# SAND DUNE FIELD PALEOENVIRONMENT, PALEOECOLOGY, AND HUMAN ENVIRONMENTAL INTERACTION IN THE MIDDLE TANANA RIVER VALLEY NEAR THE GERSTLE RIVER, SUBARCTIC ALASKA: THE LATE GLACIAL TO THE MIDDLE HOLOCENE

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of

Master of Arts
In
Anthropology

University of Alaska Fairbanks
August 2017

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# Abstract

This study was conducted to explore paleoenvironmental change within the Gerstle-Sawmill Dune Field (GSDF), located just west of the Gerstle River in the middle Tanana River valley, Interior Alaska from the late Glacial to the middle Holocene. Specifically, this study was undertaken to document human-environment interaction on the landscape. Geoarchaeological methods were used in order to determine the history of sand dune development across the area, how the local ecological systems changed through time, and determine prehistoric human use of environment and response to environmental and ecological change. The data collected from these locations was used to create a model for sand dunes and human land use regarding local ecological stability and dynamic sand dune deposition. Patterns of human land use within the GSDF were then compared with data collected from sites in proximity to the GSDF to determine how this portion of the environment operated within the larger geographic area. This geoarchaeological research aids in understanding ecological patterning within terrestrial lowland systems from the Late Glacial to the Middle Holocene, with regard to human land use dynamics within a changing geomorphological system.

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# Chapter 1 Introduction

Hunter-gatherer behavior is reliant on the landscapes and environments with which they interact everywhere. This must be the case for people who directly use faunal, floral, and geological resources occurring naturally around them to sustain life. Landscape, as an aspect of environment, is very broad in definition and approach, but incorporates within it the dynamics of geography and geomorphology (Butzer 1982). Human interactions with geography and geomorphology are and were ever changing, both spatially and temporally, and are often as dynamic as geography and geomorphology themselves. In many cases, especially in Alaska, when archaeology uses paleoenvironmental reconstruction issues in spatial and chronological scale exist. In particular paleoenvironmental reconstructions tend to be at a smaller scale than applicable for archaeological interpretations. This creates gaps in interpretation from both the paleoenvironmental and archaeological perspectives. This study uses high resolution paleoenvironmental proxy data alongside similarly scaled archaeological data in order to reconstruct changes in environment and human land use through time. The Gerstle-Sawmill Dune Field (GSDF) represents a dry terrestrial valley lowland environment, whereas other archaeological and environmental studies in the middle Tanana River valley have been confined to either lakes and bogs or more highly elevated portions of the landscape.

Prehistoric human land use has been discovered and recorded in the middle Tanana River valley near the Gerstle River at the Gerstle River site dating as far back as around 11,000 Cal BP (Potter 2005). The lowest components at the North Gerstle Point site, located approximately 30 kilometers (km) (19 miles [mi]) to the northwest are approximated to be contemporaneous; however, these components still lack direct dating (Vanderhoek et al. 1997). Both sites appear to have operated as logistical spike camps for forays into nearby game rich locations (Potter 2005; Vanderhoek et al. 1997). Logistical spike camps function as temporary field camps where a number of activities may occur, including scouting for game and initial processing of acquired game prior to removing material to a residential base site

(Binford 1980; Potter 2005). Around these two sites exists a low lying region west of the Gerstle River referred to herein as the Gerstle-Sawmill Dune Field (GSDF). This area is a geomorphically dynamic landscape, within the Middle Tanana River valley where little archaeological study has been conducted. The area is comprised of a relatively large sand dune field that experienced periods of dynamic dune development and ecosystem development, and periods when landforms were stabilized with increased biological activity leading to more mature vegetation and soil growth (Reuther et al. 2012; Bowman 2016). Within the lower lying dune field there is a lack of research with regard to aspects of both prehistoric land use and subsistence practices. Close by at the Gerstle River site, a large quantity of processed large mammal faunal is present (Potter 2005); acquisition of these faunal resources may have taken place directly in the dune field area. Furthermore, little is known about the paleoecology and paleo-geomorphology of the area, as few studies have been conducted with an aim to understand its landscape history. Prehistoric landscape histories and environmental contexts are paramount to archaeological and hunter-gatherer research. Not only because they provide matrices in which prehistoric life existed, but because environment can have influence over human behavior. Different environmental contexts may influence decisions in resource acquisition with regard, but not limited to what portions of the landscape are best used for game acquisition (Albanese 1974). This factors into decisions regarding mobility (Grove 2009), and creates other factors both spatially and temporally that cause synchronic and diachronic variation in human behavior.

## 1.1 Interior Sand Dune Fields and Prehistoric Human Behavior

In non-coastal, interior settings, dune field systems are a function of many combined forces. Alluvial processes and colluvial forces are often at play even before aeolian processes can take hold. In coastal systems, dune fields are often even more complex, with many other factors contributing to development, deflation, and stabilization (Bloom 1998). From a formation perspective, three environmental characteristics are the most vital for the creation of sand dunes in interior settings; availability of a sediment source, relatively high degrees of aridity, and the presence of turbulent wind regimes (Bloom 1998). Dunes and dune fields take on many different shapes and sizes and can differ based on their proximity to water or mountainous areas. Valleys and location within valleys in which dunes and dune fields form also shape their creation. Differences in directionality of wind regimes dictated by valley constriction, over long periods of time, or seasonally, affect the morphology of dunes (Dijkmans and Koster 1990). Increases and decreases in moisture often cause dune building activity to increase or decrease (Dikmans and Koster 1990; Mann et al. 2002). In general though, dune and dune field formation leads to topographic change within a bounded portion of a landscape. This can lead to changes in local regimes of surficial moisture retention, vegetation development, and changes of animal abundance.

Humans have used these geomorphic features in many different ways. As dunes are free to move, divide, grow, and shrink during their active phases, local vegetation can be outcompeted by rapidly deposited sediment allowing for only the earliest successions of vegetation to form on them (Bloom 1998: 295). Animals attracted to these vegetation regimes may then gather in numbers to feed on these plant resources, creating predictable patterns for subsistence acquisition by humans (Reuther 2013). Dune relief also has the potential to offer promising advantages in hunting practice. Constriction of lower lying areas may cause moisture retention to increase in these areas, creating attractive watering and feeding locations for animals and those who prey on them (Albanese 1974). Constriction of lower lying interdunal areas may also cause animals to follow a path of least cost in search of vegetation and water. Humans can then use the higher crests of the surrounding dunes built to plan and execute resource extraction tasks (Albanese 1974). After the peripheral edges of dune fields are stabilized, dunes can also provide advantageous view sheds to surrounding portions of a landscape where residential bases or logistical spike camps can be located to scout for game and tactically plan its extraction (Potter et al. 2011). This is particularly advantageous in locations where a combination of dune fields and escarpments exist next to one another, such as that at the Upward Sun River site (Reuther 2013). Stabilized and even non-stabilized dunes with high relative elevations can also offer opportunities to establish short term occupation encampments at one particular time (Odess and Rasic 2007) or potentially repeatedly at the same optimal location (Holmes et al. 2008).

Research regarding prehistoric land use of dune fields in Alaska, such as those incorporated within this area, suggests differing patterns of land use through time. Some archaeological research suggests that parcels of dune fields within the Tanana River valley represent the residential portion of the prehistoric seasonal round with logistical hunting forays occurring within the dune fields and farther abroad (Potter et al. 2011), while research at other dune fields in the region suggests that these environments were used for solely for logistical hunting and resource procurement practices, with residential bases located elsewhere (Esdale et al. 2012; Gaines et al. 2011; Potter 2005; Reuther 2010, 2013).

## 1.2 Research Objectives

The purpose of this research is to provide new information on dunes for the geological, paleoecological, and prehistoric human land use history within the middle Tanana River valley, specifically within the Gerstle River drainage area. This research from the GSDF will also be incorporated into the local prehistoric subsistence and land use pattern system, spatially, through comparison with prehistoric and ethnographic data accumulated from sites and villages in proximity. Prehistoric land use of the area at different time periods will be equally addressed in order to produce an ecological model with regard to human land use and change over time. This research will be used to assess the role of the GSDF landscape within the general settlement system of prehistoric people in this region over time, and if its use changed in conjunction with environmental and ecological changes. In general, my research approach uses the geomorphic history of the GSDF landscape to assess potential changes in lowland environments and ecosystems in interior Alaska; this approach includes humans and their behavior as part of that ecological system. To accomplish this, it is necessary to document local changes in aeolian sediment deposition and erosion (deflation and subsequent movement) that denote landscape instability or alteration and disturbance, or change to ecosystems, soil formation indicative of landscape and ecosystem stability, and landform morphology (Aguilee et al. 2011; Albanese 1974; Hugenholtz et al. 2010; Hugenholtz and Wolfe 2005). In turn, the potential response of human behavioral systems (technological, subsistence, and settlement and mobility strategies) to landscape and ecological change will be approached through the framework of human behavioral ecology. In particular the use of optimal foraging and patch choice models are used to provide some idea of preference in subsistence pattern choice or subsistence location choice to potentially describe the use of dune and interdunal formations for hunting preference in regards to change through time.

The area around the GSDF, including the Gerstle River site, North Gerstle Point, and the Healy Lake basin, was used for faunal resource acquisition as part of the Native Alaskan subsistence seasonal cycle (Bowman 2015; Potter 2005; Reuther 2013; VanderHoek et al. 1997). It also contains at least one logistical procurement camp (Gerstle River Site [Potter 2005]) and at least one residential habitation (Old Healy Lake Village, presumed as a residential base by Cook [1969] through multiple components [Younie 2016]). The objective of this research is to identify whether this lower lying landscape actually functioned as a resource extraction location with hunting stations and if this function changed over time as the geomorphology, environment, and local ecology changed. Further, from limited previous examination of the archaeology within the GSDF, there appears to be a difference in abundance of preserved prehistoric material between the Sawmill Creek area and the Bison Range area (Bowman 2015; Reuther 2010). This research will attempt to address why this difference in archaeological material abundance exists. Both of these overarching objectives will be answered using the following, more specifically directed, research questions.

## 1.3 Research Questions

Several research questions will be addressed throughout this project:

1. Are technological changes through time within the GSDF related to environmental change? As the regional geomorphology of landscapes changed, so too did environments and ecosystems. Through time, different vegetative communities were represented within these low lying areas (tundra-steppe, riparian spread from the rivers, early deciduous forestation, and later mixed coniferous and deciduous forestation) and with these changes populations of faunal species changed (wapiti [elk] and bison extirpated and moose entering) (Bigelow and Powers 2001; Potter 2005, 2008a, 2011; Potter et al. 2013; Stephenson et al. 2001). With these changes do we see alterations to game acquisition technologies?
2. Given that the Gerstle River site shows that human land use occurred during both periods of dynamic sediment deposition and periods where sediment deposition is stabilized by soil development (Potter 2005), are similar patterns of human land use and soil development evident in the lowlands? Geomorphological change occurred throughout the area as a mixture of gradual and dynamic change. In turn, ecological systems were altered in parallel to geomorphic changes (Bigelow and Powers 2001; Reger et al. 2008; Reuther 2013). For example, transitions from glacial to post-glacial environments in the area and adjacent areas caused changes to sediment loads in local alluvial systems. This created a potential for the creation of new landforms and expansion of ecosystems capable of supporting plants, animals, and subsequently human life. One such time where these changes in environment

occurred around global shifts through the Younger Dryas (Reuther 2013). Chronologically, do patterns such as these occur in tandem between the more upland Gerstle River site and the GSDF lowlands?

3. What happens to site land use strategies and site locations during fluctuations of local ecological regimes? During synchronic time periods what kinds of sites exist within differing portions of the ecological system? Different ecosystems offer opportunities for differing resources (i.e. browsers and grazers typically use different ecosystems [Guthrie 1968a]) to be exploited. Consequently human land use may have functioned differently based on those distinctions. Given the variety of possible ecosystem differences that could have been present in the area reflections of site types may show distinctive tasks or tools for the acquisition of particular game species or a larger range for broader spectrum acquisition activities.
4. If patterns suggesting that these locations did in fact operate as hunting stations within lowland resource extraction areas holds true for the early Holocene, was it altered from an existing subsistence pattern during early human activity in the area beginning around 14,000 years ago (Potter 2008b, 2008c, 2011; Potter et al. 2013), and how did it subsequently change approaching the middle and late Holocene, if at all?

From this section forward, this thesis will be organized beginning with a background section which outlines previous research conducted in the general area including geography, known geomorphology, modern vegetative and faunal communities, and local archaeological and paleoecological research. This section is followed by a discussion of theoretical approaches used to answer questions postulated in this introduction section, followed by a methods section which details the methodologies used to answer said questions. Results of analyses are given afterwards, followed by a discussion section where the interpretation of results made for the GSDF area are compared against other information from research in the surrounding area. Finally, conclusions are levied drawing information from the research conducted in this thesis compared with and against this presented with the surrounding area.

# Chapter 2 Background

## 2.1 Study Area-Geography, Geology, and Geomorphology

The GSDF consists of a series of low-lying dune field localities surrounded by even lower-lying sand sheets. The GSDF project area is situated within the Tanana-Kuskokwim Lowlands (Wahrhaftig 1965), beginning approximately 32 kilometers east of Delta Junction along the Alaska Highway and ending just before the Gerstle River bridge (Figures 1 and 2). From the south, the GSDF is observed to extend from the Alaska Range to the Clearwater-Gerstle River Escarpment to the north. To the east, it is abutted and truncated by the Gerstle River which flows northerly into the Delta-Clearwater River to form the Clearwater escarpment. In the west, it appears to extend only a few kilometers past Sawmill Creek.

