shallow, parallel and cross-hatched overlapping v-shaped grooves (Figure 4.3a). Round pocking is superimposed over the distal scoring (Figure 4.3b-c). Artifact 1573-5 is a long, wide midsegment of an ivory point snapped down the center axis, exposing the interior dentine of the mammoth tusk. One of its lateral margins has been abraded to create a flat plane, which is scored by a series of small, shallow, v-shaped incisions running perpendicular to the long axis of the point. Artifact 370/669/134 is refit from three pieces and scored fully around the beveled proximal end of the of point (Figure 4.3b) with the distal tip removed in a step fracture. Artifact 370/666 is an exceptional osseous point produced on rhinoceros horn with no beveling or tapering present, though detailed microscopic analysis was inhibited by the refitting and preservation methodology applied to the point (Figure 4.2f). Viewed in cross-section, the horn consists of a series of sheets of keratin, concentric on the longitudinal axis, which are relatively weakly joined together, a function of the incremental growth of a cone-like shape and the ring-like plates (Sims and Yates 2010). Horn forms a tapering cone of solid keratin with a “shallow well” at the base, which covers a bony knob on the skull (Jha et al. 2015). Artifacts 370/663/138 (811-7-138) and 1573-1 are both narrow, thin, rounded point fragments. Importantly, no points or point fragments in this assemblage displayed use wear associated with impact damage.

4.4.1.2 Novoselovo-13

Three projectile-point fragments from Novoselovo-13 Layer 3 were available for analysis (Figure 4.4a-c; Tables 4.3-4.4). All were derived from the excavations reported by Lisitsyn (1986). This assemblage consists of one midsegment produced on bone, one proximal fragment produced from either antler or bone, and one distal fragment produced on bone. The midsegment (K-84) represents a relatively long example of a bone-point midsegment with preserved wear indicative of abrasion as a manufacturing

Figure 4.4 Morphological variability in the Novoselovo-13 organic assemblage: (a) lenticular bone point midsegment; (b) unbeveled point base produced on intermediate osseous raw material; (c) cylindrical distal tip of a bone point.

Table 4.3 Novoselovo-13 Osseous Artifact Morphometrics.

Artifact Number	Point/ Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
K-84	midsegment	153.77	14.69	18.28	16.13	6.62	bone	yes	no
H-13XX	proximal	87.32	10.44	16.35	12.42	6.2	antler/bone?	yes	no
H13-1695	distal	30.99	3.74	3.64	1.9	3.59	bone	yes	no

Table 4.4. Novoselovo-13 Osseous Point Morphology and Modifications.

Artifact Number	Number Grooves	Comments
K-84	0	long midsegment abraded to uniform thickness
H-13XX	0	tapered; unbeveled proximal point
H13-1695	0	Cylindrical and pointed distal end of tool

technique to produce a uniform thickness (Figure 4.4a). The proximal fragment, H-13XX, tapers to a triangular tip with no evidence of beveling (Figure 4.4b). Artifact H13-1695 is a distal fragment of a cylindrical bone point with a circular cross-section that narrows to a sharp point (Figure 4.4c). There are no signs of impact damage on any of these point fragments.

4.4.2 LUP Osseous Assemblages

4.4.2.1 Afontova Gora-II

Eighteen organic points and point fragments from the Aftontova Gora-II assemblage were available for analysis (Figure 4.5a-j; Tables 4.5-4.6) (Abramova et al. 1991; Astakhov 1999). This assemblage was composed of four proximal fragments, three produced on antler and one produced on an indeterminant raw material (either bone or antler), seven distal fragments (five produced on antler and two produced on an indeterminant raw material, either bone or antler), two midsegments (one produced on antler and one produced on bone), and five complete or nearly complete points (four of which were produced on antler and one on an indeterminant raw material either bone/antler). Complete points 141-640, 141-118, 141-639, 1574-83, and 1574-70 averaged 152.55 mm in length, 11.96 mm in width at the midpoint, and 7.82 mm in thickness. Four points, 1574-95, 1574-83, 1574-73, and 1574-78, displayed crushing and step-fracture flake removals, possible indications of impact-related breakage. Eight points from this assemblage are grooved along one lateral

Figure 4.5 Morphological variability in the Afontova Gora-2 osseous assemblage: (a) single-grooved, lenticular point; (b) ungrooved foreshaft fragment; (c) ungrooved lozenge-shaped point; (d) point with single-grooved preform; (e-f) cylindrical points; (g) ungrooved point fragment with step fractures at proximal and distal; (h) bi-grooved point; (i) refit cylindrical distal fragment; (j) ungrooved point with parallel scoring along long axis.

Table 4.5 Afontova Gora-II Osseous Artifact Morphometrics.

Artifact Number	Point/ Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
1574-70	complete	175.14	7.6	10.41	4.1	6.43	antler/bone	yes	no
1574-72	distal	156.84	12.16	14.78	5.91	8.36	antler/bone	yes	no
1574-82	midsegment	102.11	3.97	6.45	4.27	6.7	antler/bone	yes	no
1574-80	distal	74.95	8.81	8.44	2.94	4.97	antler	yes	no
1574-78	distal	94.38	7.28	7.36	3.1	5.52	antler	yes	possible
514-77	proximal	111.22	4.74	6.93	4.63	5.4	antler	yes	no
1574-76	proximal	109.74	12.91	12.82	7.83	7.56	bone/antler	yes	no
1574-73	distal	125.74	9.67	8	4.02	5.24	antler	yes	possible
1574-85	distal	116.72	12.71	11.36	3.67	6.49	antler/bone	yes	no
1574-83	complete	166.71	4.97	7.47	2.66	7.59	antler	yes	possible
141-639	complete	112.23	13.06	10.88	6.7	7.03	antler	yes	no
141-118	complete	165.27	11.14	12.64	9.17	7.69	antler	yes	no
141-640	complete	143.38	12.66	18.41	8.3	10.35	antler	yes	no
1574-94	midsegment	144.44	19.66	20.12	13.13	12.23	bone	yes	no
1574-95	proximal	177.19	12.71	15.22	14.04	7.69	antler	yes	possible
1574-98	distal	127.04	15.61	17.67	11.13	11.39	antler	yes	no
1574-1073	proximal	124.44	18.24	21.97	22.49	9.54	antler	yes	no
1574-97	distal	116.97	28.77	23.56	11.04	13.77	antler	yes	no

Table 4.6 Afontova Gora-II Osseous Point Groove Morphology and Modification.

Artifact Number	Number Grooves	Length Groove A	Depth Groove A	Width Groove A	Comments
1574-70	1	<1	0.92	28.36	beginning of bevel at proximal end beak; possible groove preform at distal
1574-72	1	1.97	2.27	43.9	distal end crushed after manufacture of groove; proximal end slight taper; wide and deep groove; heavy parallel scoring on alternate margin from groove
1574-82	0				Cylindrical point fragment; refit from 3 pieces
1574-80	0				refit from two fragments
1574-78	1	45.44	1.5	1.42	single groove that extends through distal end of point; possible impact break at base
514-77	1	32.94	1.34	1.35	groove starts well past the midline; proximal end of point rounded and tapered
1574-76	0				tapered but not rounded tip; parallel scoring on both faces of the point but no groove; snap break at distal end

(Continued)

Table 4.6 Continued.

Artifact Number	Number Grooves	Length Groove A	Depth Groove A	Width Groove A	Comments
1574-73	1	69.77	1.78	3	wide deep groove; refit from two pieces; the proximal end crushing might be impact damage
1574-85	0				possibly an awl?
1574-83	0				cylindrical point; rounded base
141-639	1	69.81	0.49	2.19	single groove point; parallel scoring perpendicular groove; beveling 22° at the proximal end of point; distal tip removed possible crushing
141-118	1	40.03	0.96	2.01	proximal end tapered and beveled and abraded; similar abrading and tapering in the distal end with a short groove along one margin
141-640	0				thick point with rounded tapered proximal end; no scoring but the curved edges abraded to a uniform thickness
1574-94	0				narrows towards the distal end; snap breaks

(Continued)

Table 4.6 Continued.

Artifact Number	Number Grooves	Length Groove A	Depth Groove A	Width Groove A	Comments
1574-95	1	17.4	0.95	1.4	small groove that extends into the distal end of the point; some scoring on the exterior of the proximal end of the point
1574-98	0				Abraded to a rounded base
1574-1073	0				tapered and beveled 25°
1574-97	0				

margin, while none are bilaterally grooved. Artifact 1574-73 is grooved along 55% of one lateral margin, with a 3-mm wide and 1.78-mm deep groove (Figure 4.5h). Artifact 141-639 is grooved along 62% of one lateral margin, though the groove is only 2.19 mm wide and 0.49 mm deep and may represent an unfinished groove (Figure 4.5d). Points 141-118 and 1574-95 were grooved for much less of the overall length of one lateral margin (25% and 9%, respectively) (Figure 5a, h). Grooved point 141-639 was scored with a series of parallel lines perpendicular to the single groove (Figure 4.5j). Complete point 1574-83 and fragment 1574-82 both show signs of a distinctive point-manufacturing technique: each was abraded into a cylindrical shape with a rounded base (Figure 4.5i).

4.4.2.2 Bol’shoi Iakor

Five projectile points and point fragments from the Bol’shoi Iakor assemblage were available for analysis (Figure 4.6a-e; Tables 4.7-4.8). Three of the Bol’shoi Iakor points (c7-chIV, c7-ii4(iv), and c7-4IV) were produced on antler, while points ch1-c6 and x23-4IV-c8 were produced on bone. The assemblage is comprised of two proximal fragments (c7-chIV and ch1-c6), one distal fragment (c7-ii4(IV)), one midsegment (c7-4IV), and one complete point (4IV-c8). The proximal antler-point fragment c7-chIV is refit from two fragments and grooved along one lateral margin for the full length of the fragment (Figure 4.6a). Its groove dimensions are 114.72 mm long, 0.64-0.75 mm deep, and 1.31 mm wide. It still bears the base of the point, which is neither tapered nor beveled, and its distal end was removed in a snap fracture possibly related to impact. The proximal fragment ch1-c6 is produced on bone and ungrooved

Figure 4.6 Morphological variability in the Bol'shoi Iakor organic assemblage: (a) single grooved point midsegment; (b) ungrooved fragment with scored single bevel; (c) cylindrical point distal fragment; (d) robust midsegment fragment; (e) lenticular point distal fragment with groove preform.

Table 4.7 Bol’shoi Iakor Osseous Artifact Morphometrics.

Artifact Number	Point/ Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
c7-chIV	proximal	114.72	8.93	7.95	5.62	5.77	antler	yes	possible
ch1-c6	proximal	112.84	13.1	11.8	7.65	7.96	bone	yes	possible
c7-ii4(iv)	distal	66.14	8.54	7.17	3.84	4.64	antler	yes	possible
c7-4IV	midsegment	90.06	25.36	20.71	15.38	7.09	antler	yes	no
x23-4IV-c8	complete	276.34	17.08	14.07	8.23	7.23	bone	yes	no

Table 4.8. Bol’shoi Iakor Osseous Point Groove Morphology and Modifications.

Artifact Number	Number Groove	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
c7-chIV	1	114.72	0.70	1.31				narrow refit from two fragments; proximal base rounded but not tapered or beveled; distal end removed; snap fracture-could be impact related

(Continued)

Table 4.8 Continued.

Artifact Number	Number Groove	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
ch1-c6	0							thick point; proximal base beveled on both faces but not tapered to a point; scoring on bevel faces; distal snap fracture
c7-ii4(iv)	0							rounded tip; broken in midsegment possibly related to impact; multiple step fractures; groove preform along one lateral edge of the point
07-4IV	2	73.45	0.62	0.74	28.01	2.48	1.27	edges abraded to uniform thickness; grooves on both lateral edges; groove A runs the length of the point and groove B originates from the distal, ending near break; natural scoring on the outer surface of the point

(Continued)

Table 4.8 Continued.

Artifact Number	Point/ Frag	Number Groove	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
4IV-c8	Complete	1	270.18	2.3	1.86				microblades reinserted; beveled base (25°) with slight taper; full point refit from 4 pieces; U-shaped groove runs nearly the full length of the point

Figure 4.7 Bol’shoi Iakor (a) grooved bone point 4IV-c8 with inset microblades and (b) inset microblade at 25x magnification.

(Figure 4.6b). This fragment is thick (7.96 mm) and beveled on both faces of the preserved proximal end, with some scoring preserved on both beveled faces. Its distal end was removed in a snap fracture possibly related to impact. The distal point fragment c7-ii4(IV) possesses a rounded base with multiple step fractures at the midsegment break, as well as a preform of a groove along one lateral margin of the point (Figure 6e). Midsegment fragment 07-4IV is grooved along both lateral margins, with margin edges abraded to uniform thickness. Its groove A runs the length of the point fragment (73.45 mm), while groove B originates from the distal end of the fragment and ends before the break (28.01 mm). The outer surface of the point displayed extensive natural scoring (Figure 6d). Complete bone point 4IV-c8 is grooved along one lateral margin for nearly the length of the completed point (270.18 mm) (Figure 4.4.7a). This groove is U-shaped with a depth of 2.3 mm and a width of 1.86 mm. Three microblades are inset into the groove (Figure 4.7b). The complete point was refit from four pieces and has a base beveled at 25° with slight tapering resulting in a triangular shape.

4.4.2.3 Kokorevo-I

Kokorevo-I. Twenty-two organic points and tools from the Kokorevo-I assemblage were available for analysis, from the excavations by Z. A. Abramova (1979b) (Figure 4.8a-h; Tables 4.9-4.10). The assemblage is composed of six complete or nearly complete points and foreshafts, seven proximal fragments, three midsegments, and six distal point fragments. Nineteen points were manufactured on bone, and five of these preserve evidence of production on large-mammal rib bone. Three points were manufactured on ivory (Figure 4.8h). Striations and abrasions along the long axis of the four points produced on ribs (7449-4, 7449-2, 7449-3, 7449-1), are indicative of manufacture through splitting and abrading of margins to create a uniform thickness. Thirteen of the points and point fragments are grooved along one lateral margin. Only two points in this assemblage were bilaterally grooved (b, c). Only one midsegment

Figure 4.8 Morphological variability in the Kokorevo-I organic assemblage: (a) bi-beveled, lenticular foreshaft; (b) beveled proximal fragment of a single grooved point; (d-f) cylindrical points; (e) lenticular point fragment with preserved marrow cavity; (g) bi-grooved, beveled point base; (h) ungrooved ivory point distal tip; (i) large rounded point with beveled base; (j) single grooved bone point base; (h) large single-grooved foreshaft base with snap fracture.

Table 4.9 Kokorevo-I Osseous Artifact Morphometrics.

Artifact Number	Point/ Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
7449-10	complete	267.92	18.09	25.78	21.68	9.2	bone	no	no
7449-4	distal	96.86	24.03	22.87	16.11	8.31	bone-rib	yes	no
7449-2	proximal	172.72	16.65	25.49	25.16	9.64	bone-rib	yes	no
7449-3	midsegment	178.42	13.88	19.04	14.97	9.53	bone-rib	no	no
7449-1	distal	245.03	19.85	24.89	14.48	8.96	bone-rib	yes	no
7449-13	distal	115.75	10.84	12.17	5.44	5.57	ivory	yes	no
7449-15	midsegment	81.12	15.29	14.26	7.77	6.55	ivory	no	possible
7449-31	complete	154.83	13.14	12.13	7.76	9.39	bone	no	no
7449-21	distal	105.02	13.52	13.92	7.62	6.18	bone	no	no
7449-34	midsegment	147.7	7.23	7.25	9.29	7.25	bone-rib	yes	no
7449-24	complete	97.1	6.81	7.31	4.74	6.13	bone	yes	no
7449-32	complete	107.86	5.53	6.93	4.43	4.17	bone	no	no
7449-7	proximal	60.77	16.15	26.94	25.03	11.71	bone	yes	no
7449-16	distal	103.34	17.52	15.9	8.98	6.91	bone	yes	no
7449-13	complete	115.59	6.69	12.56	9.15	5.48	bone	yes	no
7449-18	Distal	148.53	22.84	20.45	8.32	8.52	bone	yes	no
7449-20	proximal	130.35	10.47	16.97	16.84	8.25	bone	yes	no
7749-12	complete	130.81	13.92	19.26	15.99	8.35	bone	no	no
7449-4	proximal	94.49	17.99	23.75	23.39	8.3	bone	no	no
7449-5	proximal	97.72	21.07	25.04	19.64	8.37	bone	no	no
7449-22	proximal	70.78	10.45	18.51	19.22	9.4	ivory	no	no
7449-1X	proximal	93.06	8.42	15.25	16.4	6.6	bone	no	no

Table 4.10 Kokorevo-I Osseous Point Groove Morphology and Modification.

Artifact Number	Number Grooves	Length Groove A	Depth Groove A	Width Groove A	Comments
7449-10	1	180.51	1.15	1.26	beveled at both ends 22° and 25°; groove extends within 14.64 mm of the distal tip
7449-4	1	54.47	4.53	2.16	distal end beveled 26°; large deep groove; curled edge of rib visible
7449-2	1	111.73	2.48	1.8	proximal tip rounded; large deep groove that ends 51.56 mm from tip; curled natural edge of rib visible; cross-hatched scoring on inside of rib
7449-3	1	135.03	1.63	1.15	heavily degraded; surface nearly destroyed
7449-1	1	213.81	1.72	2.05	groove extends near entire length; some edges of groove destroyed
7449-13	1	97.01	2.75	2.23	both surfaces heavily scored by natural etching
7449-15	0				steeply beveled, highly fragmented distal (28°)
7449-31	0				rounded point; no bevel
7449-21	0				small distal fragment refit of two pieces; curved inside of rib preserved

(continued)

Table 4.10 Continued.

Artifact Number	Number Grooves	Length Groove A	Depth Groove A	Width Groove A	Comments
7449-34	0				narrow bone-rib; heavy natural scoring on one surface
7449-24	1	35.77	2.68	2.81	single wide shallow groove along on long axis
7449-32	0				very small bi-beveled point; no grooves; refit two pieces
7449-7	0				tapered and slightly beveled < 10° large bone point; scored on inside portion of bone
7449-16	1	85.94	1.06	1.25	tapered distal end of point with single groove
7449-13	1	97.23	1.11	2.13	tapered; proximal end heavily degraded; single groove with edges degrading
7449-18	1	143.99	3.88	1.7	wide point with single groove; distal curved sides of ribs visible
7449-20	0				tapered slightly beveled 25°; heavy natural scoring along outer surface
7749-12	0				bi-tapered point; possible groove preform

(Continued)

Table 4.10 Continued.

Artifact Number	Number Grooves	Length Groove A	Depth Groove A	Width Groove A	Comments
7449-4	1	55.26	3.89	2.59	rounded proximal end; single groove; heavy of natural scoring on surface
7449-5	1	75.9	3.82	2.34	single groove; heavily degraded
7449-22	0				tapered and beveled 22°; damage to tip (flaking) and large flake removals from distal end of fragment
7449-1X	1	35.5	0.88	1.26	beveled 23°; rounded proximal; a single groove along one long axis

point fragment, 7449-15, yielded possible evidence of impact damage with some crushing and overlapping step fractures on one break (Figure 4.8b). The largest complete point measures 267.92 mm in length, while the shortest measures only 97.1 mm in length. Artifact 7449-10 is an extremely large point, beveled on both ends, with a single groove extending within 14.64 mm of the distal tip. Point 7449-31 is cylindrical in cross section (Figure 4.8d), while point 7449-20 is lenticular and tapers to a rounded unbeveled base (Figure 4.8f). Foreshaft 7449-2's proximal end is rounded to a blunt point while a large deep groove extends 51.56 mm from its tip, and there is abrasion wear on the curled edge of the large mammal rib, which was scored in a cross-hatched pattern (Figure 4.8j). Point 7449-1 is a large point manufactured on a rib and is grooved nearly the length of one lateral margin of the point, with possible scoring on the rounded beveled base (Figure 4.8k). Complete point 7749-12, manufactured on bone, is tapered on both proximal and distal ends with no beveling, and a possible groove preform along one lateral margin (Figure 4.8l).

4.4.2.4 Kokorevo-II

Forty organic points and foreshafts from the Kokorevo-II assemblage were available for analysis (Abramova 1979a) (Figure 9a-l; Tables 11, 12). The assemblage is comprised of eight complete or nearly complete points, fifteen midsegments, two proximal fragments, nine distal point and foreshaft fragments, and six indeterminant fragments. Thirty-six of these points and tools were produced on bone, three points were manufactured on ivory (Figure 4.9f, l), and one point

Figure 4.9 Morphological variability in the Kokorevo-II organic assemblage: (a) bi-grooved antler point with decorative incised lines; (b) cylindrical bone point distal fragment; (c) distal fragment of an ungrooved point with incised line perpendicular to long axis; (d) bi-grooved point proximal fragment with beveled base; (e) distal fragment of a bi-grooved point; (f) proximal fragment of an ungrooved ivory point; (g) tapered unbeveled small foreshaft; (h) midsegment of a single grooved bone point, with incised lines perpendicular to the long axis of the point; (i-j) fragments of beveled bone foreshaft; (k) distal fragment of a bi-grooved antler point; (l) proximal fragment of an ungrooved bone point.

Table 4.11 Kokorevo-II Osseous Artifact Morphometrics.

Artifact Number	Point/ Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
7450-32	fragment	179.06	12.32	14.47	6.56	9.98	bone	yes	yes
7450-19	complete	104.49	14.29	11.6	6.09	9.39	bone	no	no
7450-24	complete	106.42	15.49	14.66	10.82	11.55	bone	yes	no
7450-21	fragment	51.72	14.44	13.21	9.25	7.47	bone	yes	possible
7450-36	fragment	49.89	14.33	12.01	7.28	8.32	ivory	yes	possible
7450-26	fragment	110.25	8.76	7.33	7.63	8.34	bone	no	no
7450-29	fragment	94.29	10.09	6.65	6.13	7.64	bone	no	no
7450-34	distal	54.25	7.12	13.82	15.75	8.96	bone	yes	no
7450-33	midsegment	109.42	14.85	17.89	13.41	10.88	bone	no	no
7450-56	distal	100.15	19.36	25.07	19.55	8.81	bone	no	no
7450-18	complete	208.78	11.24	20.64	14.29	9.22	bone	yes	no
7450-62	distal	44.12	9.58	9.84	11.9	7.18	bone	no	no
7450-22	midsegment	94.68	10.78	14.55	15.97	10.79	bone	possible	possible
7450-57	distal	103.47	24.14	26.44	23.89	12.43	bone	possible	no
7450-20	distal	116.31	13.52	11.49	7.66	8.23	bone	yes	yes
7450-14	complete	152.56	9.64	13.22	9.08	5.23	bone	no	no
7450-55	midsegment	125.52	23.81	20.59	14.12	13.09	bone	no	no
7450-35	distal	83.31	9.24	13.81	4.62	9.43	bone	no	possible
7450-23	midsegment	140.14	18.64	17.72	12.86	11.33	bone	no	possible
7450-25	midsegment	83.89	18.21	15.95	9.48	9.1	bone	yes	no
7450-27	midsegment	92.11	8.41	8.61	5.36	6.27	bone	no	no
7450-59	midsegment	43.21	8.13	8.4	7.53	4.3	bone	no	no

(Continued)

Table 4.11 Continued.