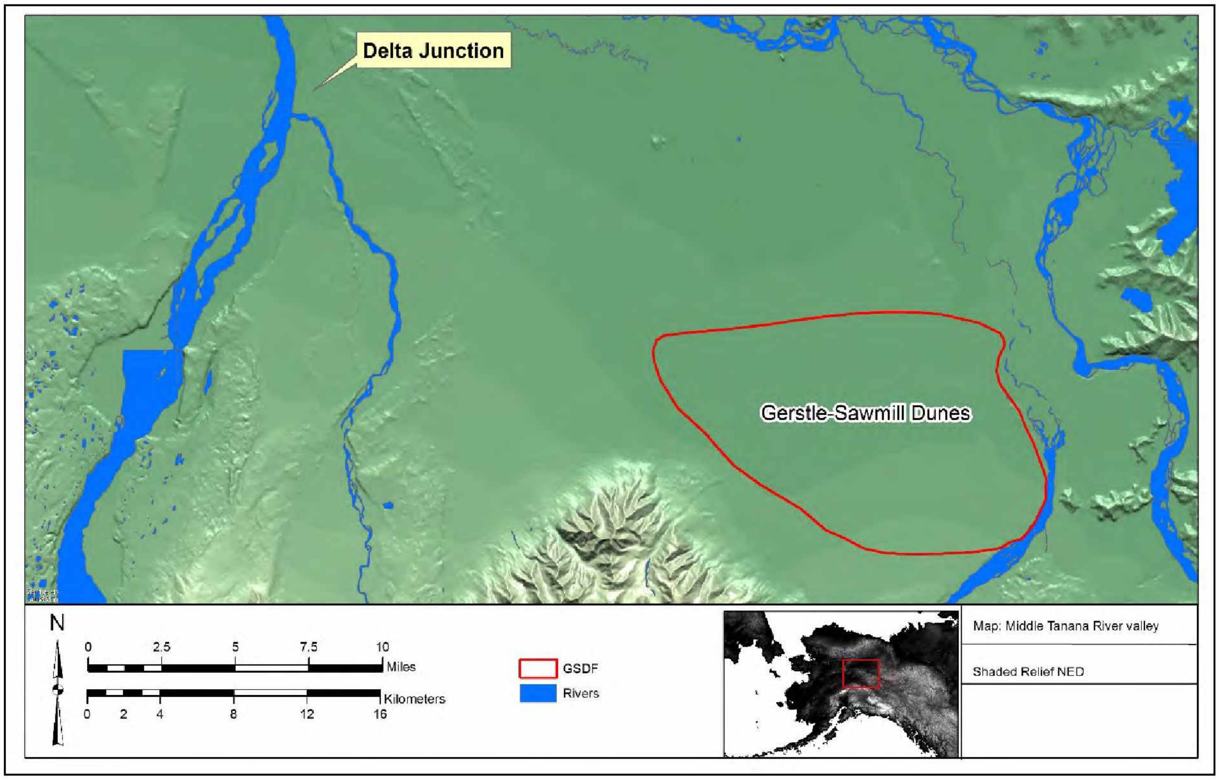


Figure 2-1. Middle Tanana River valley, GSDF outlined in red.

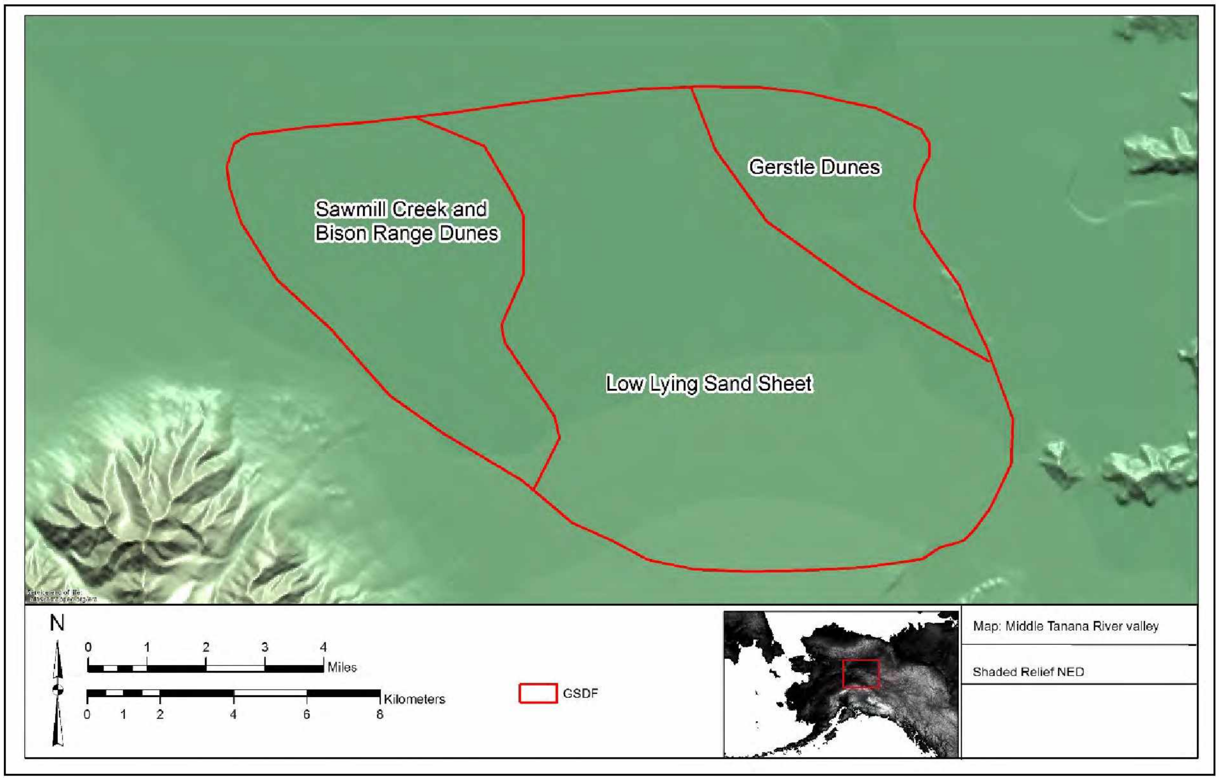


Figure 2-2. GSDF, divided by geographic area.

Holmes and Péwé (1965) initially mapped the surficial geology of this region and noted the deposits in the area surrounding Sawmill Creek as Quaternary-age silt and peat underlain by permafrost and glacial and non-glacial gravels. However, recent field reconnaissance (Potter et al. 2009; Reuther 2010; Reuther et al. 2012) in the areas around Sawmill Creek and the Delta Junction Youth Bison Range (hereafter referred to as the "Bison Range") have identified lower lying dunes that Holmes and Péwé (1965) did not differentiate from glacio-fluvial deposits (gravels and fine sand and silt alluvium). Additionally, Hamilton (1973) noted the presence of several more dune formations north of the Alaska Highway along the Gerstle River and outside of the Potter et al. (2009) survey boundary; these dune formations constitute the northern boundary of the GSDF.

Reger et al. (2008) separated the GSDF into three distinctive sedimentological categories; Quaternary aeolian sand, outwash of the Donnelly Glaciation, and outwash of the Delta Glaciation. Based on their observations, the sand sheet within the GSDF is constituted primarily of outwash deposits from the Donnelly and Delta Glaciations with well-sorted gravels and numerous subrounded-to-subangular cobbles and boulders increasing in coarseness in proximity to river systems. The age of the Delta glaciation is controversial and currently reliant on the relationship between tephra deposits and Delta Glacial deposits to provide a chronological relationship (Reger and Pewe 2002; Reger et al. 2008). According to Reger et al. (2008) in proximity to the GSDF two sets of Delta glacial moraines have been identified and are most reasonably considered to range from Oxygen Isotope Stage (OIS) 6 to OIS 4, ranging from the Illinoian to early Wisconsinan Glaciations (roughly 160,000 to 54,000 years before present). The Donnelly Glaciation is believed to be associated with the late Wisconsin Glaciation at OIS 2 (around 25,000 to 15,000 years before present) (Hamilton 1994; Reger et al. 2008). This whole system is overlain by aeolian sand and loess deposits. One distinctive area of study within this project, which was originally mapped by Reger et al. (2008) as the Delta Glaciation outwash, is the Bison Range sand dune formation. Areas fitting Reger et al.'s (2008) Quaternary aeolian sand description included Sawmill Creek, which is described as one massive sand dune formation and several separated smaller dune formations, including those mapped by Hamilton (1973), Potter et al. (2009), and a portion described by Reuther (2010) and Reuther et al. (2012). Reger et al. (2008) described these formations as vegetated cliffhead dunes with steep crowns measuring between 1.5 to 4.5 m in elevation above the outwash/ sand sheet plain, and generally covered by 0.3 to 0.9 m of loess.

The study area used within this thesis encompasses approximately 1,674,000 acres of GSDF (Figure 2-1 & 2-2). Approximately 802,200 acres (47.9%) of this area has been heavily impacted by agricultural activities, road and pipeline development (Haines-Fairbanks [HFP] and Canadian Oil [Canol]), all-terrain vehicles, seasonal camping, and bison wallowing and trampling (Hollinger 2003; Potter et al. 2009; Reuther 2010; Reuther et al. 2012). The northern extent of the GSDF has been destroyed and altered by the establishment of agricultural fields. Impacts to these dunes have caused losses in vegetation coverage and deflation of the landforms. However, a small portion of the northeastern GSDF remains untouched. The southern extent of the GSDF has been impacted by the development of the Bison Range with modifications to the landscape including the construction of various undeveloped road and trail systems for hunting access, and landform destabilization occurring from bison wallowing and trampling. However, small portions unaltered dune features remain intact in both the northern and southern ends to the GSDF.

## 2.2 Current Ecology of the Middle Tanana River Valley Area

### 2.2.1 Flora

The GSDF is located in an area of the middle Tanana River Valley termed the Interior Bottomlands (Gallant et al. 1995). Soil conditions and vegetation communities vary across these due to topographic differences present within the dune system. Perennial frozen ground has a tendency to dictate the kinds of plant species and distributions on the landscape within the lower lying portions of this area (Chapin et al. 2004). As a result, the area's overstory is dominated by deciduous and coniferous tree species with shallow root systems, including white spruce (*Picea glauca*), black spruce (*Picea mariana*), tamarack (*Larix laricina*), paper birch (*Betula papyifera*), and quaking aspen (*Populus treuloides*) (Gallant et al. 1995; Viereck et al. 1992). The understory typically contains some mixed portions of alder (*Alnus spp.*), willow (*Salix spp.*), poplar (*Populus spp.*), and scrub birch (*Betula glandulosa*) (Gallant et al. 1995; Viereck et al. 1992). Herbaceous taxa observed within the area also include grasses (*Graminoids*), horsetail (*Equisetum spp.*), and varieties of sedges (*Carex* spp.) (Gallant et al. 1995; Viereck et al. 1992).

The difference between the lower interdunal areas and the crests of dunes can often make a difference in the degree of frozen sediment preservation with crests typically thawing out completely during the summer months (Bowman 2015). This seasonal thaw can create higher temperatures and an enhanced degree of moisture drainage in thawed out sediments, drying them and leading to the propagation of more broadleaf deciduous species within these areas with intermittent coniferous species creating more of a mixed forest environment. Several flowing bodies of water exist within the GSDF including the Gerstle River and Sawmill Creek as well as boggy areas which have formed riparian and stagnant zones around them with increased poorly drained soils and extensive black spruce coverage (Gallant et al. 1995).

Plant species colonization and patchiness is also dictated by the aspect of the topography in the area; black spruce trees have a tendency to colonize on the north facing portions of slopes and white spruce, birches, aspen, popular, juniper, willow, rose hips, and berry plants tend to colonize on the south facing ones (Gallant et al. 1995). In denuded areas within the GSDF, revegetation tends to begin with earlier successions of grasses and sedges occurring in patches before spreading more ubiquitously across the totality of the denuded area. In some cases, where large mammals tend to wallow and disturb exposed sediment, it has been observed that these vegetation patches co-occur with large mammal tracks and wallowing areas. This likely occurs because these disturbances create subtle catchments for windborne seeds and potential moisture. Colonization of grasses and sedges is often followed by woody shrub vegetation in denuded areas.

Figure 2-3. Bison and human disturbance in the Bison Range.

### 2.2.2 Fauna

Many species of fauna can be found throughout the GSDF and the rest of the middle Tanana River Valley, despite the area's classification as a marginal environment (Reuther 2013). These fauna include many species of mammals, birds, and fish. The list of animals which can be found within the GSDF has been compiled from Potter (2005) and Reuther (2013), who conducted archaeological research in portions of and areas peripheral to the GSDF area. Some of these animals were observed directly in the field alive, as recent kills, and were also determined based on the location of their scat.

Mammals found throughout the area include moose (*Alces alces*), grizzly bear (*Ursus arctos*), black bear (*Ursus americanus*), caribou (*Rangifer tarandus*), red fox (*Vulpes vulpes*), snowshoe hare (*Lepus americanus*), lynx (*Lynx canadensis*), wolf (*Canis lupus*), wolverine (*Gulo gulo*), beaver (*Castor Canadensis*), porcupine (*Erethizon dorsatum*), pine marten (*Martes Americana*), mink (*Neovision vision*) , weasels (*Musetela* spp.), muskrat (*Ondatra zibethicus*), and river otter (*Lutra Canadensis)*. Among these species, Plains bison (*Bison bison*) was reintroduced within the last century with direct land use of the species within the Bison Range portion of the GSDF (Coates 1997; Glassburn 2015). Dall sheep are known to inhabit the highlands within the Alaska Range to the south (Heimer 1992; Potter 2005; Reuther 2013) but are not usually found within the GSDF area; however, it is possible that prehistoric hunters may have traveled through the GSDF area in order to acquire this species. Small mammals that inhabit the GSDF area include shrews, red squirrel, voles, bats, mice and lemmings (Potter 2005).

Fish species from the area include burbot (*Lota lota*), arctic grayling (*Thymallus arcticus*), pike (*Esox lucius*), sheefish *(Stenodus leucichtrhys*), trout (*Oncorhynchus mykiss*) and whitefish *(Coregonus nasus*). Only one variety of salmon (*Oncorhychus* sp.) appears to penetrate the interior to the depth of the GSDF. Birds species found within the GSDF differ depending on the season as many migratory waterfowl use the area from the spring through the fall. These migratory birds include sandhill cranes (*Grus canadensis*), gulls (*Laridae* sp.), loons (*Gaviidae* sp.), and a variety of geese, ducks, and swans (*Anatidae* sp.). Avian species found within the GSDF year-round include ravens (*Corvus corax*), hawks (*Accipitridae* sp.), eagles (*Aquila* sp.), falcons (*Falco* sp.), owls (*Strigiformes* sp.), and other species of raptors. Ptarmigan (*Lagopus muta*) and spruce grouse (*Falcipennis canadensis*) are also found throughout the area, as well as smaller birds such as woodpeckers (*Picidae* sp.), finches (*Fringillidae*), jays (*C. cristata* sp.*),* sparrows (*Passerdae*), thrushes (*Turdidae*), and warblers (*Parulidae*).