Artifact Number	Point/ Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
7450-28	midsegment	54.86	4.45	7.57	8.8	7.38	bone	no	no
7450-58	midsegment	133.06	21.52	24.46	17.78	13.23	bone	no	no
7450-30	midsegment	94.67	22.46	20.71	5.23	9.6	bone	yes	no
7450-60	midsegment	33.51	5.21	4.75	4.12	2.74	ivory	yes	no
7450-31	distal	135.48	16.84	17.46	14.26	11.53	bone	yes	no
7450-37	proximal	45.78	7.76	14.85	11.69	7.32	bone	yes	no
7450-61	fragment	19.06	5.09	7.36	3.25	5.61	antler	no	no
7450-54	midsegment	67.65	5.52	5.24	4.21	6.11	bone	no	no
7450-45	midsegment	41.01	4.4	5.36	2.66	2.68	bone	no	no
7450-46	distal	60.81	2.23	5.3	3.05	5.12	bone	no	no
7450-47	midsegment	81.54	3.41	5.97	4.41	5.9	antler	yes	no
7450-52	distal	102.67	4.51	6.33	3.79	4.11	bone	yes	no
7450-49	complete	76.78	4.52	6.48	4.72	5.66	bone	yes	no
7450-50	complete	61.26	4.16	5.94	3.3	7.58	bone	yes	no
7450-51	proximal	95.3	8.09	10.36	10.1	7.62	bone	yes	no
7450-48	complete	43.36	4.66	6.44	4.48	4.8	bone	yes	no
7450-53	midsegment	94.78	6.71	7.42	3.89	4.25	bone	yes	no
7450-17	complete	334.4	9.73	17.34	9.53	9.39	bone	no	no

Table 4.12 Kokorevo-II Osseous Point Groove Modifications and Morphology.

Artifact Number	Number Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
7450-32	0							
7450-19	0							grooves along both lateral margins; second pair grooves along one face; beveled base 27°
7450-24	1	58.61	2	2.31				
7450-21	2	36.65	1.5	1.16	19.65	1	1.77	
7450-36	0							
7450-26	1	106.62	< 1	1.11				
7450-29	0							
7450-34	0							
7450-33	0							rib fragment
7450-56	0							rib fragment

(Continued)

Table 4.12 Continued.

Artifact Number	Number Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
7450-18	2	130.46	<1	1.76	156.86	<1	2.33	rib fragment
7450-62	0							size precluded full analysis
7450-22	1	79.75	1.66	1.65				
7450-57	1	56.03	<1	1.13				very thick
7450-20	2 (1)	76.44	2	1.68	53.69	<1	1.29	three grooves
7450-14	0							
7450-55	0							
7450-35	0							
7450-23	1	68.79	1	1.17				cross-hatched perpendicular to groove
7450-25	1	11.62	1	1.13				cross-hatched perpendicular groove
7450-27	1	35.01	<1	1.34				cross hatched perpendicular groove

(Continued)

Table 4.12 Continued.

Artifact Number	Number Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
7450-59	0							highly degraded
7450-28	1	35.17	1	1.54				cross-hatched perpendicular groove
7450-58	0							
7450-30	0							steeply beveled base 35°
7450-60	0							cylindrical point
7450-31	0							rounded and beveled distal end (23°)
7450-37	0							beveled rounded
7450-61	0							small, rounded fragment
7450-54	0							cylindrical point
7450-46	0							cylindrical with beveled base 21.5°
7450-47	0							cylindrical point
7450-52	0							cylindrical point

(Continued)

Table 4.12 Continued.

Artifact Number	Point/ Frag.	Number Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
7450-49	complete	0							cylindrical body and distal tip; beveled proximal end
7450-50	complete	0							rounded body and rounded tip; beveled base
7450-51	proximal	0							rounded body; beveled proximal end; heavy natural scoring down the length of the midsegment
7450-48	complete	0							rounded body; rounded ends; not likely a point
7450-53	midsegment	0							thin, rounded midsegment; heavily degraded
7450-17	complete	0							complete point refit from three parts; cross-hatched on most distal end

is produced on an indeterminant organic raw material. The largest bone foreshaft in the assemblage, 7450-17, was manufactured on bone and measures 334.4 mm long, 17.34 mm wide at its midpoint, an 9.39 mm thick (Figure 4.9i). The smallest foreshaft, 7450-48, is rounded to tapered distal and proximal tips, but lacks bevels (9g). Artifacts 7450-21, 7450-36, 7450-22, 7450-35, and 7450-23 display step-fracture flaking and crushing that possibly represent impact-related breakage; however, the poor condition of the artifacts precludes making definitive determinations. Eight points and point fragments are grooved along one lateral margin, and two points are grooved along both lateral margins (4.9d, e, h, k). Nine points are cylindrical, round in cross-section, and tapering to a sharp tip (Figure 4.9b-c). Six the points and point fragments, 7450-17, 7450-19, 7450-20, 7450-23, 7450-25, and 7450-28, are decorated in some way. Artifacts 7450-17, 7450-23, 7450-25, and 7450-28 all display a series of small grooves incised perpendicular to the long axis of the point and spanning the main groove for inset microblades (Figures 4.9h, 4.10a-e). Point 7450-20 is grooved along both lateral margins, and also decoratively scored linearly on one face of the point (Figure 4.9a). These decorative grooves were manufactured following the same scoring process as the more substantial grooves intended for inset blades; however, the two grooves on the face of the point are not convergent and would not have been functional for inserting lithic elements.

4.4.2.5 Kurla-III

Fifteen points, point fragments, and foreshafts from the Kurla-III assemblage were available for analysis (Figure 4.11; Tables 4.13-4.14) (Medvedev et al. 1990).

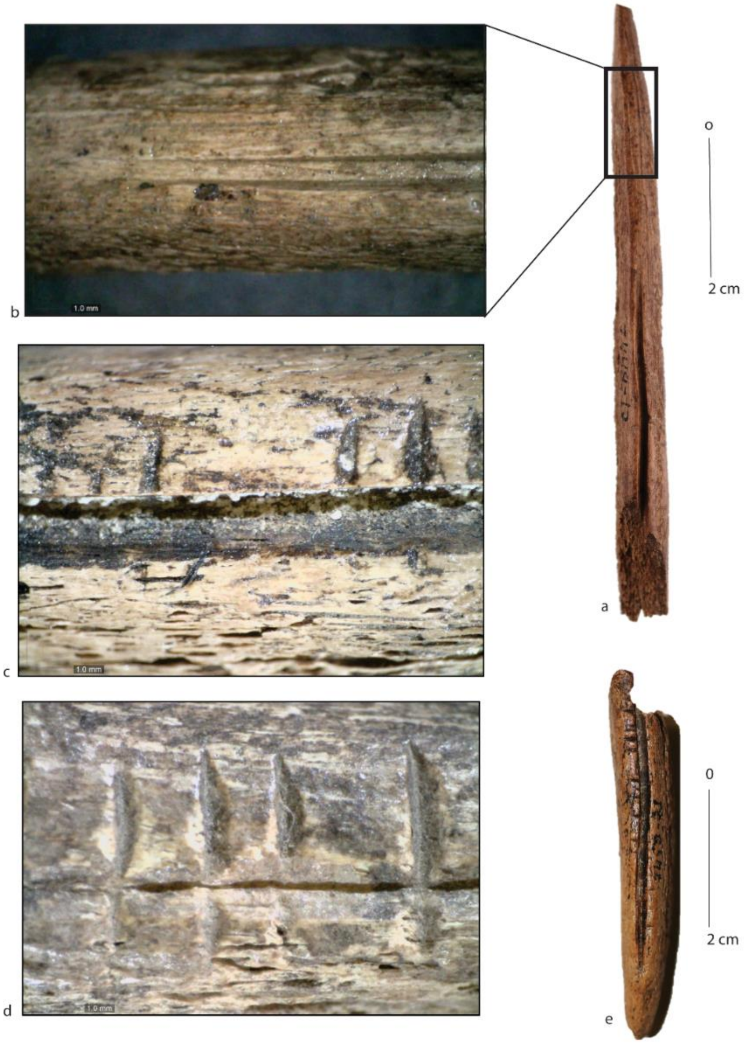

Figure 4.10 Manufacture and modification of LUP grooved points: (a) Kokorevo-II bi-grooved projectile point 7749-12 with groove preform and incised lines preserved; (b) point 7450-12 groove manufacture lines at 20x magnification; (c) Kokorevo-I point 7449-2 with "U" shaped groove with scoring visible along the base of groove and perpendicular incised lines bisected by groove at 30x magnification; (d) series of "v" shape incised lines perpendicular to early stage groove preform on Kokorevo-II point 7450-28; (e) grooved point base 7450-17 from Kokorevo-II with perpendicular scoring along one lateral margin.

The assemblage is comprised of nine midsegments, four proximal fragments, and two distal fragments. Eight of the nine midsegments were produced on bone, and one midsegment was produced on ivory (Figure 4.11f).

Figure 4.11 Morphological variability in the Kurla-III assemblage: (a) lenticular biface; (b) bigrooved beveled proximal bone point fragment; (c) single grooved bone point midsegment; (d) bone foreshaft midsegment with step fracture at the proximal break; (e) bibeveled bone foreshaft midsegment; (f) ivory point midsegment fragment; (g) cylindrical point with parallel incised lines on one long axis.

Table 4.13 Kurla-III Osseous Artifact Morphometrics.

Artifact Number	Point/Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
45	proximal	136.02	16.25	17.82	10.09	7.44	bone	yes	possible
59	proximal	160.57	22.48	23.96	21.64	10.12	bone	yes	no
60	proximal	61.54	20.37	20.16	20.79	9.08	bone	no	no
61	proximal	53.83	16.16	19.88	21.34	8.03	bone?	yes	possible
47	midsegment	104.84	23.15	21.43	19.59	9.6	bone	yes	no
65	distal	53.97	9.18	9.4	7.74	5.26	bone	no	no
XX	midsegment	53.44	21.04	19.9	18.5	8.35	bone	no	no
64	midsegment	102.36	9.8	6.96	4.47	4.53	bone	no	no
57	distal	178.46	19.74	21.68	15.45	8.12	bone	yes	possible
62	midsegment	179.38	21.89	21.97	18.25	8.81	bone	yes	no
58	midsegment	188.34	23.17	26.99	19.21	11.1	bone	yes	no
46	midsegment	204.58	27.43	27.54	24.37	12.42	bone	yes	no
56	midsegment	230.76	16.84	25.99	18.71	9.94	bone	yes	no
68	midsegment	130.2	25.81	24.89	17.24	11.33	ivory	yes	no
60b	midsegment	172.24	18.31	19.8	16.73	8.48	bone	yes	no

Table 4.14 Kurla-III Osseous Point Groove Morphology and Modifications.

Artifact Number	Number Groove	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
45	2	130.17	3.23	1.3	112.28	2.85	1.42	scoring on proximal end; distal end refit; grooves that extend through distal and within 5 mm/10 mm of proximal; distal lateral margins abraded prior to grooving
59	0							distal end removed with hinge snap; abraded to uniform thickness; foreshaft
60	0							rounded and tapered base
61	0							tapered base with two large flake removals on proximal end originating from distal, possibly related to hafting contact

(Continued)

Table 4.14 Continued.

Artifact Number	Number Groove	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
47	0							midsegment with most of base preserved; rounding at the proximal end of point, tapering may be the result of large flake removal
65	0							small; very rounded
XX	0							
64	0							cross-hatched scoring on one face at distal end of fragment and parallel scoring on same face at midpoint
57	0							refit from 3 fragments; flake removal at proximal end, possible impact; distal end has multiple step fractures
62	0							refit from numerous fragments

(Continued)

Table 4.14 Continued.

Artifact Number	Number Groove	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
58	0							slightly rounded at both ends, no tapering; possible foreshaft?
46	0							
56	0							slightly rounded at both ends, no tapering; possible foreshaft?
68	0							
60b	0							possible foreshaft fragment

Three of the proximal fragments were produced on bone and one is manufactured on an indeterminant osseous raw material, likely bone. Both distal fragments were produced on bone. Osseous foreshafts in this assemblage were relatively robust, with the largest midsegment fragment (artifact number 56) measuring 230.76 mm long, 25.99 mm wide at the midpoint, and 9.94 mm thick (Figure 4.11e). The median width of the artifact sample is 21.43 mm and median thickness is 8.81 mm. Three of the Kurla-III points and foreshafts were damaged in a way that suggests impact damage. Foreshaft fragment 59, manufactured on bone and abraded to a uniform thickness, has a large hinge-snap fracture at the proximal break (Figure 4.11d). Ungrooved distal point tip 65 is produced on bone (Figure 4.11a). Proximal fragment 61, manufactured on an indeterminant raw material, likely bone, has a tapered base with two large flake removals originating from the distal break, bending onto one face of the fragment. Fragment 64 is a rounded midsegment of a point with a series of parallel incisions along one long axis (Figure 4.11g). Proximal point fragment 46 is produced on bone, bigrooved, beveled and scored along the face of the bevel (Figure 4.11b).

4.4.2.6 Maina

Thirty-three projectile points and point fragments from the Maina assemblage were available for analysis, from the excavations carried out by S. Vasil’ev (1996) (Figure 4.12a-k; Tables 4.15, 4.16). This assemblage is comprised of ten midsegments, six distal fragments, nine proximal fragments, and three complete points, all produced on bone. Five indeterminant fragments were also part of this assemblage, two produced on bone, one produced on antler, and two produced on an indeterminant raw

Figure 4.12 Morphological variability in the Maina organic assemblage: (a) large bigrooved bone point midsegment; (b) bone point distal tip fragment; (c) single grooved bone point proximal fragment; (d) single grooved bone point distal tip; (e) cylindrical point distal fragment with single groove; (f) cylindrical point midsegment with single groove preform; (g) lozenge-shaped bone point; (h-j) lenticular bone point bases; (k) large ungrooved lenticular bone point.

material, either antler or bone. The organic points and point fragments in this assemblage were relatively large in size. The largest complete point in the assemblage, M-82-500a,

Table 4.15. Maina Osseous Artifact Morphometrics.

Artifact Number	Point/ Frag.	Length	Width Proximal	Width Midpoint	Width Distal	Thickness	Raw Material	Indication of Use	Impact Damage
M-83-684	midsegment	83.27	14.99	15.91	16.6	8.44	bone	no	no
M-84-406	distal	41.92	13.91	12.51	8.56	12.06	bone	no	no
M-XX-XXXa	midsegment	126.28	8.51	5.96	4.1	6.19	bone	no	no
M-818-1490	complete	151.02	8.52	11.51	9.94	8.27	bone	possible	possible
M-82-500a	proximal	96.74	13.46	24.94	24.46	8.43	bone	no	no
M-80-133	distal	132.51	13.44	13.53	9.67	6.91	bone	no	no
M-83-7	proximal	56.15	5.65	10.57	11.96	7.67	bone	no	no
M-83-6-0	midsegment	91.69	9.25	7.62	4.45	4.72	bone	yes	possible
M-91 P11 A-1 N8	fragment	26.53	4.06	6.57	7.24	5.62	antler?	no	no
M-91-2	fragment	22.58	11.8	10.3	6.71	9.45	bone	no	no
M-91-1	complete	105.34	6.04	7.4	6.06	4.97	bone	no	no
M-XX-XXXb	fragment	52.33	5.58	9.19	8.51	6.73	antler?	no	no
M-91-3	distal	50.82	13.32	13.09	7.39	8.97	bone	no	possible

(Continued)

Table 4.15 Continued.

Artifact Number	Point/ Frag.	Length	Width Proximal	Width Midpoint	Width Distal	Thickness	Raw Material	Indication of Use	Impact Damage
M-91-(9) 11	fragment	52.46	9.29	12.64	8.53	9.68	bone	no	no
M-82-504	midsegment	62.64	9.65	9.31	8.51	8.27	bone	possible	possible
M-82-502	midsegment	151.1	15.13	17.21	13.27	8.25	bone	no	no
M-82-500b	distal	193.62	18.59	18.95	5.89	7.63	bone-rib	no	possible
M-80-134	complete	224.49	8.72	13.26	6.7	7.11	bone	no	no
M-80-135	proximal	164.54	14.74	14.92	12.82	6.11	bone	no	no
M-80-132	proximal	214.79	20.16	16.61	10.75	7.86	bone	no	no
M-83-4	distal	148.27	14.38	12.78	7.93	7.92	bone	no	no
M-81-1484	midsegment	73.6	12.59	11.05	9.98	7.51	bone	no	no
M-82-505	proximal	56.11	17.34	15.87	10.6	7.93	bone	no	no
M-80-415	proximal	81.95	14.53	15.37	10.71	9.34	bone	no	no
M-82-506	distal	74.27	12.44	13.16	9.14	7.84	bone	no	no

(Continued)

Table 4.15 Continued.

Artifact Number	Point/ Frag.	Length	Width Proximal	Width Midpoint	Width Distal	Thickness	Raw Material	Indication of Use	Impact Damage
M-81-1484	midsegment	73.96	11.95	10.87	10.37	7.52	bone	no	no
M-81-1485	proximal	71.92	11.8	9.63	6.17	5.96	bone	no	no
M-81-1486	fragment	46.7	8.53	6.52	4.37	4.7	antler/bone?	no	no
M-81-1482	proximal	66.8	4.29	7.01	5.18	5.67	bone	no	no
M-81-1427	midsegment	51.64	12.11	12.31	10.97	6.42	bone	no	no
M-81-1488	proximal	42.02	13.77	12.55	9.52	12.41	bone	no	no
M-91-4	midsegment	188.62	17.69	18.37	10.81	9.8	bone	no	no
M-80-136	midsegment	126.91	8.37	13.29	4.02	9.05	bone	no	no

(Continued)

Table 4.16 Maina organic point groove morphology and modification.

Artifact Number	Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
M-83-684	0							Abraded a uniform thickness
M-84-406	0							rounded distal tip
M-XX-XXX	0							tapered, rounded
M-818-1490	2	75.19	<1	1.86	75.12	1.21	1.93	rounded base no bevel; both grooves extend through distal tip

(Continued)

Table 4.16 Continued.

Artifact Number	Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
M-82-500a	0							beveled and tapered point base; abraded to uniformed thickness; natural scouring
M-80-133	2	65.77	1	1.56	68.79	<1	1.76	nearly complete; grooves do not extend to the tip
M-83-7	0							small fragment
M-83-6-0	0							thin point with beveled base 29°
M-91 P11 A-1 N8	0							rounded tip; heavily degraded

(Continued)

Table 4.16 Continued.

Artifact Number	Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
M-91-2	0							rounded tip fragment; highly fragmented
M-91-1	0							tapered on both ends with one rounded tip; refit from 3 pieces; heavy natural scoring;
M-XX-XXXb	0							rounded; tapered fragment; heavy natural scoring
M-91-3	2	38.37	2.18	1.86	19.08	<1	1.56	grooved on both lateral margins; large hinge fracture at proximal end; grooves through end of point

(Continued)

Table 4.16 Continued.

Artifact Number	Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
M-91- (9) 11	0							rounded tip; heavy natural scoring
M-82-504	1	60/60	0.97	1.23				single groove that runs the entire length
M-82-502	0							rounded point; 3 pieces refit
M-82-500b	1	161.26	<1	0.71				manufactured on rib; groove off center on top of point; possible groove preform
M-80-134	1	81.35	1.19	1.78				tapered, beveled proximal end of point; long groove

(Continued)

Table 4.16 Continued.

Artifact Number	Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
M-80-135	1	31.41	0.3	0.71				rounded, tapered proximal end; groove barely preserved
M-80-132	0							tapered and round proximal point base
M-83-4	2	130.67	1.87	1.19	100.69	<1	1.54	bi-grooved distal point fragment
M-81-1484	1	30.61	2.66	2.64				
M-82-505	0							beveled (26 °), tapered; heavy natural scoring

(Continued)

Table 4.16 Continued.

Artifact Number	Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
M-80-415	0							tapered proximal manufactured on a rib; abraded to a uniformed thickness;
M-82-506	1	40.46	3.03	3.85				single groove through break; abraded to uniform thickness;
M-81-1484	1	59.87	2.53	2.29				
M-81-1485	0							
M-81-1486	0							very narrow

(Continued)

Table 4.16 Continued.

Artifact Number	Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
M-81-1482	0							
M-81-1427	1	32.82	2.17	1.59				small midsegment fragment
M-81-1488	0							rounded unbeveled possible point tip
M-91-4	1							
M-80-136	0							rounded distal; abraded to a uniform thickness

measures 224.49 mm in length, 13.26 mm in width at the midline, and 7.11 mm in thickness (Figure 12k). The median size of complete points is 160.28 mm in length, 10.72 mm wide at the midpoint, and 6.78 mm thick. The widest proximal fragment in the assemblage, M-82-500a, measured 24.94 mm at the midpoint (Figure 4.12a). All bone points were manufactured using a splinter-and-abrade technique resulting in a uniform thickness along the compact bone, in some exposing the marrow cavity on one side of the point and the periosteum surface on the other. Three point fragments in the assemblage retain beveled distal bases with a mean bevel angle of 25 degrees (Figure 4.12h-j). Nine of these points were grooved along one lateral margin (M-82-504, M-82-500b, M-80-134, M-80-135, M-81-1484, M-82-506, M-81-1484, M-81-1427, M-91-4; Figure 4.10c-f), and four points and point fragments exhibited grooving on both lateral margins (M-818-1490, M-80-133, M-91-3, and M-83-4; Figure 4.12 a, b). Points with only one groove each had a median a groove width of 1.59 mm and a median groove depth of 2.02 mm, while bi-grooved point grooves had a median width of 1.56 mm and depth of 1.76 mm. All grooves were manufactured through repeated scoring, resulting in relatively narrow groove widths with ‘U’-shaped profiles. Five of the points in the Maina assemblage displayed possible damage related to impact. For example, M-82-500a is a nearly complete lozenge-shaped bone point with distal crushing, likely related to high velocity impact (Figure 4.12g). Artifact M-XX-XXXb, grooved on both lateral margins, displays a large hinge fracture at the proximal end of the point. This too is possibly related to impact.

4.4.2.7 Ui-II

Five projectile points and point fragments from the Ui-II assemblage were available for analysis, from the excavations carried out by S. Vasil'ev (1996) (Figure 4.13 a-d; Tables 4.17, 4.18). This assemblage is comprised of two midsegments

Figure 4.13 Morphological variability in the Ui-II osseous assemblage: (a) lenticular foreshaft proximal fragment; (b) midsegment of a lenticular bone point; (c) proximal fragment of a lenticular, tapered bone point; (d) distal tip of a small antler point.

Table 4.16 Ui-II Osseous Artifact Morphology.

Artifact Number	Point/Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
903-6	midsegment	165.22	16.57	17.9	11.38	6.43	bone	yes	possible
Yu-2-87 C-22 N2	distal	13.59	7.36	6.46	4.35	6.56	antler	no	no
Yu-2-11-87 6 (1)	distal	119.86	16.88	16.49	10.5	6.73	bone	no	no
Yu-2-11-87 6 (2)	midsegment	69.12	17.32	16.61	15.64	6.19	bone	no	no
Yu-2-11-87 6 (3)	proximal	82.53	14.67	11.49	6.77	5.18	bone	no	no

Table 4.17 Ui-II Osseous Point Groove Morphology and Modifications**.**

Artifact Number	Number Grooves	Indication Manufacture	Comments
903-6	0	yes	rounded and blunted tip; possible crushing; heavy natural scoring; margins of bone abraded to create a uniform thickness
Yu-2-87 C-22 N2	0	yes	rounded distal tip
Yu-2-11-87 6 (1)	0	yes	tapered and rounded on both ends; abraded to uniform thickness; 3 parts of point housed together
Yu-2-11-87 6 (2)	0	yes	tapered and rounded on both ends; abraded to uniform thickness
Yu-2-11-87 6 (3)	0	yes	tapered and rounded on both ends; abraded to uniform thickness

manufactured on bone (Figure 4.13a, b), one distal point fragment produced on antler (Figure 4.13d), and two distal fragments produced on bone (Figure 4.13c). None of the points in this small assemblage were grooved, but all were manufactured using a split-and-abrade manufacturing technique to create relatively uniform thicknesses. Where preserved, point bases and proximal ends were tapered and rounded with no indication of beveling. Midsegment 903-6 represents the most complete point fragment in the assemblage, measuring 165.22 mm long, 17.9 mm wide at the midpoint, and 6.43 mm thick (Figure 4.13a). This midsegment displays crushing at the proximal break, possibly the result of impact-related breakage.