## 2.3 Paleoenvironmental Reconstructions from the Middle Tanana River Valley Area

### 2.3.1 General Climate and Paleoecological Trends

This section summarizes general climatic trends occurring from the terminal Pleistocene to the late Holocene. In general, these trends have been documented throughout geographic regions across the Northern Hemisphere. However, reliance on these more climatic global trends as indicators of environmental change at a regional scale is problematic due to more localized environmental reactions based on variation in local and regional topography. For instance, it is well known that lakes in valley basins act as catchments for vegetation seen only sparingly or not at all in more highly elevated areas (Ager 1975). Constrictions of topography caused by dune topography and riparian zones around streams also create similarly isolated vegetative communities in valley bottoms (Albanese 1974; Zinko et al. 2006). All of these aforementioned landscape factors play out at a much larger scale and require a higher degree of resolution than the broader strokes painted by our current global trend models. While it is likely that these climatic trends had some effect on the climate and ecology of an area (Bigelow and Powers 2001; Kaufman et al. 2004; Kokorowski et al. 2008), localized conditions, those which will be reported in this thesis, must be recognized as having an overwhelming effect on both the human behavior and landscapes at a local geographic scale (Bigelow 1997; Reuther 2013).

### *Delta and Donnelly Glaciations*

According to Reger et al. (2008) surface evidence for multiple glaciations is present in close proximity to the GSDF area. During the late part of the Pleistocene the Delta and Donnelly Glaciations comprise the majority of this activity (Kaufman et al. 2016; Reger et al. 2008). Glacio-fluvial sediments originating from the Alaska Range, but transported into the northern foothills and middle Tanana River valley from these two glaciations comprises the majority of source sediment activated into dune formations within the GSDF itself (Reger et al. 2008).

The Delta Glaciation has been roughly dated between OIS 4 and 6 (Reger et al. 2008), based on proximities to the Old Crow tephra deposit (luminescence dating) and later paleosol radiocarbon dating. This places the overall glaciation between 160,000 to 54,000 years before present, as stated above. More recent cosmological dating of Be isotopes conducted by Matmon et al. (2010) on exposed glacial till places at least part of the Delta Glaciation moraine stabilization between OIS 4 and 3. Within the Dry Creek valley, approximately 23 km (14.3 mi) away from the GSDF, two terminal moraines assigned to the

Delta Glaciation are present (Reger et al. 2008). Outwash of glacio-fluvial sediments from beyond these moraines further into the middle Tanana River valley constitutes a significant portion of material from which dunes in the valley originated.

The Donnelly Glaciation has been dated using radiocarbon and cosmologically using Be isotopes to OIS 2 (around 25,000 to 15,000 years before present) (Matmon et al. 2010; Reger et al. 2008). Moraines from this glacial advance were extensive along flanks of Granite Mountain, projecting into alpine valleys and into the foothills and the middle Tanana River valley (Reger et al. 2008). Glacio-fluvial outwash from this glaciation transported sediment extensively across the middle Tanana River valley within and proximity to the GSDF, including within the Sawmill Creek area within the GSDF (Reger et al. 2008), providing large amounts of source material for aeolian transport to make the dunes within the GSDF area.

### *The Bolling/Allerod*

The Bolling/Allerod warming period began at approximately 16,000 cal. years ago (Viau et al. 2008), and was comparatively warmer and wetter than the LGM. This period is locally referred to as the Birch Period (Ager 1975), as it marks a significant shift from the herbaceous tundra species to the increased presence of dwarf birch shrubbery, as recorded in pollen counts from lake cores (Bigelow and Edwards 2001; Mann et al. 2001). In general, the expansion of dwarf birch and the establishment and increases in lake levels across many areas of northern and interior Alaska conforms to the global signatures of a warmer and wetter climate after the LGM (Barber and Finney 2000; Edwards and Barker 1994; Hu et al. 1996).

### *The Younger Dryas*

The Younger Dryas, dating from between 12,900 and 11,700 Cal BP (Broeker et al. 2010) generally describes a colder period at northern latitudes. Evidence for this event has manifested itself in various locations throughout the northern hemisphere, particularly within $^{18}$O ratios from ice core records from Greenland (Steffensen et al. 2008). Within parts of the interior Alaska, this period marks a shift in vegetation communities, evident in pollen records from lake cores, to a sage and grass dominated herbaceous tundra (Begét 1990; Bigelow 1997; Bigelow et al. 1990; Bigelow and Edwards 2001; Kokorowski et al. 2008); however, this change appears to be variable between records and across local landscapes. Toward the end of this period, woodland conditions appear on the landscape with the first increases of *Alnus* and *Populus* pollen within the record (Anderson et al. 1994).

While this period has been generally interpreted to represent a time of increased aridity and wind intensity, as well as increased aeolian sediment deposition with increased coarsening of particle sizes and decreased vegetation development (Bigelow 1997; Bigelow et al. 1990; Potter et al. 2008), some areas within the middle Tanana River valley and Nenana River valley show signs of forest soil development, including areas within the GSDF (Bowman 2016; Dilley 1998; Gilbert 2011; Hoffecker and Elias 2003; Reuther 2013). For the most part, the Younger Dryas signal is variable in expression within the middle Tanana River valley terrestrial landscapes, displaying aeolian sediment deposition in some areas and soil development in others. This may indicate that the overall cooling and drying that occurred during this period may have had a minimal effect in terms of aridity and possibly temperature variation within this portion of Alaska. Possible localized glacial advances may have occurred in the uplands of the Alaska Range during this time (Matmon et al. 2010), which may account for the geographic variability mentioned above.

### *The Holocene Thermal Maximum*

The Holocene Thermal Maximum (HTM), occurring between 11,500 to 9,100 Cal BP, was most likely caused by a shift in the Milankovitch cycle, or an alteration of earth orbital rotation around the sun, observed to occur in cycles (Kaufman et al. 2004; Mason et al. 2001; Short et al. 1991). Some have argued that this shift caused temperatures in the arctic and subarctic to increase to approximately 5-8° C warmer than present. This shift may have occurred within a short period of time, possibly within a matter of 50 years (Hoek and Bos 2007; Prasad et al 2006). Alternatively, other studies indicate that temperatures were highly variable during this time frame, and in many cases both higher and lower than the mid-20th-century average (Kaufman et al. 2016). Glaciers also appear to have been as extensive as they were during the late Holocene (Kaufman et al. 2016). This period marks the geographic expansion of several animal and plant species within subarctic Alaska, including beaver, *Populus*, and some species of beetle (Brubaker et al. 1983; Mann et al. 2002; McCulloch and Hopkins 1966; Nelson and Carter 1987). Prior to these expansions, however, the majority of the landscape was highly susceptible to erosion, placing serious restrictions on landform (as well as site) preservation (Mason and Bigelow 2008). Toward the end of this period, pollen and macrofossil records suggests that spruce began to move into the middle Tanana River valley as well (Bigelow 1997; Bigelow and Powers 2001).

### *The 8.2 kya Event*

The 8.2 kya Event has been referred to as the "younger" Younger Dryas, being interpreted to as cooling trend after the HTM (Beget 1990; Mason et al. 2001). This period was also observed to occur much more quickly than the cooling shift during the Younger Dryas, possibly coming into existence within a few short months (Alley 2007; Alley and Agustdottir 2005). However, the effects on local biotic systems appear to be ephemeral with little change indicated within regional pollen, $^{18}O$, and methane proxy records. A decrease in spruce pollen counts occurs in some pollen records from lake cores, but may have occurred due to competition from other species rather than a direct effect from a shift to cooler temperatures (Ager 1975). Caribou populations also appear to have increased during this time, possibly with the expansion of lichen vegetation associated with cooler environments (Mason et al. 2001).

### *Middle to Late Holocene*

Throughout the middle to late Holocene, temperature and ecological conditions appear to have generally stabilized into what appears within the subarctic Alaskan landscape today (Ager 1975; Anderson 1975; Carlson and Finney 2004; Wooller et al. 2012). Based on stratigraphic, geomorphological, pollen, captured $CO^2$, Na isotopes, and $^{18}O$ proxy records several rapid cooling events and global Neoglacial expansions were determined to have occurred throughout this period (Mayewski et al. 2004; Shakesby et al. 2007; Way et al. 2015), but each proxy record bounced back to the environmental standard observed today. Accordingly, several localized neoglacial advances occurred within the Alaska Range (Kaufman et al. 2016). Overall, the climate within the middle Tanana River Valley between 4000 to 400 Cal BP appears to have been somewhat drier and warmer than at present, which has been evidenced by a lesser degree of flooding deposits dating to this time range (Mason and Beget 1991). The treeline also retreated during this time as well as the development of wider spread forests and peatland (Mason and Bigelow 2008).

## 2.4 Ecological Reconstructions near the Gerstle-Sawmill Dunes Field

Cook (1969) attempted an early reconstruction of the paleoenvironment at the Healy Lake Village site, just to the east of the GSDF across the Gerstle and Tanana Rivers, using terrestrial soil samples for pH analysis, stratigraphy, and the geomorphology of the area. His reconstruction extended into the past only as far back as earliest record of human occupation observed at the Healy Lake site location. This early paleoenvironmental reconstruction characterized the area as a grassland or tundra environment from 10,000 to 12,000 Cal BP. Following this period, spruce began to increase within the area (Ager 1975). Healy lake itself dates to between 4,000 and 5,000 Cal BP (Anderson 1975), indicating that the initial occupations at the village site predate the formation of the lake.

Table 2-1. Elevations of lake cores and terrestrial test sections.

| Lake Cores and Terrestrial Test Sections | Elevation (ft) | Elevation (m) |
|---|---:|---:|
| Birch Lake | 965 | 294 |
| GSDF: Bison Range | 1210 | 370 |
| GSDF: Sawmill Creek | 1220 | 372 |
| GSDF: Gerstle Dunes | 1250 | 381 |
| Healy Lake | 1130 | 345 |
| Hidden Lake | 1130 | 345 |
| Jan Lake | 1650 | 503 |
| Lake George | 1400 | 427 |

Hidden Lake, a lake in the vicinity of Healy Lake, was cored by Anderson (1975) in order to provide pollen data and constitutes the closest lake core taken to the GSDF area. Though analysis of this core showed that this lake only existed back as far as approximately 6,000 Cal BP, pollen results showed that from this period forward no significant changes occurred between the ecosystem then and now. Alternatively, Lake George, only a few more kilometers away was cored by Ager (1975) and was determined to be much older than Healy Lake or Hidden Lake. Ager's (1975) analysis of the George Lake core showed that the pollen record extended to approximately 16,000 Cal BP, and the vegetative history of the area could be broken down into three periods. First, Pollen Zone 1 was interpreted to represent a steppe-tundra environment extending from 16,000 to 14,000 Cal BP based on pollen count proxy records. Second, Pollen Zone 2, from 14,000 to 10,000 Cal BP, which displayed a three-fold increase in dwarf birch pollen counts marking an intrusion and expansion of shrubs into the area. Pollen Zone 3, beginning at 10,000 Cal BP and running until the present, marks the increase and full colonization of the spruce forest into interior Alaska. Pollen Zone 3 is further divided into two separate intervals based on percentages of alder and other plant species on the landscape within the dominant spruce forest. Subzone 3A is characterized as being 80% spruce with up to 12% willow, 10% sedge, and 10% grass. Subzone 3B is characterized as having only 10% spruce pollen in sum, with 30 to 80% birch, up to 25% alder pollen, and limited amounts of grass sedge, willow and Artemisia occurring.

Though Ager's (1975) analysis showed increased time depth and ecological change within the middle Tanana River valley and the dates produced for this work have proven to be problematic due to problems with running bulk sediment samples (problems with potential sample sizes and the dating of different plant tissues leading to differing dates) (Bigelow and Edwards 2001; Bigelow and Powers 2001; Oswalt et al. 2005). As a result, the overarching timeline in which Ager placed these ecological changes are, in general, too old in the timing of vegetation transitions. Jan Lake however, which was analyzed by Carlson and Finney (2004), and is only 60 kilometers to the east of the GSDF, provides a similar pattern of ecological change. This area has the added benefit of providing more accurate dating to the timing of vegetation and ecological regimes for the area.

The Jan Lake core was broken down like Lake George into three analytical units: Jan-I, Jan-II, and Jan-III. Jan-I extends from 12,400-11,600 Cal BP and displays what Carlson and Finney (2004) call a unique herb-tundra pollen assemblage that was rich in plants such as Poaceae and Artemisia, but with very high densities of Chenopodiaceae-Amaranthaceae and Asteraceae. Cichoriodae were used by the authors to interpret the local environment as being cold and dry with somewhat saline or alkaline soils and were not uncommon for a steppe-tundra environment. Jan-II, referred to as the Betula zone, extends from 11,600 to 10,000 Cal BP. At its inception, this period is dominated by birch pollen, which shows a sharp increase from 3% in Jan-I to more than 35% by 11,600 Cal BP and is consistently maintained throughout Jan-II. Salix also likely reached its peak presence during this period. The Betula referred to from this time period is interpreted to be dwarf birch, and not assumed to be white or paper birch, leading to an interpretation that this period shows an overall climatic amelioration but not the development of an expansive deciduous forest. *Picea* species (i.e., spruce) begin to show up within this period in the Jan Lake core but likely do not represent a vegetation regime beyond the patchy development near low flow or stagnant water sources. Jan-III is referred to as the forest period and is broken down into two sub-periods. First, Jan-IIIa, between 9,200 to 6,600 Cal BP displays drastic Populus, *Picea glauca* (white spruce), and Betula *papyrifera* pollen count increases. Second, Jan-IIIb, between 6,600 Cal BP to now, which includes Alnus (at 20-40% and not before described in the pollen record here) and Picea *mariana* (black spruce, at 10-50% and also not previously described in the pollen record here) displays pollen counts consistent with the modern forest communities in this part of interior Alaska. Intrusion of Alnus into the area is interpreted to indicate the proliferation of dense thickets on flood plains and hillslopes. Picea *mariana* is interpreted to mark the establishment of the modern boreal forest in the area.

Between Ager (1975) and Carlson and Finney (2004) there appears to be a high degree of agreement in general trends in the pollen trends and vegetation transitions recorded in lake cores. First, the earliest period recorded within both cores shows an environment that generally appears to correlate to a steppe-tundra vegetative communities. Second, white spruce appears before black spruce in the first phase of forestation. Lastly, after approximately 6,500 Cal BP, the modern taiga forest that is known today becomes represented in the pollen record.

Lost and Birch Lakes have also had significant lake core research done at them and are located 80 km to the north west of the GSDF. The record at Lost Lake reaches back to 14,700 Cal BP and displays significant pollen record change over time as well (Tinner et al. 2006). According to Tinner et al. (2006) at Lost Lake, the oldest section, around 14,600 to 14,400 Cal BP, is dominated by herbaceous plants including Poaceae, Cyperaceae, and Artemisia. From 14,400 to 13,200 Cal BP Salix pollen percentages increase and peak around 13,400 Cal BP. From 13,200 to 11,200 Cal BP, a rise in shrub Betula occurs along with a decline of herbaceous pollen including Artemisia. Betula pollen decreases then between

12,500 to 11,600 Cal BP, when herbaceous taxa again increases. The first tree pollen reaches high values between 11,200 to 9,700 Cal BP and is Populus. This is referred to in the lake core as the Populus period and is accompanied by a rise in P. *glauca.* Between 9,500 Cal BP and 8,400 Cal BP the dominate pollen types are Picea *glauca,* and Betula with *P. mariana and Alnus virdis* increasing to become codominant moving into the middle and late Holocene.

According to Bigelow and Powers (2001), the Birch Lake record begins at about 14,000 Cal BP and is dominated by sedges such as Betula and Cyperaceae up until around 13,500 Cal BP. From 13,500 Cal BP to 12,500 Cal BP, Birch Lake shows a high frequency of Betula pollen with Salix contributing around 10 to 15 percent of the overall pollen count. Artemisia appears to contribute approximately 7% of the overall pollen count at this time period as well. From 12,500 to 11,500 Cal BP Betula is dominant with percentages ranging between 45 and 80. Salix is also strongly present taking up most of the remaining percentage. From 11,500 to 10,500 Cal BP, Betula is still prominent with Populus percentages increasing. From 10,500 to 9,500 Cal BP, Betula still dominates with sedge and grasses making up the majority of the rest of the taxa during this time period. From 9,500 to 8,500 Cal BP conditions such as those at Lost Lake are evident with the dominant pollen types are *Picea glauca,* and Betula with *P. mariana and Alnus virdis* increasing to become codominant moving into the middle and late Holocene.

Comparatively, the general tends seen between the two lake sets first presented at George and Jan Lakes are similar to those presented for Lost and Birch Lakes. First, beginning with steppe-tundra conditions, followed by an influx of shrubs, and ultimately followed by white and then black spruce. However, Lost and Birch Lakes appear to become forested with spruce trees earlier than George and Jan Lakes, allowing for a continued presence of woody shrub dominance at least for an extra two thousand years.

It is important to note that while lake cores provide a comprehensive record of pollen counts within a catchment system and likely offer the best chance for the reconstruction of paleoenvironmental variables on the landscape, they are not without flaw. Pollen counts within lakes can be highly affected by the vegetation types surrounding the lake environment itself and how those plants transport their pollen (Rapp and Hill 2006: 171), the chemistry of the lake and its flow regime (Rapp and Hill 2006: 170), and many other environmental conditions and factors. As an example, Bigelow and Powers (2001) describe how between 9,500 to 8,500 Cal BP the absence of alder pollen in Birch and Dune Lakes is quite surprising given alder makes up 15% of pollen in Windmill Lake. They conclude that it is possible that the local ecological conditions near Windmill Lake are more suitable for alder leading to local plant life overriding broader patterns, despite all three being located in interior Alaska. Pollen records in lakes also habitually only represent pollen from plants closer to shore as well as longer distance arboreal pollen influx, but not those from zones in between (Erdtman 1969). As a result, lake core results should be viewed to be mostly representative of the local lake area itself first, but also including some elements of the surrounding terrestrial environment around it as well.

Potter (2005), Dilley (1998), and Reuther (2013) provide terrestrial records for paleoenvironmental change across the middle Tanana River valley. Potter (2005) focused on the record present at the Gerstle River site and provided a high degree of large mammal faunal resources for the early Holocene. Prehistoric human land use at the site, at least during the early Holocene, occurred during periods without soil development (based on analysis of the stratigraphic sequence), but with high degrees of ungulate richness, in fact the presence of wapiti and bison fauna in cultural components during this time indicates that productive ecosystems for these animals existed in the proximity, likely within the surrounding lowlands, and potentially in the GSDF itself. A lack of preserved soils within the Gerstle River site stratigraphy may also indicate the development of only thin and short lived grasses at this location which may not have preserved well in the Gerstle site location. Dilley (1998) focused in the Shaw Creek region of the middle Tanana River valley. His work indicates that the early Holocene within the area was warm and dry, with open popular –willow scrub forest based on faunal remains at local sites (Swan Point, Mead, and Broken Mammoth) and analysis of soils within stratigraphic context (Dilley 1998). Reuther's (2013) work sources from the Shaw Creek flats area and the proximity of the Upward Sun River site, approximately 3 km (2 mi) south of the Tanana River and 7 km (4.3 mi) west of the Delta River. This work indicates, based on extensive stratigraphic analysis of acidity, carbon content, and observation on soil development, that the early Holocene landscape was moderately stable with high degrees of aeolian silt and sand deposition, fostering the presence of earlier to middling stages of vegetation successions. Reuther (2013) points out that it is in fact these early successions of vegetation that acted as attractants to grazing large mammals and prehistoric humans acquiring them.

## 2.5 Middle Tanana River Valley Cultural Chronology and Proxy Records of Human Responses to Ecological Change

In this section, the various complexes and traditions of interior Alaska's cultural chronology will be presented with regard to the reconstructed environments they appear to have occupied. This material will be presented chronologically beginning with the Terminal Pleistocene and will end at the beginning of the Historical period. General agreements and disagreements between within the chronology will also be discussed along with various interpretations on how these people interacted with their environment. It should be stated that, due in no small part to taphonomic issues, the majority of chronological similarity and dissimilarity presented for the interior Alaskan cultural chronology rests on morphological differences from lithic tool remains at archaeological sites, prior to the Athabaskan Tradition portion of the record, which contains more organic based artifacts. With this in mind, it must be understood that these lithic materials reflect a limited portion of the activities taking place at these archaeological sites. Unfortunately, though, due to poor preservation of organic materials, such as bone and antler and plant remains, there is a lack of certain insights into many activities which may clue researchers into other factors that could cause either further lumping or splitting of sites into groups of cultural relatedness.

### 2.5.1 Terminal Pleistocene (Initial human migrations to 10,000 Cal BP)

As discussed earlier, lake core analyses point to the Terminal Pleistocene as being rather cool and dry, generally correlating to a steppe-tundra environment. However, by the time humans arrive in Alaska, shrub presence on the landscape has increased (Ager 1975; Carlson and Finney 2004). Faunal remains show that many animals that are not present on the landscape today, including mammoth, horse, and bison (Guthrie 1968a; Potter et al. 2013), were present during the Terminal Pleistocene. The earliest known occupation of the region occurred at the Swan Point site in the Shaw Creek area, dating to approximately 14,000 Cal BP (Holmes 2011; Potter et al. 2013). At this location, remains of horse and mammoth were found in association with stone tools and hearth features. The lithic material from the oldest component of the Swan Point site was observed to most closely match microblade and core technology found in Siberia termed Dyuktai (Holmes 2001; Yu and Holmes 2016), a lithic technology where a biface is struck in a particular fashion in order to turn it into a core capable of producing small consistently sized blades, which were then inset into larger organic implements in order to create a composite tool technology. Though regarded as an anomaly by some (see Dixon 2001), Holmes (2001, 2011) used Swan Point and the earliest component at the Healy Lake Village site to describe a distinctive older period in interior Alaska of sites existing prior to 13,000 Cal BP in a pre-forested environment that he terms the Beringian Period. Yu and Holmes (2016) examined microcore technological changes and microblade morphological changes between the earliest component at Swan Point and later Northern Archaic material from this site and concluded that production of microblades for manufacturing composite technologies was stable through time, despite cultural change, indicating some continuity based on the multi-functionality of the technology in the area. To date, several other sites in this portion of interior Alaska display components dating to what Holmes (2001, 2011) termed the Beringian Period, including the earliest components at the Mead site (Potter et al. 2011, 2013), Broken Mammoth (Potter et al. 2013; Yesner 1996), and the Upward Sun River site (Potter et al. 2011).

As these sites are few and far between, and are typically hard to excavate as they constitute the deepest portions of sites, little can be said about a general pattern of human land use during this period. In several cases, such as at Swan Point, Broken Mammoth, and Mead, people appear to be seeking large mammals as well as avian resources, whereas at the Upward Sun River site, faunal remains show a high degree of focus on avian species and salmon (Choy et al. 2016; Potter et al. 2013). To date, Swan Point is the oldest location and the only one where the Siberian Dyuktai lithic technology has been identified.

The complexes of Denali and Nenana also begin to manifest in Interior Alaska during the end of the Pleistocene. Denali, which as originally defined by West (1967) based on the Donnelly Ridge site, was observed to have bipointed bifaces in direct association with microblade technology. Nenana, on the other hand, occurs around the same time period in many locations just prior to Denali (Broken Mammoth, Dry Creek, Moose Creek, the Little John site) and does not contain microblade technology. The Nenana complex is also defined by the presence of a small projectile point type similar to as Chindadn point types at the Village site (Hoffecker et al. 1993).

It is important to remember that one of the defining artifact types of the Nenana complex- Chindadn points- were found in direct association with the defining artifact types of the Denali complex (microblades and microcores) (Cook 1969) at some, but not all sites. That is not to say that the Denali complex lacks bifaces, as these have been documented in many locations (Bowers 1980; Potter et al. 2011; Thorson 2005; Thorson and Hamilton 1977; West 1967, 1975). What was originally noticed, however, in the Nenana River valley was that within the earliest components in many sites (Dry Creek, Moose Creek, and Walker Road [Powers and Hoffecker 1989]), bifaces, particularly projectile points, sometimes typed to Chindadn points, were found in contexts without microblades and with older radiocarbon dates than components above them containing microblade technology with bifaces? This observation has led to the distinction and separation of earlier non-microblade components (Nenana complex) from those containing microblades (Denali complex) (Hoffecker 2005). This distinction was considered to be an earlier relative to Clovis technologies, which represents the earliest widespread technological system in that portion of North America, contains bifaces with some typological similarities to Chindadn (Goebel et al. 1991). Therefore, these early Nenana complex wielding peoples (who are in some cases regarded as separate people than those who used Denali materials [Dixon 1985; Goebel et al. 1991; Hoffecker 2005]) must have traversed the ice free corridor and then began fluting their points once they reached the continental United States. To look at this connection, Buchanan and Collard (2008) used a cladistical approach to determine the technological relatedness between Clovis, Nenana, and Denali. Results from their examination suggest that Denali and Clovis are actually more related that Nenana and Clovis. Considering the close connection of Denali and Chindadn at Healy Lake, this might not be as much of a shock as suggested. If the Nenana complex materials actually exist as a seasonal or topological (used in high lands as opposed to in lowland situations [Potter 2005; Wygal 2011]) subset of the Denali complex, then relatedness between the totality of a complex (meaning the Denali complex altogether) to an antecessor complex should show more of a relationship than just one subset when compared to an antecessor like Clovis.

### 2.5.2 Early Holocene and Middle Holocene (10,000 to 1,000 Cal BP)

The early Holocene marks a period of general climatic amelioration for interior Alaska (Ager 1975; Carlson and Finney 2004) with patches of white spruce forest expanding across the landscape. This period also displays the continued utilization of Denali Complex lithic materials, prior to the beginning of the Norther Archaic tradition (Mason and Bigelow 2008). It appears that several larger mammal species, including horse and mammoth, died out in the area prior to this period; species such as bison and wapiti populations were present on the landscape but there numbers were likely lower than in the terminal Pleistocene (Guthrie 1968a; Potter 2011). Later occupations at Broken Mammoth (Component 2), Mead (Component 2), Swan Point (Component 3), and Gerstle River (Component 3) display Denali Complex technology in association with bison and wapiti remains suggesting an association between this composite technology and large mammal acquisition (Potter 2005 ; Potter et al. 2013; Yesner 2007).

Toward the middle Holocene (approx. 8,000 to 1,500 Cal BP), ecological change consisting of the infiltration of larger black spruce forests (Ager 1975; Carlson and Finney 2004; Mason and Bigelow 2008) occurred within the area, creating in many locations a more closed spruce forest ecosystem. Within this time period the Northern Archaic Tradition also appears upon the landscape.

The Northern Archaic tradition was originally defined by Anderson (1968) as having a distinctively different material culture than its predecessor the Denali complex and those that would come after. Chief among the material cultural differences associated with this group were the proliferation of basally indented bifacial points, often referred to as “notched points,” and notched asymmetrical knives which were not associated with cultural components before. Anderson originally defined this tradition as being devoid of microblade technology and proposed it was related to the spread of the boreal forest. Esdale (2008), Cook and Gillispie (1986), Potter (2008b), and Ackerman (2004) have questioned these last two associations. Esdale (2008) demonstrated statistically that microblades were present within at least 30% of Northern Archaic sites and that at least several Northern Archaic sites are located outside of the boreal forest boundary, both in southwestern Alaska and on the North Slope. Cook and Gillispie (1986) spatially mapped the presence of Northern Archaic sites in and outside of association with the boreal forest showing that many sites existed outside of the boreal forest boundary. Potter (2008b) examined subsistence economy changes, settlement, and site structure patterns in tandem with technological change from before and into the appearance of

Northern Archaic technology and found that dietary breadth appears to confine as time progresses within the Holocene. This would suggest that resource scheduling and land use strategies shifted with regard to particular species presence on the landscape and with less regard directly to forestation. Ackerman (2004) located several sites in southwestern Alaska outside of the boreal forest boundary, suggesting that the Northern Archaic goes beyond the boreal forest boundaries. Anderson (2008) provides a reassessment of Northern Archaic notched point collections, proposing that notched points were multi-use tools with no individual activity associated with them, as such, in some situations they would be useful in conjunction with microblade technology and potentially beyond the ecological bounds of the boreal forest.

Within the middle Holocene, Northern Archaic notched bifaces are found alongside microblades and scrapers (Esdale 2008). The retention of microblade technology between the early Holocene and the middle Holocene suggests that some cultural continuity is present through these two periods in time, as suggested by Potter (2008c). The introduction of the new notched biface technology, likely from Canada (Esdale 2008), also suggests that an influx of people or at least ideas traveled west and with them new hunting and general mobility strategies. Others have suggested that the influx of the Northern Archaic into Alaska was directly tied to the expansion of the boreal forest (Anderson 1968), though counter arguments can be made for associated sites that do not follow this pattern (Ackerman 2004; Lobdell 1986).