4.4.3 Mesolithic Osseous Assemblages

4.4.3.1 Zhokhov

Ten projectile points and point fragments from the Zhokhov assemblage were available for analysis, from the excavations of V. Pitul'ko et al. (2015) (Figure 4.14; Tables 4.19, 4.20). This assemblage is composed of one complete point produced on an indeterminant raw material (likely antler), and eight distal fragments produced on either bone (2), antler (4), ivory (1), or indeterminant raw material (either antler or bone) (1). Additionally, one complete, massive ivory artifact with a modified base and pointed distal tip was included in the analysis (Figure 4.14a). Five points and point fragments (N507, N625, N625b, N661, NXXXX) were grooved along one lateral margin, and three of these had microblades from the associated lithic assemblage re-inset into their grooves (Figure 14b). N625 point fragment is also scored with two parallel grooves approximately 5 mm apart, running perpendicular to the long axis of the point at the proximal break (Figure 4.14). Point NXXXX is a large distal fragment produced on bone in relatively poor condition with one microblade inset into the point's single lateral-margin groove (Figure 4.14e). N625b is grooved along one lateral margin, but it i4.

Figure 4.14 Morphological variability in the Zhokhov organic assemblage; (a) large ivory spear tip; (b) single grooved ivory point distal tip with inset microblades; (c) ungrooved bone point distal fragment; (d) bigrooved distal bone fragment; (e) single grooved bone distal tip with inset microblade; (f) bigrooved cylindrical distal tip.

Table 4.18 Zhokov Osseous Artifact Morphology.

Artifact Number	Point/ Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Raw Material	Thickness	Indication of Use	Impact Damage
N625a	distal	204.42	21.16	17.64	6.09	4.24	ivory	yes	possible
N661	distal	44.98	10.97	8.83	4.39	5.04	bone	yes	possible
NXXXX	proximal	179.02	21.16	22.38	1338	13.24	bone	yes	possible
N507	distal	243.98	18.97	18.23	7.83	8.09	antler/bone	yes	possible
N66	distal	215.14	21.48	18.19	5.2	7.1	antler	yes	no
N512	distal	169.83	23.84	21.91	10.31	8.59	antler	no	no
N625b	distal	107.83	4.59	8.15	5.28	7.81	antler		
N319	distal	139.82	12.06	13.68	5.22	5.88	antler	yes	no
N532	complete	295.46	18.22	18.76	7.55	9.42	antler?	yes	no

Table 4.19 Zhokhov Osseous Point Groove Morphology and Modification.

Artifact Number	Number Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
N625a	1	191.36	3.23	1.79				10 microblades inset, mostly in place at most distal end; two parallel scored lines near the proximal end of the point
N661	1	17.79	2.48	1.09				small distal point fragment with 2 small microblades inset
NXXXX	1	98.69	4.09	1.66				antler/bone point with triangular cross section; one microblade inset; groove continues through break
N507	1	19.64	0.67	0.86				large point with possible groove preform
N66X	2	148.44	2.47	1.63	148.12	2.67	1.66	two grooves longitudinal to long axis

(Continued)

Table 4.20 Continued.

Artifact Number	Number Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
N512	2	161.19	1.59	1.55	163.87	1.55	1.54	Two grooves longitudinal to long axis; proximal end removed
N625b	1		5.31					triangular, very wide, very deep groove
N319	0							
N532	0							

Figure 4.15 Zhokhov point decoration: Point N625b with parallel lines incised near proximal break.

cylindrical and morphologically distinct from other grooved points in the assemblage (Figure 4.14f). This point is triangular in cross section with a wide (8 mm), deep (5.31 mm) U-shaped groove. Two points, N66X and N512, were grooved along both lateral margins. N512 is a large, bi-grooved distal point fragment measuring 169.83 cm in length, 21.91 mm at the midpoint, and 8.59 mm thick (Figure 4.14d). The two grooves of N512 run nearly the length of the point and measure 161.19 mm long, 1.59 mm deep, and 1.55 mm wide, and 163.87 mm long, 1.55 mm deep, and 1.54 mm wide, respectively. N5625a is a remarkable spear produced from one length of ivory (Figure 4.14a). It measures 295.46 mm in length, 18.76 mm wide at the midline, and 9.42 mm thick, with only minor modifications, with rounding of the base of the point and shaping of the distal end of the artifact through abrading into a sharp tip. N625b is as large ivory distal fragment with one grooved lateral margin and ten chert microblades inset into the groove, largely clustered towards the distal tip of the fragment (Figure 4.14b). Interestingly, N625b has a decorative groove that runs from the proximal break to within 5 cm of the distal tip of the point (which is ~129 mm in length) along the preserved face of the point (Figures 4.14d, 4.15).

4.4.3.2 Trail Creek Cave-2

All seven osseous projectile points and point fragments from the Paleoarctic assemblage at Trail Creek Cave-2 were available for analysis (Figure 4.16a-g; Table 4.21 and 4.22). These were from the excavations carried out by H. Larsen (1968). The assemblage includes three proximal fragments, two midsegments, and two distal fragments all produced on antler. Six of the points recovered at Trail Creek Cave-2 were grooved along both lateral margins, and midsegment 6835 was also likely bi-grooved, but the fragment is broken down the center axis obliterating groove channels (Figure 4.16d). The well-preserved condition of the point fragments in this assemblage facilitated a detailed analysis. Proximal fragment 6845 was beveled at the base with scoring along the bevel (Figure 4.16b). Lateral margins were grooved with V-shaped slots that have steep sides and a narrow channel. Both lateral grooves extend through the
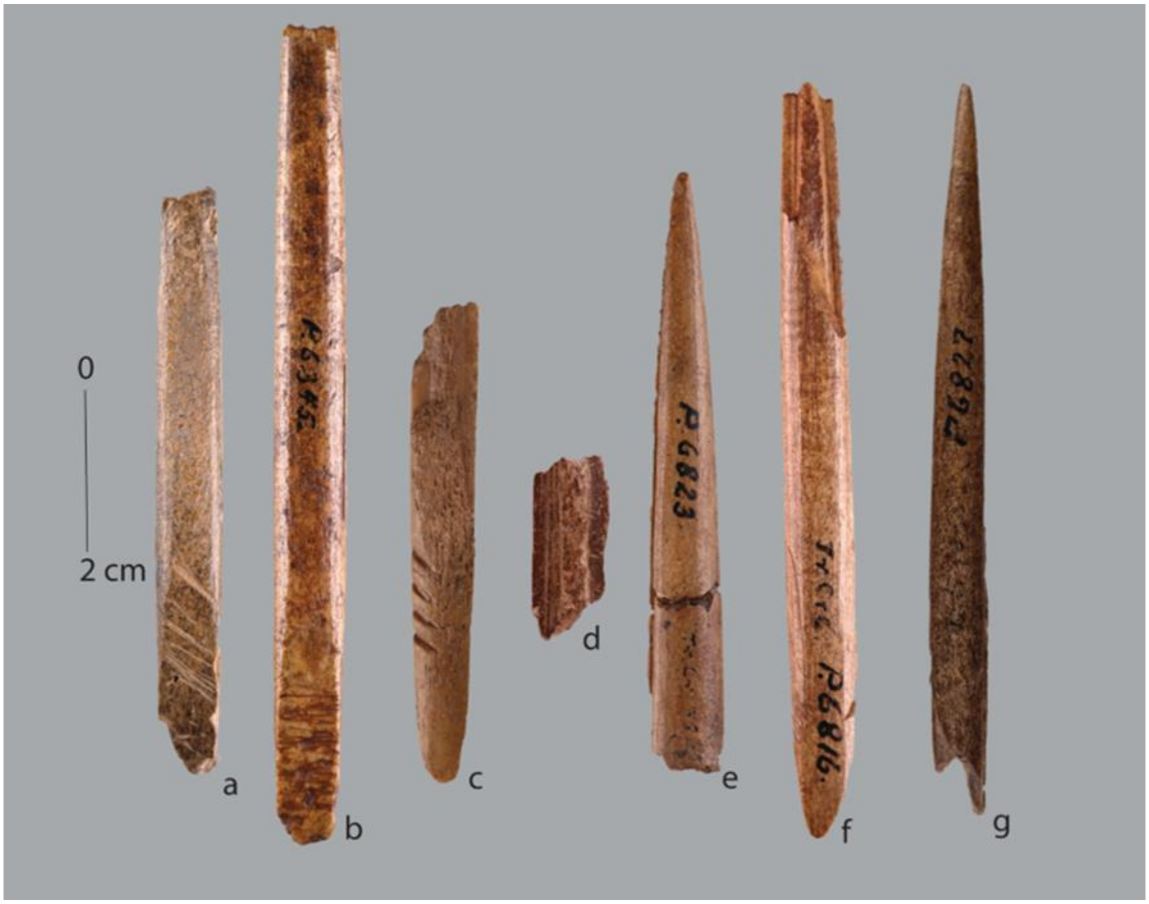
Figure 4.16 Trail Creek Caves (a, b) bi-grooved beveled points with distal crushing ;(c) bi-grooved base with impact burination; (d) possible bi-grooved midsegment; (e) bi-grooved distal tip; (f) keeled bi-grooved point with impact burination; (g) bi-grooved rounded distal tip.

distal break of the point, although one groove runs through the bevel (94 mm in length), and the reverse groove ends before beveling begins (74.04 mm in length). Proximal fragment 6826 is sharply beveled at the base and bi-grooved with U-shaped slots measuring 20.23 mm long, 3.44 mm deep, and 1.07 mm wide and 30.01 mm long, 3.03

Table 4.20 Trail Creek Cave-2 Osseous Point Morphometrics.

Artifact Number	Point/ Fragment	Length	Width Proximal	Width Midpoint	Width at Distal	Thickness	Raw Material	Indication of Use	Impact Damage
6845	proximal	101.95	7.79	8.92	7.29	6.79	antler	yes	possible
6826	proximal	61.06	7.16	8.06	7.24	5.12	antler	yes	yes
6825	midsegment	74.26	8.3	8.57	7.21	6.37	antler	yes	possible
6835	midsegment	24.04	9.7	9.49	9.35	4.94	antler	yes	no
6816	proximal	92.63	7.19	8.21	6.76	6.96	antler	yes	possible
6823	distal	72.86	9.11	7.88	5.27	6.87	antler	yes	possible
6827	distal	92.91	7.11	6.51	2.71	6.03	antler	yes	no

Table 4.21 Trail Creek Cave-2 Osseous Point Groove Morphology and Modification.

Artifact Number	Number Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
6845	2	74.04	2.8	1.5	94.83	2.98	1.6	beveled base; scoring along the bevel; V-shaped grooves with steep sides and narrow channel; grooves through break at distal; one groove runs through the bevel and reverse groove ends before bevel
6826	2	20.23	3.44	1.07	30.01	3.03	< 2	sharply beveled proximal base; 4 large incisions on the outer surface of the antler

(Continued)

Table 4.24 Continued.

Artifact Number	Number Grooves	Length A	Depth A	Width A	Length B	Depth B	Width B	Comments
6825	2	66.31	2.25	1.74	68.76	2.37	2.07	one groove narrower with a V-shape; the second groove wider with squared base of groove U-shaped
6835	0							broken down the center axis and only one lateral margin of the point preserved
6816	2	63.88	2.05	1.52	63.47	2.39	2.34	heavily beveled and smoothed along one side of the base; two grooves, one deeper and more U-shaped than the reverse (more V-shaped); broken in a long fluted break from the distal end with a large step in the break on one face; at the most distal end there is also a flake removal starting from the inside of the point and rolling off of the longer more preserved half of the point

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mm deep, < 2 mm wide, respectively (Figure 4.16b). These grooves span 33% and 49%, respectively, of the entire length of the point. Midsegment 6825 is also bi-grooved, though the morphology of each groove varies slightly (Figure 4.16a). One groove is narrower, with a V-shape, measuring only 1.74 mm wide, while the alternate groove is wider with a squared base of a U-shape groove and is 2.07 mm wide and 2.37 mm deep. Proximal fragment 6816 is bi-grooved with a long impact burination removal originating at the distal tip, with a step terminating fracture in the break on one face of the fragment (Figure 4.16f). At the most distal end there is also a flake removal bending off the alternate face of the point. Distal fragment 6823 is a bi-grooved distal point fragment refit from two pieces with two V-shaped grooves extending through the proximal break (Figure 4.16e). Distal fragment 6827 is also bi-grooved with V-shaped grooves that extend through the distal tip of the point (Figure 4.17g). No diagnostic impact fractures were identified on either of these fragments.

4.5 Discussion

Based on the descriptions and analyses of the osseous artifacts presented above, we now revisit the questions posed at the outset of the paper.

What is the range of morphological variability in middle Upper Paleolithic, late Upper Paleolithic, and Mesolithic osseous projectile-point assemblages? Do these morphologies change over time? Is morphological variation tied to raw-material selection?

Though our sample of MUP osseous projectile points and tools is relatively small, interesting raw-material selection, manufacturing, and morphological patterns were observed. The use of ivory as a primary raw material of manufacture at Mal'ta (64% of the osseous artifacts analyzed) is a distinct difference from raw-material selection patterns observed in more task-specific sites of the LUP and Mesolithic assemblages. The Mal'ta assemblage also contains the only observed artifact produced from rhinoceros horn (*Coelodonta antiquitatis*). Contrary to the evidence from Mal'ta, however, ivory was absent from the Novoselvo-13 osseous point assemblage. Instead, all of these points were made on bone and antler. The lack of ivory in the Novoselvo-13 assemblage is particularly interesting considering the faunal assemblage contains mammoth elements (Abramova 1979b; Lisitsyn 2000).

Most of the LUP osseous projectile points and tools included in this project were produced on bone (70%), with much smaller amounts of antler (19%), ivory (6%), and indeterminant raw materials (5%) present across all seven assemblages. Although this suggests a predilection toward the use of bone, this raw-material distribution is heavily weighted by the large Kokorevo-I, Kokorevo-II, and Maina assemblages. The smaller assemblages from Afontova Gora-II, Bol'shoi Iakor, and Kurla-III are alternatively characterized by higher proportions of antler points than bone points, and Ui-II also contains antler points.

The 'co-dominance' of bone and antler in LUP assemblages has been documented by other studies (e.g., Derev'anko 1998). This repeated pattern, along with a lower reliance on ivory and horn, is likely related to woolly rhinoceros becoming extinct early and mammoth becoming more scarce during the late glacial, as well as the strong LUP focus on reindeer hunting, especially in the Yenisei and Baikal areas (Graf 2013; Vasil'ev 2003). Reindeer antler is a suitable material for osseous-point manufacture during specific seasons and stages of the annual growth cycle, while 'green' (freshly harvested) bone can be worked whenever harvested (Guthrie 1983). Exploitation of large populations of reindeer meant that LUP foragers had ready access to bone for the production of osseous tools, and this could have been supplemented with antler during the late summer and fall when it was available. Thus, in addition to subsistence resources, this raw-material procurement strategy should be considered when defining economies, technological organization, and mobility strategies of LUP foragers in Siberia and Beringia. Further investigations of raw-material selection patterns in the LUP from different regions of the mammoth-steppe, where different regional economies may have existed across space and through time, will create a clearer picture of LUP forager raw-material selection patterns.

LUP assemblages presented the most morphological variation encountered in this project, not surprising given the large sample size for this period. When observing the cross sections and proximal-base morphologies of osseous elements of LUP hunting implements, three broad categories of morphological variation emerge: (1) massive bases 'lozenge'-shaped in profile (e.g., Figure 4.5c) (similar to those observed in European Gravettian assemblages; Knecht 1993), (2) spindle-shaped points with cylindrical cross-sections and rounded bases (e.g., Figure 4.5f); and (3) points lenticular in cross section, which were frequently grooved and beveled at the base (e.g. Figure

4.8e). Lozenge-shaped points and beveled-based lenticular points were largely manufactured from osseous raw-material blanks split in half along their length, then formed through longitudinal abrading and grinding. The curvature of the diameter of the osseous blank dictated the final cross section of these points. Spindle-shaped points were manufactured from a segment of antler or bone shaped by longitudinal abrading, but, unlike in lozenge-shaped or lenticular points, material was removed from all surfaces simultaneously, eliminating the flat lateral edges clearly visible in other point morphologies. Experimental testing of lozenge-shaped point morphologies identified in Gravettian sites suggests that these points were hafted into “U”-shaped housings produced in the distal ends of foreshafts or main spear shafts (Knecht 1991, 1994), However, no such foreshafts were identified in the analyzed Siberian samples. Alternatively, spindle-shaped points were likely hafted by inserting the tapered, rounded proximal end of the point into an open socket in spear mainshaft or foreshaft, creating a seamless contact designed to decrease the drag produced by the full projectile as it penetrates a target (Goutas 2016). The beveled projectile-point bases were likely integrated into “hafting-by-contact” systems in which flat planes of the point and foreshaft (or mainshaft) were brought into contact and bound by mastic and binding (Pètillon 2006; Goutas 2016), as shown in Figure 4.8b. Beveled hafting systems are mechanical adaptations suggested to reduce damage to foreshafts and mainshafts of spears (Pètillon 2006; Goutas 2016), a consideration of special importance to highly mobile LUP foragers with technological organization emphasizing curation and maintenance (Goebel 2002; Graf 2013). This morphological variability in LUP osseous-point form, along with the equally variable approaches to hafting technology represented in their bases and identified foreshafts, should be experimentally investigated.

The small sample size of early-Holocene osseous projectile points analyzed in this study limits an assessment of Mesolithic raw-material selection pattering and morphological variability. However, the full record of osseous projectile points dated to the early Holocene, especially from eastern Beringia, is quite limited. Foragers at the Zhokhov site utilized a full range of osseous materials in the production of hunting toolkits (Pitulko et al. 2015). In a robust site assemblage comprised of 54,000 faunal elements, 19,000 lithic artifacts, and 400 modified artifacts of antler, mammoth ivory, bone, and wood, representation of osseous tools at Zhokhov is unparalleled in the Siberian and Alaskan Arctic. In the very small sample of Zhokhov points available for analysis, artifact morphology was largely related to raw material of manufacture. Ivory points and spears were quite robust, while points manufactured on antler and bone were considerably smaller. All grooved osseous points were manufactured using a split-and-abrade technique, with grooves manufactured through repeated incisions after the margins of the point had been established. The large ivory spear tip, N532, was detached from a large ivory core by exfoliation and wedging, then shaped through abrasion to a distal point and rounded proximal base (Pitulko et al. 2015). Trail Creek Cave-2 represents a dramatically different site type than the extensive occupation at Zhokhov (Larsen 1968; Lee and Goebel 2016). it is a partially open-air site associated with a small limestone cave on the Seward Peninsula of western Alaska, which was revisited by foragers through the Holocene (Larsen 1968; Lee and Goebel 2016). The small assemblage of osseous projectile points with high expended utility, however, still represents the most robust assemblage of osseous projectiles in the early Alaskan archaeological record (Hoffecker and Elias 2007; Lee and Goebel 2016). All seven points in this assemblage were produced on antler, bi-grooved, and beveled at the base (where the base is preserved). These points are often referred to as 'arrowheads', though use studies of these points, and experimental testing of small bi-grooved point morphologies more generally, have been limited (Maschner and Mason 2013; but see Lynch n.d.). Manufacturing wear on these points has been largely obliterated, though proximal bevels were created through abrasion and grinding. Grooves were manufactured through repeated linear incising, resulting in narrow, deep 'slots' with U- and V-shaped morphologies. The point assemblage from Trail Creek Caves-2 has come to be representative of a small, grooved point form in Alaska, though other terminal-Pleistocene assemblages have produced larger antler and ivory point preforms suggesting multiple osseous point morphologies could be present in Paleoarctic toolkits (Ackerman 1996, 2011; Graf and Bigelow 2011; Graf and Buvit 2017; Holmes 1996, 2011; Holmes et al. 1996; Potter et al. 2014; Potter et al. 2017; Wygal et al. 2018).

Are certain morphologies more likely to have served specific functions (i.e., as hand-thrust spear points vs. tips of spear-thrower darts vs. alternate, non-weapon functions)?

Though the MUP sample presented here is too small to definitively conclude whether certain morphologies served specific functions, several interesting observations are suggestive of morphological function and warrant future study. For example, it is notable that the small Novoselovo-13 assemblage appears to reflect hunting toolkits based on the morphology of distal point fragments. These artifacts indicate resource extraction behaviors at task-specific hunting sites, different than behaviors exhibited at the Mal’ta residential site. At Mal’ta, there is increased osseous variability, but a lack of finished hunting tool elements such as those seen at Novoselovo-13. If there is indeed no connection between observed morphology and site function, we might expect to see similar osseous variability in both residential and task-specific sites, which is not the case at Novoselovo and Mal’ta.

Among the seven analyzed LUP assemblages, 63% of the artifacts with lenticular cross sections, which are traditionally considered ‘projectile points’, were ungrooved, though this includes many artifacts only represented by small proximal and distal fragments, the overall morphologies of which were difficult to determine. Many of these ungrooved artifacts, however, are morphometrically similar to foreshafts, like those recovered from Component 3 at the Upward Sun River site in central Alaska, the Yana site complex, and Clovis ‘rods’ in temperate North America (Pearson 1999; Pitulko et al. 2014; Potter et al. 2014). These LUP foreshafts are lenticular in cross section and bi-beveled on the exposed trabecular bone surface, they have relatively robust widths and thickness, and their margins were created through abrasion. Length is variable and difficult to analyze because of their fragmentary nature, but several complete and midsegment artifacts identified as possible foreshafts exceed 200 mm in length. A number of these artifacts are also incised with parallel and cross-hatched scoring along the trabecular face of the foreshaft, the same axis as both bevels.

Among the seven LUP assemblages analyzed for this project, 26% of the osseous points were grooved on one lateral margin to facilitate the insetting of lithic microblades, while only 10% of the points analyzed were grooved along both lateral margins. Points and point fragments with one groove tended to be more robust than bi-grooved points, the former with a mean width of 14.79 mm (SD 5.9) and mean thickness of 8.05 mm (SD 1.8), compared to a mean width and thickness of 13.15 mm (SD 4.2) and 7.695 mm (SD 2.1), respectively. Despite difference in robusticity, both forms of projectile points were manufactured through similar splitting and abrading techniques, and similarly grooved through repeated, convergent scoring with sharp, narrow lithic implements, presumably lithic flakes (e.g., Figure 4.9i) (Graf 2013).

The large number of bone points with only a single groove has major implications for our understanding of the technological organization of the osseous hunting tool kit in the LUP. First, it should be considered that the more robust, single-grooved points and their fragments likely represent hand-delivered spears. Hand-thrust or thrown spears are subject to less force at the point of impact than those launched from a spear thrower, resulting in less catastrophic failure during impact (Lynch n.d.). Additionally, hand-thrust or thrown spears are typically deployed at close range in disadvantaged hunting situations, using techniques that limit the escape of the animal or exploit a naturally disadvantaged animal so that the hunter has more time to employ the weapon, decreasing the probability of total point loss and increasing the curation of maintainable osseous technologies that represent significant time investments to Beringian foragers (Bonnichsen 1979; Guthrie 1983). Moreover, manufacturing a complete, functional composite point with only one groove may represent an aspect of lithic raw-material conservation and curation observed widely in LUP lithic assemblages combined with the structural features of bone that allow this osseous raw material to maintain sharp cutting edges better than antler or ivory (Goebel 2002; Graf 2010; Guthrie 1983).

Though our sample of MUP organic projectile points and tools is relatively small, interesting raw material selection, manufacturing, and morphological patterns were observed. The use of ivory as a primary raw material of manufacture at Mal'ta (64% of the organic artifacts analyzed) is a distinct difference from raw-material selection patterns observed in more task-specific sites of the later LUP and Mesolithic assemblages. The Mal'ta assemblage also contains the only observed artifact produced from rhinoceros horn (*Coelodonta antiquitatis*). Contrary to the evidence from Mal'ta, ivory was absent from the Novoselvo-13 organic point assemblage. Instead, all of these points were made on bone and antler. The lack of ivory in the Novoselvo-13 assemblage is particularly interesting considering the faunal assemblage contains mammoth elements (Abramova 1979b; Lisitsyn 2000).