Based on interior Alaska datasets Potter (2005) suggests that subsistence changes began occurring when populations using Northern Archaic technologies lived in interior Alaska. These changes included resource scheduling alterations and shifts in land use strategies associated with more upland area usage, likely associated with more extensive caribou hunting, expansion of dietary breadth to incorporate smaller mammals, and a gradual replacement of earlier larger mammals like bison and wapiti with the aforementioned caribou. Alongside these subsistence shifts came a change in mobility patterning from residential to logistical with increased use of food caching and storage, potentially due to an expansion of territory. Esdale (2008) cites a lack of preservation in many locations where Northern Archaic proliferated, indicating that less is known about the broadness of the subsistence base during this time due to poor preservation of faunal material. The spatial association of Northern Archaic sites with identified caribou drive lines in northern and southeastern Alaska, however, suggests a potential deep reliance on caribou as a subsistence resource and evidence of organization of cooperative effort beyond small familial groups. That is, if the drivelines in these areas are in fact directly related to the Northern Archaic occupations. Late Holocene sites with bison remains also line Delta River overlook, which may suggest this species was utilized in lower lying areas (Holmes and Bacon 1982). In the middle Tanana River valley Northern Archaic technology appears to have persisted in use into the Late Holocene.

### 2.5.3 Late Holocene (1,000 Cal BP to present)

In the late Holocene, ecological conditions were most similar to what is seen on the landscape today, and materials that have been associated with the Athabaskan tradition proliferate. Subsistence patterns during this time period show shifts into logistically organized systems with sustained use of residential villages and a proliferation of storage related features (Potter 2008c). Potter (2008c) tested three different models against the archaeological record regarding the changes occurring during this time period; first, that technological and economic change persisted within existing populations, second, that population replacement or assimilation may have occurred during this time frame accounting for these shifts, and third, that taphonomic bias has obscured the reality of past human behaviors for this time period. Archaeological evidence most strongly supported Potter (2008c) first model, suggesting a shift from multiseasonal large mammal hunting strategies and higher residential mobility to use of more seasonally abundant resources and increased logistical mobility. Sites containing these materials still contain microblades and expedient lithic tools but also contain a much higher abundance of organic tools (Plaskett 1977; Shinkwin 1976, 1977, and 1979). Sites associated with this tradition include the Nenana River Gorge site, Dakah De'nin's Village and the Dixthada site. In general, Athabaskan tradition materials are said to be most closely related to the materials of the ethnographic record (Shinkwin 1979; Shinkwin et al. 1980). In the ethnographic record for the area, as in much of Alaska, the majority of tools used consisted of organic materials. Due to preservation issues associated with the acidic nature of the boreal forest, very few of these sites exist in Interior Alaska where this portion of the archaeological record is preserved for Athabaskan sites, with Nenana River Gorge site, Dakah De'nin's Village and the Dixthada site being exceptions. In locations where these materials have been found there appears to be abundant material for interpretation, however long distances between these sites, with little to no material from sites of this age have left large interpretive gaps which have been, for better or worse filled by accounts from the ethnographic record and historic accounts (Cook 1989; Plaskett 1977; Shinkwin 1976, 1977, and 1979; Shinkwin et al. 1980). While the use of these datasets likely does lend some credence to interpretation of behaviors during these time periods it should not be expected that all people followed the same practices throughout the entirety of the last one thousand years.

## 2.6 Terminal Pleistocene to Middle Holocene Economy and Human Mobility Systems in the Middle Tanana River Valley

### 2.6.1 Terminal Pleistocene

Just as ecological systems offer attractions for non-human animals, humans are also prone to differential ecosystem attractants for the purposes of resource utilization, habitation, and many other reasons (Binford 1980; Butzer 1982; Grove 2009; Itami and Gimblett 2005). In cases where ecosystems change over time, as they tend to do, animal and subsequently human behavior has a tendency to change along with it, causing adjustments to mobility and technology (Butzer 1971; Mann et al. 2001;

Potter 2008a, 2008b, and 2011; Reuther 2013). Within the case of the middle Tanana River valley, ecosystem change, as documented through lake core and faunal analysis (Ager 1975; Carlson and Finney 2004; Guthrie 1968a, 1968b), occurred in some cases from a patchily vegetated environment of herbaceous tundra, to shrub tundra, to an increasingly forested environment as time progressed into the Holocene. With these ecological changes, human behavior dynamics in terms of mobility also changed.

Human movement on the landscape occurs for many different reasons; the acquisition of tool material and food resources are two main reasons and, in most archaeological cases, the easiest to study. Human-ecosystem interaction through time, for the purposes of this thesis, will be discussed broadly in terms of generalized mobility patterning as specific extraction points on the landscape are still currently unknown and would be necessary to build a more detailed mobility system for each time period. However, with known sites of both tool stone resource and faunal resource procurement types, and other site types through time in the middle Tanana River valley, generalized interpretations on human mobility systems can be made.

As little is known about the initial occupations of the area, mobility data for the middle Tanana River valley must be gleaned from a small number of sites including the earliest components of Swan Point, Broken Mammoth, the Mead site, McDonald Creek, the Healy Lake Village site, and the Keystone Creek dune site (Cook 1969; Mueller et al. 2015; Potter et al. 2013; Reuther et al. 2015). As these sites are few in number and located within one rather small geographic area, little can be said about the long distance mobility system at work here, beyond the acquisition of obsidian as a tool resource (Reuther et al. 2011). At the scale of the flats itself, sites with similar functions are present within this time frame. The Mead and Broken Mammoth sites, at their lowest components, appear to function as tool manufacturing stations as well as faunal processing centers. However, spatial patterning of lithic material suggests the possibility of residential occupation at the Mead Site, whereas no such patterns exist for Broken Mammoth, suggesting that this location was a shorter term encampment (Krasinski and Yesner 2008; Potter et al. 2013). The Keystone Creek site, for its part, displays what appears to have been a short term processing site after a wapiti kill (Reuther et al. 2015). All of these sites together suggest a pattern of a centralized residential base, inhabited by a small group of hunter-gatherers, with task specific sites located in proximity, potentially based on specific activities. Selection of these locations likely related to ecological differences, view sheds, distance to resources being acquired, and many other factors. The lowest component of Swan Point, which predates all other discoveries in the area, presents lithic tool manufacture (Dyuktai microblade reduction activities) and fauna resource use (horse and mammoth) that are absent among the other sites in the area (Holmes 2001, 2011). Based on the assemblage of material at Swan Point, this site has been interpreted as a specialized workshop for the production and maintenance of organic based composite tools (Lanoe and Holmes 2016). As a result and due to the lack of other sites relating to this time period mobility patterns for this earliest period of human occupation can only be tentatively interpreted.

### 2.6.2 Early Holocene

Evidence exists for an analysis of mobility regarding the early Holocene in the middle Tanana River valley. Evidence collated from sites such as the Gerstle River site, Mead, Swan Point, Broken Mammoth, and several others suggest a logistical pattern with the utilization of high nutritional yield large mammals (Potter 2005 and 2007; Potter et al. 2013). The Gerstle River site, the closest postulated logistical spike camp to the GSDF, displays a pattern of faunal resource extraction focusing on wapiti and bison, with an inference that the GSDF area may have functioned as a potential location where these resources may have been acquired from (Potter 2005).

Recently, evidence for salmon exploitation has also been found at the Upward Sun River site (Halffman et al. 2015). Evidence from the middle and late Holocene suggest that with the increased use of fish and other locally available resources, higher degrees of territoriality and residential behaviors occurred (Potter 2008c). However, early exploitation of fish resources may also have been a reflection of residentially mobile patterns where stable food resources were followed across the landscape, not unlike with large mammals. The presence of these fish at the Upward Sun River site within the hearth of a dwelling feature does lend some credence to the idea that salmon as a resource provided enough stability at this time period to establish at least a single residence with women and children present (Potter et al. 2011).

An analysis of the fauna from the Gerstle River site and the others listed above suggests that high yield fauna could be accessed at many points within the middle Tanana River valley and meeting nutritional needs during this time period was achievable through a pattern of acquisition that required less logistical time in acquisition. One point that must be made about the majority of known sites dating to this time period within the middle Tanana River valley, though, is that by type most have been interpreted as logistical spike camps or intermediary points (Krasinski and Yesner 2008; Potter 2005). Since these represent the middle portion of the faunal material acquisition cycle where neither acquisition nor the final residential location are represented, it is difficult to know what resources were left behind during the initial acquisition portion of the process or what finally does make it to the residential portion of the cycle. As such, these sites only offer a single glimpse into the entirety of the early Holocene subsistence cycle. As of now very few potential residential occupations are known for this time period as well, with some potential locations being the Healy Lake old village site and Linda's Point (Cook 1969; Younie and Gillespie 2016) and a single known dwelling feature present at the Upward Sun River site (Potter et al. 2011). The only known interpreted hunting stations and potential locations for faunal resource extraction exist within the GSDF (Bowman 2016) and potentially at the Keystone Creek Dune site within the Shaw Creek Flats (Reuther et al. 2015).

### 2.6.3 Middle and Late Holocene

During the middle to late Holocene a general shift occurred in the local environment from the drier grassy parklands present in the early Holocene and associated erosional regimes to a more paludified and stable wetlands and densely forested boreal forest (Ager 1975; Jones et al. 2014; Mason and Bigelow 2008). During this time period, human land use and mobility also appears to have shifted from the earlier behavior of multi-seasonal large mammal hunting strategy with high residential mobility to a strategy of seasonally abundant resources with increased logistical mobility and a reliance on storage (Potter 2008c).

In general, it has been suggested that of the mobility systems that came into the area with the Northern Archaic Tradition, those with higher residential mobility and seasonal reliance on faunal resources such as fish and caribou (Anderson 1988, 2008; Esdale 2008; Potter 2008c) worked quite well and were potentially adapted for boreal forest living. Both were also suitable enough to expand peripherally beyond the forest extent when necessary resources did so (Ackerman 2004; Lobdell 1986).

During the late Holocene, in association with the Athabaskan Tradition and later the ethnographic record, the loss of microblades from the technological record occurs. However, in some locations within the middle Tanana River valley and surrounding area this technology remains active (Cook 1989; Shinkwin et al. 1980) an even higher degree of logistical mobility and territoriality. Some factors they may have led to this include the loss of bison and wapiti herds on the landscape (Potter 2008c) leading to a higher reliance on moose in the lowlands (Yesner 1989) and caribou in the uplands (Potter 2008c). Greater spatial division of the resource base may have led to the necessity to maintain a larger territory and retention of a more long term residential point. At this point, based on the data set present now, this hunting and gathering system was even more reliant on locally available seasonal resources and caching including fishing resources in the spring and summer (McKennan 1959) and increased use, as seen through the ethnographic record, of other lacustrine resources including both flora and fauna (McKennan 1959).

The GSDF, as a part of the landscape where this cultural history was recorded, represents a portion of the overall cultural historical record. The cultural activities interpreted in the following chapters are of the middle Tanana River valley landscape where little research has been conducted, namely the low lying river valley basin. As such, the incorporation of archaeological data from the GSDF into the cultural history of the middle Tanana River valley provides more information on the cultural history and land use of the area as it extends geographically into the low lying river valley basin.

# Chapter 3 Theoretical Approaches

## 3.1 Geoarchaeology and Landscape Reconstruction

The integration of geological applications to archaeological questions is not new. Naturalists as far back as Thomas Jefferson have noted the relationship between stratigraphy and archaeological deposits (Trigger 1996), and the understanding of using stratigraphy as a method of determining chronology through the Law of Superposition has been understood since the times of Charles Lyell (1830). The further incorporation of geological methods in an archaeological context also aid in answering other questions regarding human-environment interactions, as well as post-depositional effects on anthropological deposits (Rapp and Hill 2006). First and foremost to this research is determining the chronology of events using stratigraphic positions and numerical dating methods (e.g., radiometric and luminescence dating) to set a timeline for determining paleoenvironmental variables.

As the geologic law of superposition is commonplace in archaeology, as is the use of radiometric dating (in particular, radiocarbon dating), a further discussion of these methodological applications seem unwarranted in a section describing application of theory, as such this theoretical analysis will focus on theoretical aspects concerning paleoenvironment and geoarchaeology.

According to Butzer (1982), humans are both subjected to the whims of geomorphology and at the same time are one of the largest agents of geomorphological change. In essence, as humans, we interact and generally deal with the world as it is, in a geological context, but we also have the ability to alter the world around us. This very basic tenant of human ecology is the central-most theory for interpretation in geoarchaeology. As creatures influenced by environment and particularly by the ecosystem they live in, human adaptation and response to change operates as any other function within the overall ecosystem dynamic itself (Butzer (1982). Humans either adapt, move, or die. Humans however, unlike other animals, mitigate environmental change, not as much through biological adaptation, but through cultural adjustment, which can be reflected in many different ways, only some of which are preserved in the archaeological record.

Butzer (1980) points out three fundamental considerations when looking into the matter of environment and ultimately human interactions; intraregional correlation, regional delimitation, and causation. Interregional correlation requires that within and across a region, morpho-stratigraphic detail is closely considered, in conjunction with chronology in order to build a model of geological change over time. In terms of regional delimitation, environmental components exist within space on the landscape. This means that landforms are related to one another by the factors that played their parts in forming them and suggests that in order to get a real idea of geomorphological, environmental, and even ecological histories and contexts an examination of space is necessary beyond the key location or landform a researcher may wish to interpret. This approach includes prehistoric occupation as well since one site, in space and time, makes up only one component of a broader system. Finally, given temporal and spatial control, causation can be examined. This is where factors such as change over time (geomorphological, environmental, ecological, and cultural) and responses to it can be interpreted. In essence, in order to understand factors that influence change and adaptation a researcher must begin by looking at how things correlate in an area through time, make sure the area of research is broad enough to encapsulate the desired question, and then look at how the whole of the system works together before ascribing change and influence.

As humans are subject to the environment, analysis of environmental indicators such as difference in depositional particle sizes, carbon contents, and soil acidities can lend some information on how environments and ecosystems form, function, and change (Gladfelter 1981; Hassan 1978; Rapp and Hill 2006). Secondly, humans change landscapes, meaning as they use a landscape they add or subtract components of it, such as elements like phosphorous being added to sediments and soils when processing bone (Holliday and Garnter 2007), carbon and iron being altered when making fires (Tite and

Mullins 1971), clustering and accumulation of other elements occurring during differing accumulation and processing events associated with human behavior (Parnell et al. 2002), even lithic raw material when reducing and making tools. By analyzing elements and other aspects of human deposition, we can also learn about how people utilized environments and how this may have changed along with it (Hassan 1978; Rapp and Hill 2006). Through analysis on both of these fundamental theoretical geoarchaeological premises, reconstruction of human/environmental interactions at an interpretive level can become realistic and feasible.