As in MUP assemblages, a majority of wear observed on LUP osseous points and tools is related to manufacture. It is significant, however, that manufacturing techniques are largely consistent from the MUP through the LUP. Consistent manufacturing techniques are possibly related to the nature of shaping osseous raw material to produce projectile points, which inherently limit the morphological range of efficient, effective points, but also suggests conservative hafting technology and stable weapon-system designs through the Upper Paleolithic (Campana 1989; Olsen 1984). Cumulative taphonomic and curation processes affect the preservation of function-related wear in osseous projectile points more than lithic points; however, 22 points and foreshafts observed in LUP assemblages show clear signs of impact-related damage. Step fractures bending through distal breaks and crushing of distal tips were the most frequently-documented indications of impact damage, though a lesser amount of hafting-contact damage was also observed. In more robust, lenticular osseous tools interpreted as foreshafts, proximal and distal snaps with bending step fractures or large flake removals are indicative of breaks resulting from sheering or flexing forces, additional signs of catastrophic failure during use.

Mesolithic osseous point assemblages demonstrated a higher frequency of use wear related to impact than assemblages in the MUP and LUP. Distal crushing, large ‘flute-like’ flake removals, and bending hinge fractures with step terminations were present in both assemblages. The Trail Creek Cave-2 artifacts in particular show signs of extensive damage through impact, leading some to suggest these features resulted from bow-and-arrow technology (Ackerman 1996; Machsner and Mason 2013). As Lynch (n. d.) found, however, such damage could be due to their use as atlatl tips. Site function is likely one factor influencing the high level of impact damage in both assemblages. The Zhokhov site is a primary resource-extraction and initial-processing locality where foragers targeted reindeer and denning polar bears during the spring and summer seasons (Pitulko and Kasparov 2017; Pitulko et al. 2015). Trail Creek Cave-2, however, was likely only occupied during brief re-tooling and hunting-toolkit-maintenance events, though the radiocarbon chronology established through direct dating of the tools suggests the site area was occupied more than once (Lee and Goebel 2016). The higher level of expended utility observed in the Trail Creek Cave-2 assemblage may relate to differential raw-material availability constraints, a pattern observed in Magdalenian osseous projectile-point assemblages (Langley 2015), a situation in which the Trail Creek Cave-2 occupants did not have ready access to osseous raw material like at Zhokhov.

Are cultural application spaces recognizable in osseous artifact assemblages?

The well-preserved osseous tool assemblage from Mal'ta offers a rare opportunity to investigate an osseous toolkit in the context of a 24,000-cal-BP MUP human burial and residential site (Gerasimov 1964; Richards et al. 2001) Decorative modification is present in the osseous 'hunting' toolkit at Mal'ta, associated with the burial, in three forms. First, both ivory 'rods' displayed extensive parallel and cross-hatched scoring (Figure 4.3). Second, rounded, evenly-spaced pocking overlies the cross-hatched scoring on artifact 370/669/135 (it should be considered that these pock marks a osteons) (Figure 4.3a-b). Third, artifact 370/666, the large rhinoceros horn "dagger" interred directly with the Mal'ta individual, is likely a ritual object, rather than a functioning component of a toolkit. While the condition of the artifact prevents detailed use-wear analysis, this is a rare example of a tool manufactured on the horn of a wooly rhino in the Siberian archaeological record and bears little morphological resemblance to the rhinoceros-horn foreshaft from the Yana RHS site (Pitulko et al.

2014), considered by Nikolskiy and Pitulko (2013) to represent one of numerous specially-designed artifacts, mostly full ivory-tusk spears, in a functioning hunting toolkit. The special raw-material and design features of the Mal'ta assemblage likely reflects their ritual context as grave goods in an MUP burial.

Multiple decorative modifications to osseous projectile points in LUP assemblages were documented, including scoring perpendicular to the long axis of points, often spanning both margins of functional grooves, parallel and crossing

Figure 4.12 LUP point decoration: (a) Korokevo-II point 7450-19 with parallel incised lines oriented with long axis of point face; (b) Korokevo-II point 7450-20 with single incised line oriented with long axis of point face; (c) Kurla-III foreshaft with possible feather or leaf motif (representative of fleshing?).

incisions on trabecular surfaces of lenticular points, and linear scoring on one face of bi-grooved projectile points (Figure 4.17). Five bone artifacts (7949-2, 7450-17, 7450-23, 7450-25, 7450-28) from the Kokorevo-I and Kokorevo-II sites and point 141-639 from Afontova Gora-II are scored with a series of small grooves perpendicular to the deep groove cut for insetting lithic microblades. These small decorative grooves were generally triangular (V-shaped) in profile, shallow, and present on both long 'faces' of the points, bisecting both margins of the larger, functional grooves (Figure 4.17a). Complete point 7450-19 in the Kokorevo-II assemblage is grooved with parallel lines on the face of the point (Figure 4.17a). These grooves are triangular and shallow, manufactured using the same scoring technique as those designed for insetting lithic microblades; however, these lines are not overlapping or convergent and are scored into the face of the point. A similar decorative feature is documented on point 7450-20 from Kokorevo-II, a single incised line along the face of one point from the distal break nearly to the proximal end of the point (Figure 4.17b). This single incised line is similar to the decorative grooves incised along the length of both faces of the iconic grooved-and-microblade-inset projectile point from Chernoozer'e II in western Siberia (Gening and Petrin 1985).

Only one example of decorative modification to osseous hunting toolkits was documented in the analyzed Mesolithic assemblages. Large ivory point N625 in the Zhokhov assemblage was scored on one face with two parallel lines running perpendicular to the long axis; this scoring is partially obscured by the proximal break.

Reports describing the full Zhokhov assemblage highlight additional morphological variability but do not particularly describe other forms of decorative incising (Pituko et al. 2015). Although the points from Trail Creek Caves-2, Ilnuk, and Lime Hills Cave are not obviously decorated, the Upward Sun River foreshafts are (Potter et al. 2014). Thus, although osseous components of hunting toolkits remained important components of early-Holocene peoples in Beringia, they do not appear to have conveyed the same cultural meaning as during the MUP and LUP, except in rare ritualized cases.

Osseous material culture is an ideal medium for exploring cultural variability, as not only do these artifacts have widespread social, economic, political, and symbolic importance (Wiessner 1983), but also they are highly visible to foragers familiar with the individual carrying the implement, as well as those encountered on the landscape during the course of subsistence activities (Tostevin 2007). This visibility makes osseous points prime candidates for use in transmitting social messages to those in 'the middle distance' (Wobst 1977), and thus, they are not often more than mere "hunting tools". Additionally, while these tools were carried around the landscape by an individual, their manufacturing techniques and morphologies were guided by a community of practice (Dobres and Hoffman 1994). Consequently, forms and use should have conformed to cultural ideals regarding manufacturing techniques, morphology, use, and discard. I contend that because the production and use of osseous hunting toolkits occurs within cultural parameters, they can be utilized as a central element for investigating cultural variability in the Paleolithic.

4.6 Conclusions

There are distinct differences among the osseous projectile technologies of the Siberian MUP, LUP, and Beringian Mesolithic. While manufacturing techniques are largely stable through time and determined by raw material, the points' overall morphologies and functions were highly variable. Ivory appears to have occupied a more central role among MUP foragers' projectile-point production than in later Siberian and Beringian contexts, perhaps in relation to changes in ecology and human subsistence and mobility during the collapse of the 'classic' mammoth-steppe ecological regime (Graf 2013; Vasil'ev 2003). Although not directly analyzed here because of small sample sizes, in the MUP osseous toolkits with high intersite variability support suggested logistically-organized land-use patterns (Graf 2010). Additionally, the best evidence of ritual behavior in the Siberian Upper Paleolithic record comes from the Mal'ta burial context where human remains were found in clear association with buried funerary objects. While such sites are rare, burial sites have provided important insights into Paleolithic, Paleoarctic and Paleoindian ritual practices. For example, at the Upward Sun River site two infant burials dating to ~11,500 cal BP were identified interred in a pit feature with associated lithic and osseous grave goods (Potter et al. 2014; West 1996). The grave goods recovered include four bibeveled wapiti antler foreshafts directly associated with lanceolate Denali-complex bifaces, all coated in ochre (Potter et al. 2014). The lithic bifaces are morphometrically similar to Denali bifaces recovered in non-burial contexts and suggest that the grave-good assemblage reflects components of a 'functional' Denali hunting tool kit (Potter et al. 2014). Assuming these artifacts are ‘functional’ in nature, it is significant that three of the four foreshafts are also decorated with crossing scoring that create a series of x-shaped incisions along the trabecular faces of the artifacts, the same face as both bevels on each foreshaft. Overall, this pattern is similar to what is observed at the Paleoindian Anzick site, Montana, where the remains of an infant, radiocarbon dated to approximately 12,600 cal yr BP, were found in association with a diverse assemblage that included biface fragments, hypertrophic and ‘typical’ projectile points, flake tools, unmodified flakes, a blade, and bone rod fragments (Fiedel 2017; Jones and Bonnichsen 1994; Owsley and Hunt 2001; Rasmussen et al. 2014; Wilke et al. 1991). Expressions of culture are preserved on osseous artifacts interpreted as functional and interred as grave goods across the Upper Paleolithic record, and special consideration should be given to such artifacts.

Increased mobility and site-specific targeting of reindeer, horse, and bison by foragers in the LUP heavily influenced their osseous raw-material-selection patterns. These behaviors were likely adaptive responses related to unique ecological conditions. For example, access to bone as a raw material at sites in the Yenesei would have functioned as an important raw material resource for mobile LUP foragers who had less-predictable and limited access to other organic materials like wood, and may have had to strategically plan for seasonal constraint of lithic toolstone due to winter snow cover, frozen ground, or frozen alluvial sources such as drainages creeks and rivers. The conservative, curated formalization of lithic toolkits during the LUP is further reflected by the production of single and bi-grooved osseous projectile points and robust foreshafts (Goebel 2002; Graf 2010). Foragers expanding into the High Arctic during the early Holocene at the Zhokhov site utilized a broad spectrum of osseous raw materials to produce widely variable point morphologies as part of hunting toolkits, while the Trail Creek Cave-2 assemblage was dominated by small, bigrooved antler points, though expanded samples are needed in western and eastern Beringia to establish fuller understandings of raw-material selection patterns and point morphologies in the early Holocene. Despite the established variability in MUP, LUP, and Mesolithic assemblages, osseous tools represent an ideal medium for documenting cultural variability through time. Non-utilitarian modifications, i.e. decorative elements, were documented on points and foreshafts in each major period, and expanded samples of these types of cultural modifications offer a unique window into Upper Paleolithic culture exclusive to osseous technologies.

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5. CONCLUSIONS

5.1 Introduction

The previous sections cover a series of diverse yet related topics relating projectile-point morphology, osseous-toolkit organization, use-wear data, and site assemblage variability, considering how they relate to functional and cultural application spaces of prehistoric hunting technologies. Data used to explore these topics are drawn from novel experimental testing, buried and mutli-component archaeological sites located in the Blair Lakes Archaeological District in interior Alaska, and osseous artifact assemblages from eleven Siberian and Beringian archaeological components dating to the middle Upper Paleolithic, late Upper Paleolithic, and Mesolithic periods. In Section 2, experimental testing of lithic-bifacial, simple-osseous, and composite-inset projectile-point forms observed in the Beringian record as arming elements of three weapon-delivery systems facilitated quantitative comparisons of efficiency and lethality performances for each individual combination of weapon system and projectile-point morphology. Results indicate lithic-bifacial and composite-inset projectile points are respectively most effective when hafted as spear-thrower points and hand-thrust spear tips. In a general sense, the experimental results better define functional characterizations of prehistoric hunting toolkits, furthering our understandings of adaptive responses to resource fluctuation, landscape use, and technological organization. Section 3 updates the geochronology and occupation record of the Blair Lakes Archaeological District, specifically the northern shore of south Blair Lake, confirming regional occupations that began nearly 11,000 calendar years ago and continued through the historic period. These results demonstrate the significance of the Blair Lakes Archaeological District in enhancing our understanding of late-Pleistocene and Holocene technological variability, site distribution, mobility, and landscape use in interior Alaska. Finally, this research concludes with a comparative technological, morphological, and functional analysis of eleven osseous artifact assemblages from Upper Paleolithic and Mesolithic sites across Siberia and Beringia, identifying relationships between raw material, point morphology, and function. Results show that raw material significantly influenced point morphology, morphological variability increased during the late Upper Paleolithic, and osseous artifacts offer an avenue for exploring prehistoric culturally-influenced design elements.