## 3.2 Prehistoric Human Mobility

Discussing human mobility most logically begins with models developed by Lewis Binford. Binford (1980) places hunter-gatherer mobility behavior on a continuum between two dichotomous aspects of human movement based on resource acquisition and necessity: foraging and collecting acquisition strategies. In foraging systems, a higher degree of residential mobility is assumed, as the movement of group residences occurs between productive areas or patches, perhaps throughout an annual cycle or over longer periods of time. In a collector system, more logistical behaviors are assumed to be a centralized or set of centralized residential localities where the majority of a group operates and task groups are sent into the field to acquire resources. As stated previously, Binford (1980) situated these two idealized behaviors on either end of a continuum, allowing for more realistic hunter-gatherer behavior to exist in shades of gray along it, where collecting and foraging could occur together to fill the subsistence gaps.

Alongside this discussion researchers also address problems such as risk and risk management, longer distance travel mobility, and other mitigating factors to determine how hunter-gatherers dealt with differing situations under this mobility continuum. One such analysis is provided by Grove (2009), who looked at constraints within this continuum. He found that hunter-gatherers often operated within a system of concentric circles where foraging activities occurred closer to a residential base and logistical behavior occurred simultaneously within peripheral areas. Given this behavior, when it came time to move the residential base for whatever reason, the residential base would be moved to a more productive patch and the outer ring of logistical behaviors would still occur close to or within the same relative areas, given that these behaviors typically occurred on the same targeted specific resources. Using this system of constraints, relocation distance is optimized by entering a relatively close fertile patch, and logistical forays are optimized by retaining the same peripheral area on which operations were already occurring periodically.

Other studies have looked at aspects such as fertility rates to determine if long distance residential mobility is possible while sustaining hunting and gathering populations (Surovell 2000), and have used paleoenvironmental/paleoecological and geomorphological aspects as constraints on subsistence practices to determine how hunter-gatherers may have used aspects of this continuum to their advantage in dynamic landscapes (Itami and Gimblett 2005; Reuther 2013). All in all, the basic hunter-gatherer theoretical behavioral dynamic remains the same. The approach is, through the use of known and testable mitigating factors, to view human mobility as functioning using both foraging and collecting activities advantageously.

## 3.3 Human Behavioral Ecology

### 3.3.1 Prey Ranking

Prey rank modeling analyzes variables regarding prey animal capture and subsistence and ranks prey species regarding cost incurred by the hunting party (Bettinger 2009). This is accomplished by establishing caloric values for each species available to a particular group (Winterhalder 1977), and then modifying these values with variables regarding time for processing, time for searching, cost involved for prey species encountered in groups such as schools or herds, and other variables applicable to hunting situations within a given geographic area (Bettinger 2009). After these values are tabulated, a rank is determined to give an optimal value for the lowest cost animals with the highest return. These values give a heuristic value to the preferential choices prehistoric hunter-gatherers may have made in regard to preferential hunting and treatment of various prey choices on the landscape.

### 3.3.2 Patch Choice Modeling

Patch Choice modeling is often applied in situations where local environmental reconstructions deem resources within an area to exist in limited clusters (Jones 2009). In terms of human behavior within prehistoric situations, patch choice modeling is often quite limited based on the ability to reconstruct the paleoenvironment in which people lived and operated (Janetski et al. 2012; Jones 2009). In situations where higher resolution paleoenvironmental data can be afforded from faunal remains and geoarchaeological analyses, ecological patches can be constructed (Jones 2009). Furthermore, in situations where large degrees of faunal material and high amounts of faunal manipulation occur, use of paleoenvironmental patches by prehistoric humans can be interpreted in many different and highly accurate ways (Burger et al. 2005; Janetski et al. 2012; Jones 2009; Lyman 2003). In situations where little to no faunal data exists for interpretation, such as the GSDF, archaeologically accumulated faunal resources can be interpreted from nearby sites where local fauna was accumulated to show human dietary breadth choices; for example, the Gerstle River site displays a large collection of large mammal faunal material in Component 3, likely procured near or within the GSDF area (Potter 2005). Data can then be used in conjunction with high resolution geoarchaeological data to determine more precise placements of specific sites, such as hunting stations, on the landscape at differing time periods, as environments change.

### 3.3.3 Lithic Material Analysis

Analysis on lithic material has many facets of study. For the purposes of this research, however, the focal point will be a brief analysis of lithic raw material and tool type functionality based on available tools and waste debitage at archaeological sites within the GSDF. These avenues of research are explored because of their ability to provide information on prehistoric mobility and site functions within the GSDF area and sites peripheral to it.

A primary assessment of lithic raw material, in terms of whether raw materials were locally acquired or from non-local origins, is necessary for defining characteristics of archaeological assemblages (Potter 2005). While this type of analysis is often not straight forward, methods do exist that have the potential to parse out material acquired locally from that transported from great distances (Potter 2005; Younie 2016). Kuhn (1991) states that the most important determining factor in lithic manufacture and use is distribution of raw material. He states that scarcity of raw material in vicinity to sites will result in comparatively intensive exploitation and reuse of artifacts. Andrefsky (1994) states that raw material is fundamental to tool production via abundance and quality. As such, poor quality materials tend to be used for informal tools, whereas high quality materials tend to be used for formal tools.

To wit, raw materials further from their source will be more intensively exploited and reused, meaning that these materials are much more likely to be used, retooled, and reused as much as possible before discard. This would indicate that at sites further distant from the raw material source lower quantities of raw material and lower weight should occur, with lower and lower quantities occurring with sites occurring at greater distances from the raw material source. With this in mind, comparing quantity of a raw material versus weight of material at a site should indicate local versus non-local material. Along those same lines a comparison of weight against percent retouch should indicate local versus non-local material because % retouch should increase with distance due to intensive exploitation, whereas weight should remain low.

These patterns are especially important at sites where lithic material remains are the only indicator of prehistoric human behavior, such as those presented within the GSDF. Lithic raw material locality and availability has the ability to inform researchers on many aspects of human behavior, especially mobility and organization of technology (Kelly 1988), subsistence strategies (Shott 1989), and trade (Renfrew 1977; Renfrew and Bahn 1991), among others.

Analysis of lithic tool type has been used at its core in the past to assign archaeological assemblages to differing cultures, complexes, and traditions (Whittaker 1994). Going beyond this classical approach tool type and functionality can be used to determine differences in site function (Binford and Binford 1966). Tool type and function at sites should also be a function of processes and activities taking place at the site and with respect to the activities occurring before and after it as planned (Binford 1979). Further, an analysis of debitage left behind at sites can inform researchers on what may have been created or modified at a site, either for the functions needed to be performed at that specific location, or for transportation for future use (Pecora 2001). Binford (1979) suggests that low levels of lithic debitage should be present at hunting station type sites because low levels of reduction likely occurred while waiting for game.

# Chapter 4 Methods

## 4.1 Geomorphological Assessment

Prior to the field research in 2014, geomorphology of the landscape was assessed using aerial photography and LIDAR imagery in order to discern landform type, size, morphology, and orientation. Previous geological survey reports were also used to provide necessary background on the area and to provide potential locations for testing and sampling. During previous field observations from Reuther (2010), several locations containing distinct sand dune features were mapped and tested. In 2014, the goal of the geomorphological assessment was to spatially expand the known extent of the GSDF originally described by Hamilton (1975), Potter (2005), and Reuther (2010), and record the fine-grained characteristics of the morphologies of aeolian-derived landforms, both spatially and vertically. Research then was carried out in the Bison Range and Sawmill creek areas. One visit was conducted to the Gerstle Dunes, but due to land access issues only an initial confirmation of sand dune presence could be obtained is this portion of the GSDF. In 2015, field geomorphological analysis was completed within the Bison Range and Sawmill Creek portions of the GSDF, and key locations within the Gerstle Dunes were surveyed and tested. Throughout all areas, the field geomorphological assessments allowed for on the ground verification of sand dune presence and absence, dune morphology information was collected, and the direction, orientation, spatial configuration, and elevation of geomorphological sand dune forms was recorded.

## 4.2 Testing and Excavation

During the geomorphological assessment process, key locations were selected for subsurface testing. These locations were typically associated with known archaeological sites; however, several new landforms were also selected for testing as geologic locations. Tests conducted at these locations generally consisted of excavating a series of two or three 50 x 50 cm test units that were used to document the stratigraphy of landforms. In some instances, artifacts were discovered within geological sampling locations, adding to the quantity of sites known within the GSDF.

At archaeological sites, cultural material was delineated in cardinal directions from known positive tests in order to collect information on spatial distribution of occupations. In locations where artifacts were present in quantities greater than five objects, 1 x 0.5 m and 1 x 1 m excavation units were dug in order to collect finer resolution spatial data on the relationship of cultural deposits to stratigraphic horizons.

The sampling strategy used during field work for this thesis project was designed to only locate archaeological remains within specific stratigraphic contexts from which paleoenvironmental proxy data could be obtained. In most cases archaeological material was treated as a dichotomous (presence/absence) variable on the landscape. As such, only a very small sample of archaeological material from each site was obtained. In relation to that, only very tentative conclusions can be drawn about human behavior at each site tested.

From a taphonomic perspective, due to the high porosity and high moisture permeability of the sandy sediments within the GSDF dune system, preservation of organic material is quite low. In fact, no faunal material or organic tools were found in a buried context within any of the sites tested, or during any other archaeological survey or excavation in the area. This statement can also be extended to the preservation of paleoenvironmetal proxy data as well. Due to the high acidity of the current boreal forest and the high permeability of the sediments present at most locations tested within the GSDF only portions of paleoenvironmental data were likely retained within their original contexts. However, enough environmental proxy material was retained to allow for the creation of the data sets presented in this thesis.

In general, this thesis is useful for understanding the flux of paleoenvironmental patterns and ecological conditions human beings faced through time within the GSDF portion of the middle Tanana

River valley system. In this thesis, the emphasis was placed on these environmental variables with only limited information regarding human land use beyond presence/absence. To wit, a higher degree of testing at sites within the GSDF has the potential to reveal more information on prehistoric human behavioral practices.

## 4.3 Documentation

At each location where cultural materials were exposed at the surface, artifacts were documented through photography and mapped using a handheld GPS device. In locations where cultural materials were abundant, artifacts were again documented with photography, but were mapped using a total station to collect the location and spread of artifacts. In these circumstances, tools were typically collected and flakes left in the field. The reasoning behind this collection policy relates to the history of discovery within the Bison Range. High degrees of foot and vehicular traffic in this portion of the GSDF initially lead to the discovery of archaeological material by hunters utilizing the Bison Range, who reported the presence of this material to Reuther (2010). By collecting and curating the more recognizable portion of the assemblage away from the exposed sites within the GSDF, we can protect the interpretive integrity of these site and limit the effect of more disturbance occurring at these sites.

In locations where test units (50 x 50 cm and 1 x 1 m test excavations) were placed, all pits were photographed and stratigraphy was recorded either on the most representative location from each test area, or on pits where cultural material were located. In some cases, the stratigraphy was recorded at multiple pits in order to describe variation of sediment deposition and soil stratigraphy across a landform. Each pit was marked using a GPS device and incorporated into a sketch map of the test location. Buried archaeological sites were also mapped using a total station to collect data on topography as well as placement of test units.

## 4.4 Soil and Sediment Description and Sampling

In the field and for post field analysis the United States Department of Agriculture soil taxonomy descriptive system was used (Soil Survey Staff 2014). Color variations of sediments were recorded using Munsell Soil Color Charts. Column samples of soil and sediment were taken from every horizon from each archaeological and geological test location. Samples were regularly collected from profile walls from clearly observable portions of each horizon unit. Soil samples were collected vertically starting from the bottom of each pit moving upwards in order to ensure tight contextual control of each sample. Each sample location was documented with a photograph and recorded on a stratigraphic profile. In special circumstances, especially in the case of charcoal and burnt material collection, samples were taken from within an excavation level of a 1 x 1 m unit, though these cases were rare. Under these circumstances additional photos and measurements were taken to document these sample locations.

Collected samples were used for the purposes of laboratory analyses. These analyses included loss-on-ignition tests for organic and inorganic carbon fractions within a sediment package, particle size analysis, acidity tests, inorganic carbon analyses via a chittick apparatus, and chronological assessment via radiocarbon dating when applicable.

## 4.5 Stratigraphic Analysis and Correlation

Upon returning from the field, stratigraphic profiles were digitized and incorporated into a GSDF wide profile diagram. This data was curated in order to provide a map of stratigraphic correlations and variation across the entirety of the GSDF with relation to locations outside of the boundaries of the GSDF, such as the Gerstle River and North Gerstle Point sites. Upon completion of each laboratory analysis each data series was added to a cumulative profile. This process helped to provide further parallels for large-scale variation and correlation.

## 4.6 Geoarchaeological Laboratory Analyses

### 4.6.1 Particle Size Analysis

Particle sizes were measured in order to determine wind strength and intensity during periods of sand and silt deposition. This examination was carried out on samples taken from the geological section GD-RCB-003 and archaeological sites XMH-01521 and XMH-01409. These locations were used in order to provide a cross-section of particle size changes across the Gerstle Dune area, Sawmill Creek area, and Bison Range, and throughout the GSDF. In general, methods for this analysis followed those described by Janitzky (1986) and are detailed below.

Pretreatment for particle size analysis generally followed procedures outlined by Janitzky (1986). First, a ceramic mortar and pestle was used to grind dried samples in order to allow materials to pass through a 2.0 millimeters (mm) screen so that particles larger than very coarse sand could be removed. Clumps or aggregations of sediment were gently broken up in order to allow them to easily pass through the mesh. 100 grams (g) of sample material was segregated in order to conduct analysis. Using tweezers, large pieces of undecomposed organic matter (roots and larger woody particles) were removed. Samples were then placed in labeled bags. Approximately 25 g of the less than 2.0 mm fraction was then placed in a numbered centrifuge tube. The tube was then placed in a 400 milliliters (mL) beaker.

At this point, 0.5 N HCl was carefully added until sample tubes were around 200 mL full. Samples were stirred to further disaggregate clumping sediments. Then, the 400 mL beakers were filled with deionized (DI) water until the centrifuge tubes floated. Samples were then placed on a hot plate and heated to approximately 60 degrees Celsius (°C). These samples were then monitored to ensure than DI did not fully evaporate. Samples were stirred intermittently to ensure that overflow from tubes did not occur. This process was carried out and observed for a day’s length. At the end of the first day, samples were removed from the hot plate and allowed to settle overnight. When samples were observed to be cool and clear remaining overlying fluids were pipetted away. This process was repeated until all carbonates were removed and samples no longer reacted to HCl.

After drawing off the last acid wash, 5 mL of hydrogen peroxide ($H_20_2$) was added to samples while still within the centrifuge tubes and water bath. After foaming subsided an additional 5 mL was added. Samples were then again placed on hot plates and allowed to react for 12-24 hours with no heat. Samples were then heated for 1-2 hours to allow reaction to finish. Samples were not allowed to boil in order to maintain reaction. Samples were then washed through a process of centrifuging and decanting and tubes were dried with a paper towel. Tubes were then filled 2/3 full with DI and weighted. Samples were then placed in a centrifuge and spun at 6000 RPM for 12-15 minutes.

After the final washing cycle 25 mL of sodium pyrophosphate was added with 100-150 mL of DI to aid in dispersal. Sediments were then disaggregated using a malt mixer set on low for seven minutes, then wet sieved through a 63 µm sieve with distilled water. Remaining portions of the sample were then washed through the sieve into a graduated cylinder while the sand portion remained within. This sand portion of the sample was then placed in a tared beaker and placed in an oven at 110°C overnight to dry. After drying, this portion of the sample was then removed from the oven and placed in a desiccator until cool. The sand fraction was then sieved to determine the size differences within the sand fraction. Each portion was then weighted to determine the total sand fraction within the sample. The suspended silt/clay portion of the samples within each graduated cylinder were then agitated and pipetted at known intervals in order to obtain silt/clay and clay fractions based on known settling times (Janitzky 1986). After drying, these samples are weighted in order to calculate the portion of each within samples. Particle size analysis was carried out at the Environmental Archaeology laboratory at University of Alaska Fairbanks.

### 4.6.2 Organic/Inorganic Carbon

Loss on Ignition (LOI)

LOI measures both organic and inorganic carbon contents within samples by exposing measured portions to heat in a furnace which causes carbon to ignite and turn to gas at various temperatures (Rapp and Hill 2006). Generally accepted temperatures for the ignition of organic carbon occur at 500°C and inorganic carbon at 1000°C. Measurements are conducted before ignition to obtain a base sample weight, and then are heated to 100°C to purge the samples of any latent water. Then, the samples are ignited at 500 for one hour to remove organic carbon, then again at 1000°C for the removal of inorganic carbon. The loss of weight at each period is measured after the sample cools. These weights are then inferred to be the ratio of the sample weight containing that type of carbon.

Organic and inorganic carbon measurements are used as environmental indicators for moisture in the environment, higher amounts of organic carbon indicate a moisture rich environment, whereas inorganic carbon rich environments indicate drier environments (Rapp and Hill 2006). Analysis of organic and inorganic carbon can also provide information on biological activity in an area, often higher degrees of organic carbon co-occur with higher degrees of biological activity, despite organic carbon indicators not being visually present in a stratigraphic profile (Rapp and Hill 2006). Lastly, these analyses can also be used in some cases to provide sediment source provenance information when source sediments are observed to contain high degrees of organic or inorganic carbon, such as lignite or coal for organic carbon and limestone or dolstone for inorganic carbon (Rapp and Hill 2006). Through the analysis and calculation of these percentages information on environmental types and changes can be ascertained. Loss on Ignition analysis was carried out at the Environmental Archaeology laboratory at University of Alaska Fairbanks.

Unfortunately, analysis of carbon contents through the use of LOI is not without error. In some cases clay content can cause latent moisture to remain within a sample after the 500°C ignition point

(Holliday and Gartner 2007; Holliday et al. 2004). As a result readings for organic carbon can be skewed in cases where accumulations of clay and organic carbon occur together.

### 4.6.3 Sediment Acidity (pH)/ Sediment Conductivity

In some circumstances, sediment and soil pH can be used in the reconstruction of paleoenvironmental variables such as humidity, species of plants present on a landform in the past, and forest density (Rapp and Hill 2006; Zinko et al. 2006). Sediment conductivity can be used to determine anthropogenic inputs, as well as changes in paleoenvironment type. Typically, anthropogenic inputs tend to decrease the conductivity of sediment by adding non-conductive elements, as does the development of soils (Rapp and Hill 2006). Alternatively, conductivity has a tendency to increase in locations with little to no anthropogenic input and where purely mineralized sediments, with little to no soil development are present (Rapp and Hill 2006). In a paleoenvironmental context, in cases where biological inputs increase, conductivity tends to decrease and in location where less biological occurs conductivity tends to increase (Rapp and Hill 2006).

Determining the pH and conductivity of soil samples requires several steps that must be done in the correct order. As both tests are conducted with the same device similar preparation and equipment is necessary for collecting readings for both analyses. The equipment needed to take pH and conductivity readings include:

- pH Meter, electrode, temperature probe (Oakton)
- Buffer Solutions (pH 7.00, pH 4.00, pH 10.00)
- Electrode Storage Solution
- purified water (several gallons)
- tap water
- paper towels

- glass beakers (5)
- plastic squeeze bottle (for rinse water)
- quart-size Ziploc bags (3)
- scale
- aluminum foil
- stirrer/scoop
- kitchen timer/watch
- large bucket

The first step in setting up the meter reader for pH and conductivity is calibration. This step is carried out through exposing the data collection probe and temperature probe to several solutions of know pH and conductivity in order set the device.

After the pH meter has been calibrated, the device is ready to start taking the pH and conductivity of soil and sediment samples. Only one sample was prepared at a time in order to avoid confusion. In order to take a weight measurement, a square of aluminum foil was placed on the scale. Then a measurement out 40 g of the soil sample was removed for analysis. This sample was then transferred, using the foil, into a 600 mL beaker. At this point, purified water was added to the 300 mL line and gently mixed into a soil slurry, removing any organic debris (small stick, grass). The sample was let to stand 20 minutes, then the first reading was taken. Conductivity, pH, and the temperature of the sample were then recorded in the pH/conductivity database. The electrode was then rinsed with purified water and turned off. After another 10 minutes, a second reading was taken, and after another ten minutes a third and final reading was taken. These sample readings were then averaged to produce an overall reading for each sample. pH and conductivity analysis was carried out at the Environmental

Archaeology laboratory at University of Alaska Fairbanks and at the Northern Land Use Research Alaska Laboratory.

### 4.6.4 Micromorphology

Micromorphological samples were collected from geological sections and archaeological sites throughout the western portions of the GSDF including the Sawmill Creek area and Bison Range. In general, micromorphological slides were examined using protocols set up by Fitzpatrick (1993) and Stoops (2003) in order to determine the petrographic mineralogical composition of sampled sediments, soil composition and organic matter content, as well as overall pedogenic structures present within sampled sediments.

For analysis, each sample was examined using a Meji ML9300 rotating stage, cross polarized light microscope (lighting set at full with full aperture with cross-polarization, magnification: 4x0.10 to locate items of key interest, 10x0.25 for detailed microscopic analysis) for all attributes listed above. Secondarily sediment samples were laid out on a light table in original stratigraphic position in order to gather more data regarding the vertical relationship between samples. Both methods proved useful in collecting necessary attribute data on the micro-composition of sediments packages within the column, as well as determining the relationships of sediment deposition and source. This data will provide information on proximity of sediment sources during aeolian reworking, changes in wind intensity, erosional boundaries, and biological indications for environmental change.

### 4.6.5 Wave Dispersive X-ray Florescence

Wave dispersive X-ray florescence (WDXRF) is a technique that uses directed x-rays to measure elemental concentrations within a sampled material (Goldstien et al. 2003). Elemental concentration analysis has proven useful in the study of sediments for archaeological and paleoenvironmental evidence in many cases in the past (Gilbert 2011; Muhs et al. 2004; Wolfe et al. 2000). WDXRF in particular measures samples elemental wave-lengths, which has been proven to be more effective on the analysis of sediments than energy dispersive X-ray florescence (EDXRF) and portable X-ray florescence (PXRF) (which in essence are handheld EDXRF devices) (Hunt and Speakman 2015).

A semi-quantitative WDXRF analysis was carried out on stratigraphic columns from one location each across the Bison Range, Sawmill Creek, and the Gerstle Dunes. Analysis was carried out using a PanAlytical Axios X-ray Fluorescence Spectrometer. In semi-quantitative mode, this device uses three prescribed time settings for collecting elemental data. In order to determine which setting produced the most accurate data a subset of sediments from the Bison Range area was ran on each of the three time settings. Results from this analysis were then compared to determine if a statistical difference existed between scan time settings. The analysis showed that no statistical difference existed between any time scan for any sediment tested at one, two, and three-sigma. Based on this analysis it was determined that the fast-scan setting (approximately a three minute wave dispersive analysis, with the Omnian calibration curve) produced more than adequate data with little statistically significant variation and allowed for quick analysis of multiple samples over a shorter time period. The samples were run on the PanAlytical Axios 4-kilowatt WDXRF housed in the University of Alaska Fairbanks Advanced Instrumentation Laboratory.

Prior to analysis, samples were pelletized. Pelletization required that a 10g sub-sample be taken from each stratigraphic sample. These sub-samples were then homogenized both in terms of material content and size using a mill mixer. After sample homogenization, the powder produced was mixed with an alcohol based bonding agent (Poly-Vinyl Alcohol) and pressed inside a metal disc measuring 37 mm in diameter using a manual hydraulic press. After this process, the samples were allowed to dry for at least three days before analysis.

## 4.7 Prey Ranking Analysis

A limited analysis of prey rank based on differing species availability was determined for the GSDF and surround middle Tanana River valley area. This analysis was conducted as a more heuristic generalized analysis to estimate the overall rank of known species within the area, including bison and wapiti, as they were known to persist within the area into the middle Holocene (Guthrie 2006; Holmes and Bacon 1982; Potter 2005, 2011; Shapiro et al. 2004).

The process of determining optimality ranking was based on caloric mean units (obtained from Winterhalder [1977] and Smith [2012] from modern proxy species) for each animal as a ratio against search time and handling time similar to studies conducted by Winterhalder (1977, 1981) and theoretical applications set up by Bettinger (2009). Search and handling time was estimated based generally on calculations made from geospatial distance analysis within this portion of the middle Tanana River valley and from processing techniques and general time taken to preform them, acquired from ethnographic work done by McKennan (1959). McKennan (1959) also provided the basis for species selection as well as gross level estimates for start and stop times for both searching and handling. Species used for this analysis include moose, Dall sheep, caribou, and duck/geese, fish, bison, and wapiti. While the bison used in this study is *Bison* instead of *Bison priscus* and early and middle Holocene wapiti were likely larger than modern specimens, for the heuristic purposes of ranking species in this study these differences are negligible given their respective size and caloric amounts. Animals that live in herds or schools were given a low value group modifier in order to account of the likelihood of capturing more than one animal at a time. Each species set was analyzed by seasonal availability and ranked to determine which species/environment would present the most optimal choice for people during that time period. Seasonal animal behaviors are based on modern characteristics.

## 4.8 Spatial Analysis/Patch Choice Modeling

This analysis begins with the assumption that discovered archaeological sites at given time frames of occupation reflect positive patch productivity. Patch productivity is defined in this exercise similarly to that described by Burger et al. (2005) where prey, and its associated ecosystem based constraints, are treated as patches using the Marginal Value Theorem (MVT) which accounts for decision making of foragers out in the field based on time and effort expended or needed to expend.

Direct value of a patch, in terms of ecosystem and therefore potential animal habitation within, is determined here through geoarchaeoogical analyses including WDXRF, soil acidity, and analysis of organic and inorganic carbon. Each analysis is used as a proxy for a set of facets for ecosystem development and change through time. By using all of these proxies together aspects of an ecosystems stability, moisture content, relative biology, and whether a forest is more open or closed can be evaluated. With this data an idea of patch productivity can be ascertained on a vegetative level, leading to an understanding of how animal populations would have operated within or around it. This is true for both archaeological and non-archaeological locations throughout the GSDF, which when used together, creates a robust proxy data set of indices for environmental dynamism, stability, and ecosystem productivity through time within the GSDF. These interpretations and their given values are then mapped spatially to show the potential for changes in ecosystem stability and animal resource fluctuation through time, as patches of productivity in association with human behaviors as they tracked productive patches.

## 4.9 Lithic Analysis

For the purposes of this project, lithic materials were analyzed in order to determine basic site function based on tool types, variety and quantity, and functions. Several key indicators can be used to determine site function. First, quantity and variety of lithics observed at sites in general can be used to obtain an idea of site type, sites with low quantities and varieties of lithic material are often interpreted to represent short term occupations and hunting stations as opposed to locations containing more and a wider variety of lithic debitage and tools (Binford 1979; Nelson 1991). Second, tool types and quantities can inform on site type. According to Nelson (1991) and Andrefsky (1994) technology can be divided into formal and informal tools based on form and raw material. While both formal and informal tools are found at many different site types (Andrefsky 1994), quantity of occurrence can be informative to site function (Hofman and Ingbar 1988; Nelson 1991). For instance hunting stations have been observed to contain high quantities of formal tools alongside informal expedient technology as they indicate side by side hunting and field processing activities (Binford 1979; Hofman and Ingbar 1988; Nelson 1991). Tool type, variety and quantity, and function were assigned based on typological analogy and context of tools, with regard to utility (Kuhn 1991; Whittaker 1994).

Lithic debitage was analyzed by size, breakage type, dorsal scar count, and typologically in order to make inferences on what tools were being manufactured at sites (Andrefsky 1998; Prentiss 2001). Secondarily, analysis was conducted to determine whether lithic materials discarded at sites were local in origin or were transported from a longer distance by separating out material types and analyzing them against the proportion of the lithic material present at sites (Andrefsky 1994; Potter 2005; Younie 2016). As previously stated raw materials further from their source will be more intensively exploited and reused, meaning that these materials are much more likely to be used, retooled, and reused as much as possible before discard (Kuhn 1991). This would indicate that at sites further distant from the raw material source lower quantities of raw material and lower weight should occur, with lower and lower quantities occurring with sites occurring at greater distances from the raw material source. With this in mind, comparing quantity of a raw material versus weight of material at a site should indicate local versus non-local material. Along those same lines a comparison of weight against percent retouch should indicate local versus non-local material because % retouch should increase with distance due to intensive exploitation, whereas weight should remain low. Both analyses were undertaken in order to place constraints on human land use within the area in terms of subsistence and mobility.