Ultimately, this dissertation provides insight into functional and cultural application spaces of Beringian projectile points, providing a better understanding of prehistoric hunting tool kits and technological organization of Beringian foragers and the relation of these adaptations to changing ecological conditions.

5.2 Experimental Testing of Beringian Projectile Point Morphologies

Traditional interpretations of the relationship of thrusting spears, spear throwers, and bows portray these weapon systems as mutually exclusive or as sequential stages of technological development and replacement driven by diffusion (see Knecht 1997; Whittaker et al. 2017). Recent research, including this dissertation, has moved away from a diffusionist approach in favor of a more evolutionarily- and ecologically-driven characterization of each weapon system by weighing respective costs and benefits dependent on context and tasks at hand (Cattelain 1997; Cundy 1989; Grund 2017; Shott 1993). Further, the experimental project presented here tested the relationships between projectile-point forms and three weapon-delivery systems: (1) dart points launched with a spear thrower, (2) arrow tips shot from a bow, and (3) spear points arming thrusting spears. Thirty-six Beringian projectile points, twelve of each form, were shot, launched, and thrust at an actualistic target to (1) identify differences in wound ballistics created by each combination of point form and weapon system; (2) assess the relative lethality of each point and weapon combination through proxies of penetration, wound type, and total wound area bolstered by the use of an actualistic target; and (3) systematically documented the function, performance parameters, and potential application spaces of ancient hunting technologies. Experimental testing results indicate that robust lanceolate bifaces were most effective when launched from a spear thrower, creating large total wound areas, ideal for dispatching medium-to-large-bodied game. Composite antler points inset with lithic microblades functioned most effectively as arming elements of hand-thrust spears navigating between protective skeletal elements and creating lethal laceration wounds. Simple osseous points produced the most consistent penetration and total-wound-area results across all three weapon systems; however, these points produced less lethal puncture wounds but were highly durable and often survived multiple impacts.

Better understanding of the relationships between projectile-point forms and specific prehistoric weapon systems have significant implications for interpreting technological organization, hunting toolkits, mobility, and land-use patterns in Upper

Paleolithic, Paleoarctic, and Paleoindian populations. The results of this experiment directly contribute to the understanding of application spaces of Beringian point classes and weapon systems, specifically in central Alaska where reported site locations, faunal data, and lithic assemblages provide support for these interpretations of behavioral use context. In a behavioral-ecology framework, weapon systems represent a series of deliberate design decisions made by the users to maximize the efficiency and effectiveness of their hunting toolkits (Torrence 1989). The functional characteristics of projectile points established in this experiment illuminates the repeated associations of microblade technology and bison faunal assemblages in lowland and lakeshore settings as well as the strong association of lanceolate bifaces with caribou and Dall sheep in montane and upland zones (Potter et al. 2011; Wygal 2011). Results also suggest that upland application spaces would have been ideally suited for foragers using lithic bifaces and spear throwers practicing approach and ambush hunting in the open and parkland landscapes of the Alaska Range foothills and alpine tundra (Guthrie 2017; Potter et al. 2011).

5.3 Holocene Landscape Use and Site Assemblage Variability in Interior Alaska

Despite promising results from initial archaeological survey and testing, the Tanana Flats of Interior Alaska remain understudied, especially in comparison to the nearby middle Tanana River valley and Nenana valley. The area has long been utilized by U.S. Army Garrison Alaska (USAGAK) as a training area, resulting in a series of cultural-resource-management surveys and small-scale excavations starting in the 1970s that identified dozens of sites in the region suggesting widespread human use of the area since the late Pleistocene (Dixon et al. 1980; Esdale et al. 2016; Gaines et al. 2011; Goebel et al. 2016). Section 3 provides a new evaluation of the geochronology and occupation history of the Blair Lakes Archaeological District, specifically occupations of the northern shore of south Blair Lake. Excavations along this lakeshore and associated topographic features within the Blair Lakes Archaeological District have identified dozens of prehistoric archaeological sites spanning from the late Pleistocene through the late Holocene, including sites positioned on relic terrace edges and multiple multicomponent, residentially-oriented occupations in lakeshore settings at SBL-1 and SBL-2. Taken together these results provide a record of use of elevated and lowland locations within the Tanana Flats, including hunting overlooks and localities of secondary lithic production or tool maintenance, throughout the Holocene, consistent with interpretations of technological and behavioral continuity in Interior Alaska and southwest Yukon during the mid to late Holocene (Bowers 1999; Easton et al. 2011; Holmes 1986; Holmes and Bacon 1982; Holmes et al. 1996; Potter 2008; Workman 1978). The laterally extensive evidence of human occupation along the shoreline of the lake indicate that south Blair Lake was a focal point on the landscape for Holocene foragers. From this base, the Holocene foragers were logistically connected to the numerous extraction sites dispersed across the district. Our combination of survey and block excavation strategies provides an important landscape perspective on the variability of hunter-gatherer technological, subsistence, and settlement organization.

5.4 Assessing Siberian and Beringian Osseous Projectile-Point Variability

Experimental testing detailed in Section 2 generated a use-wear sample instrumental in the comparative analysis exploring the morphological and functional variability of osseous projectile weapons recovered from 11 Siberian and Beringian archaeological sites presented in Section 4. That section presents the results of morphological and use-wear analysis of 163 MUP, LUP, and Mesolithic projectile points and osseous tools, among the first attempts to create a pan-Siberian/Beringian perspective on early osseous projectile technology and use, building on the earlier work of Ackerman (2011), Dixon (2011), Pitulko et al. (2015), and others.

There are significant differences among the osseous projectile technologies of the Siberian MUP, LUP, and Beringian Mesolithic. While manufacturing techniques are largely stable through time and determined by raw material, projectile points' overall morphologies and functions were highly variable. Ivory occupied a more central role among MUP foragers' projectile-point production than in later Siberian and Beringian contexts, perhaps in relation to changes in subsistence and mobility during the collapse of the 'classic' mammoth-steppe ecological regime (Graf 2013; Vasil'ev 2003). LUP osseous hunting tool kits incorporated the most morphological variability documented in this study, and included three major morphological forms: (1) massive 'lozenge'-shaped bases, similar to those observed in European Gravettian assemblages (Knecht 1993), (2) spindle-shaped points with cylindrical cross sections and rounded bases, and (3) points lenticular in cross section, which were frequently grooved and beveled at the base. Lozenge-shaped points and beveled-based lenticular points were largely manufactured from osseous raw-material blanks split in half along their lengths, then formed through longitudinal abrading and grinding. The curvature of the diameter of the osseous blank dictated the final cross-section of these points. Spindle-shaped points were manufactured from a segment of antler or bone shaped by longitudinal abrading, but, unlike in lozenge-shaped or lenticular points, material was removed from all surfaces simultaneously, eliminating the flat lateral edges clearly visible in other point morphologies. Despite the established morphological variability in MUP, LUP, and early Holocene assemblages, osseous tools represent an ideal medium for documenting cultural variability through time (Wiessner 1983). Non-utilitarian modifications, i.e. decorative elements, were documented on points and foreshafts in each major period. The well-preserved osseous tool assemblage from Mal’ta offers a rare opportunity to investigate an osseous toolkit in the context of a 24,000-cal-BP MUP human burial and residential site (Gerasimov 1964; Richards et al. 2001). Decorative modification is present in the osseous ‘hunting’ toolkit at Mal’ta associated with the burial, in three forms: (1) extensive parallel and cross-hatched scoring, (2) pocking; and (3) the inclusion of a ‘dagger’ produced on rhinoceros horn in direct burial contexts. Decorative elements were most prevalent in LUP assemblages and included repeated occurrences of series of incisions perpendicular to utilitarian grooves, scoring of trabecular surfaces of bone tools, and linear scoring on one face of grooved projectile points. Expanded samples of these types of cultural modifications offer a window into Upper Paleolithic culture exclusive to osseous technologies (Dobres and Hoffman 1994; Wiessner 1983).

5.5 Future Studies

Early studies of inter-assemblage variability in Beringia focused on the presence/absence of lithic technologies, specially microblade technology, leading to the interpretation of technological complexes that were chronologically and culturally discrete (Dixon 1985; Goebel et al. 1991; Hoffecker et al. 1993; Pearson 1999; Powers and Hoffecker 1989; West 1996). New research, however, has questioned the normative significance of the presence/absence of microblades, with archaeologists developing behavioral models to explain the variable projectile technologies, including seasonality, site-specific or prey-specific activities, and raw-material conservation as contributing variables (Elston and Brantingham 2002; Gal 2002; Goebel and Buvit 2011; Potter 2008, 2011; Potter et al. 2017; Rasic 2011; Rasic and Andrefsky 2001; Wygal 2009, 2011, 2017). These are often based on ethnographic descriptions of projectile technologies and weapon-delivery systems (e.g., Potter 2011) as well as replicative studies, many of which have underreported methodologies. Additionally, the use of osseous material to produce hunting toolkits implies a technological-organization strategy separate from, though often co-occurring with, an organizational strategy focused on lithic bifacial reduction (Elston and Brantingham 2002; Graf 2010; Potter 2005, 2008, 2011; Rasic 2011; Rasic and Andrefsky 2001; Wygal 2011). This variability necessitates the expanded experimental testing of osseous projectile-point technologies.

Moreover, experimental exploration of full weapon systems and osseous hunting toolkit components reflective of Beringian technology is needed to create a more robust understanding of variability in technological organization, land use, and subsistence patterns. Recent discoveries in the North, such as the antler foreshafts discovered at Upward Sun River and full atlatl darts recovered from ice-patch contexts in the Yukon provide a substantial opportunity for a new wave of experimental testing with increased confidence in the replication of Holocene osseous hunting toolkits (Hare et al. 2014; Potter et al. 2014;).

Additional survey, testing, and excavations in understudied landscapes across Beringia is an important way to establish better understandings of technological variability, landscape use, and mobility patterns in the late Pleistocene and early Holocene. Archaeological sites identified outside of the well-explored Tanana and Nenana valleys will continue to expand the occupation record of eastern Beringia and provide a more holistic understanding early Alaskan foragers' adaptions to varied ecological niches (Blong 2018; Krasinski 2018). Specially, initial and expanded testing results from sites across the Tanana Flats, including those along the northern shore of south Blair Lake, FAI-2043, and the Wood River Buttes, indicate that this region was occupied immediately following the initial colonization of interior Alaska and remained an important area for humans through the Holocene (Esdale et al. 2016; Goebel et al. 2016). Lakeside residential occupations in Interior Alaska are quite rare, and our excavations at SBL-1 and SBL-2 have only begun to fully document nearly the 11,000 years of occupation history there.

Finally, continued studies of osseous and composite projectile points and osseous hunting toolkit components on a Beringia-wide scale will provide a better understanding of the full range of morphological variability and the functional roles of these tools in larger technological-organization patterns. Despite the variability documented in Section 4, this analysis was limited by small sample sizes in MUP and Mesolithic assemblages. Even the more robust LUP sample represents only a small fraction of the total osseous assemblage variability present in the dozens of well-preserved LUP site assemblages already excavated across northern Asia. The application of additional methodologies such as protein analysis, direct radiocarbon dating, and high-power microscopic analysis will greatly expand our understandings of osseous technology at the level of individual tools, and expanded samples of Siberian and Beringian osseous-point assemblages will provide additional frameworks for establishing regional and temporal changes and trends in osseous toolkit organization.

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