Lithic material was analyzed using a dissection microscope and compared against the 2100 minerals and rocks of the United States lithic material chart to aid in raw material identification. Metric data on all tools and debitage was collected using a Mitutoyo digital caliper to record dimensional metrics and weighed using an Accuris instruments digital scale, with precision in the hundredths.

# Chapter 5 Results

## 5.1 Sand Dune, Sheet, and Alluvial Morphology within the GSDF

This section presents results of the geomorphologic study across the GSDF area. For the sake of ease, all sub-locations (Bison Range, Sawmill Creek, and Gerstle Dunes) used for the in-field portion of this analysis (Figure 5-1) are combined together. The results of this geomorphological analysis are displayed spatially in Figure 5-2 and Figure 5-3.

Dune and sand sheet morphologies are remarkably consistent across the GSDF and appear to originate from glacio-fluvial outwashes sourcing from moraine deposits to the south, within the foothills of the Alaska Range, mapped by Reger et al. (2008) as being associated with the Delta Glaciation in the west and the Donnelly Glaciation in the east. Reger et al. (2008) originally mapped the glacio-fluvial longitudinal flood bars present within the southeastern portion of the GSDF, reporting that these features likely formed during repeated outburst flooding events. The Gerstle-Clearwater escarpment (T2) is well known within the area, was reported by Reger et al. (2008), and is clearly visible in LIDAR maps for the area (Figure 5-2 and Figure 5-3) (Hubbard et al. 2011). LIDAR for this area also clearly displays a secondary, likely older, escarpment present just east of the Sawmill Creek dunes (T1), which marks the dunes southeastern most extent. The inception and abandonment of the ancient alluvial escarpment is unknown in age. However, glacio-fluvial flood bars are only present between T1 and the T2 escarpments; dunes of any morphological type have not been observed to co-occur within the area where the flood bars exist. This would suggest that T1 likely began to form sometime prior to the deposition of the flood bars, and it may well have confined their formation to the area. The timing of the abandonment of alluvial erosional activities at T1 is harder to define; however, the lack of any dune morphology within the area near it suggests that it may not have been fully abandoned until sometime after dune development in the GSDF (Figure 5-2 and Figure 5-3).

The sand dune morphology itself consists of a series of transverse dunes with slipfaces oriented away from the Alaska Range, indicating that the original wind direction for the formation of these dune forms was dominantly northward away from the range. This particular type of formation is typical in a landscape with thin and sparse vegetation coverage and little to nothing else as an inhibitor for sand movement (Bloom 1998). These dune sets were then overlaid by smaller parabolic dune forms with slipfaces pointing westward, indicating a wind direction from east to west moving through the middle Tanana River valley. This type of dune morphology is typical in an environment with patchy vegetative cover allowing for points on the landscape where sand movement is inhibited by plant growth and moisture retention (Bloom 1998). Both of these dune forms are present and distinguishable in LIDAR imagery from the area and visually in the field. Paleosol development in discontinuous patches is present in stratigraphy from the Bison Range and Sawmill Creek in contexts between sand layers, indicating non-ubiquitous soil coverage at various times (Figure 5-2, Figure 5-3, Figure 5-16, and Figure 5-23). A sand sheet is present in the transition areas between the glacial outwashes and the actual dune formations. It is possible that this transitional area was more uniform in the lack of vegetation coverage and topography prior to aeolian sand sheet deposition. This would have given the area a lower surface roughness, which would have promoted faster local wind velocities and may have not allowed for the deposition necessary to build sand dunes (Thorson and Bender 1985).

Chronologically it can be inferred from this geomorphic data that sometime after both glaciations, the creation of the older alluvial escarpment east of Sawmill Creek, and outburst flooding associated with the Donnelly glaciation, the GSDF consisted of a location where little to sparse vegetative cover existed, allowing for the development of transverse dune forms. These dunes then stabilized to a point in which, at least, patches of vegetation could form and allowing for the development of parabolic dune forms over the transverse forms. The transverse and parabolic dune forms were then covered by the more recent vegetation, as the landforms remained relatively stable.

The precise timing and paleoenvironmental conditions of these events will be discussed in further detail in the later sections of this thesis.

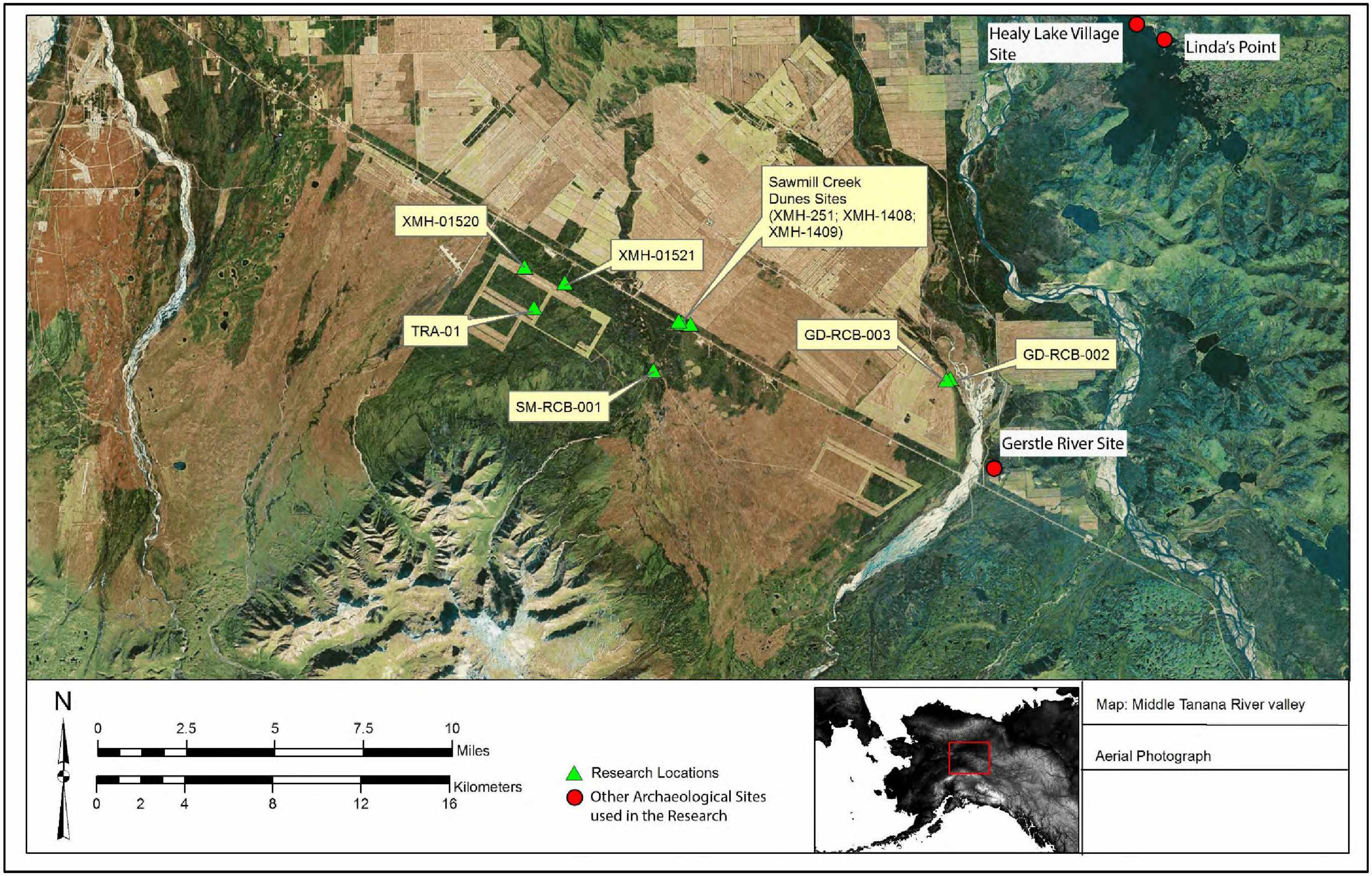


*Figure 5-1.* Sites and Geologic Test locations within the Project area

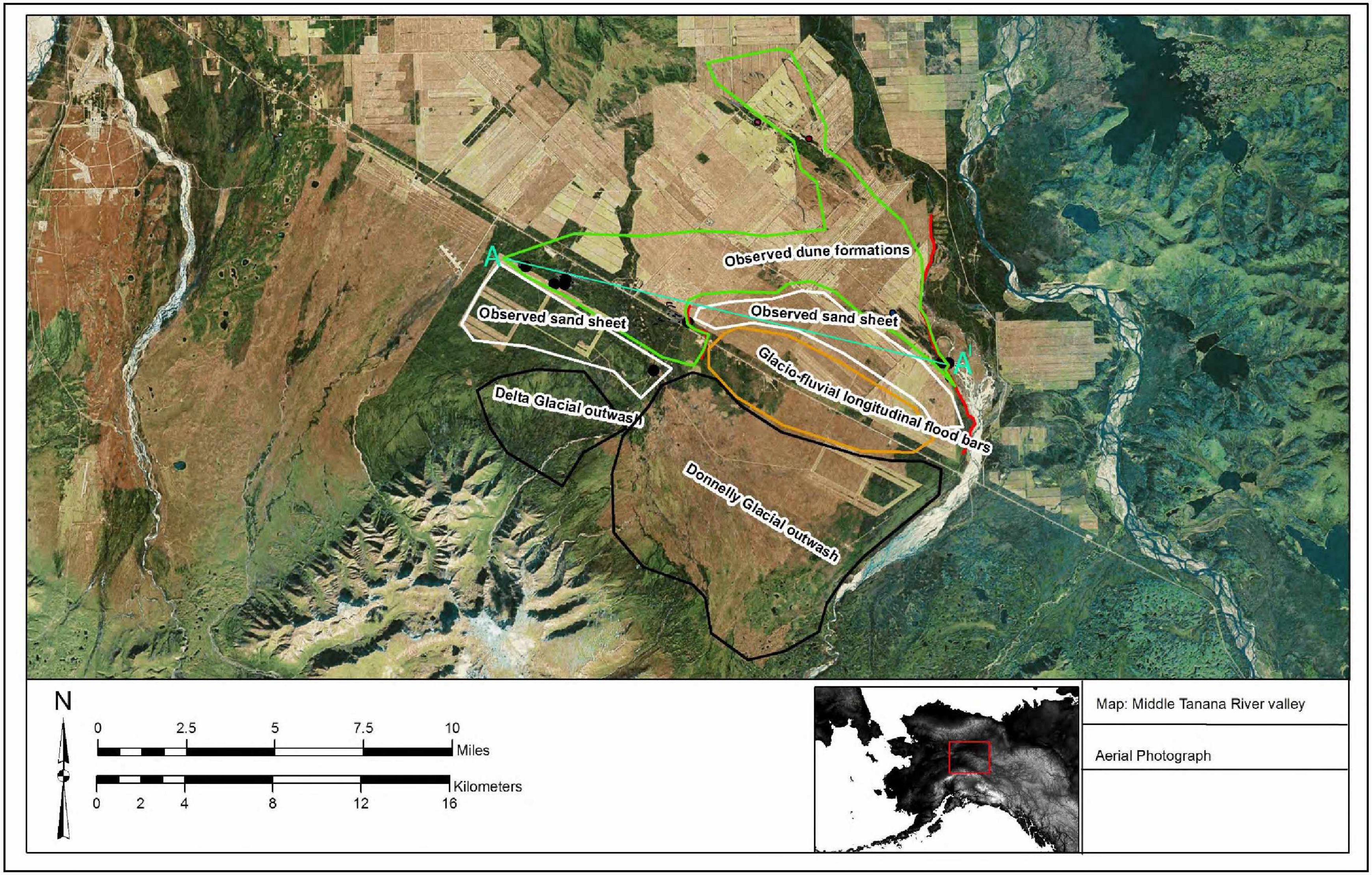


*Figure 5- 2.* Geomorphology of the project area.

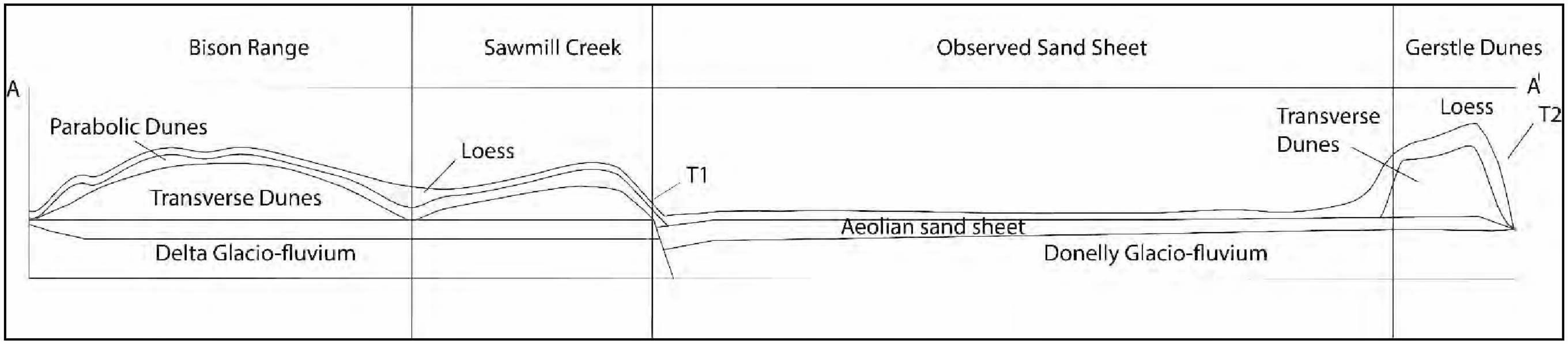


*Figure 5- 3.* Cross section of current sediment layers across the GSDF.

## 5.2 Archaeological Site Descriptions

This section focuses solely on the archaeological sites located within the different portions of the GSDF. These sites will be described geospatially, topographically, and in terms of assemblage technology and timeframe. These descriptions provide background on individual sites, then in later sections they will be incorporated with selected geological test sections for paleoenvironmental reconstruction. With the full incorporation of all data sets, correlations can be made about environment and human land use through time.

### 5.2.1 Bison Range Dunes

The Bison Range portion of the GSDF begins from the southernmost extent of the actual dune field formations after the transition from the lower lying sand sheet in the south to the GSDF's intersection with the Alaska-Canadian (Alcan ) Highway (Figure 5-1 and Figure 5-2). Two archaeological sites were found within the Bison Range portion of the GSDF: XMH-01520 and XMH-01521. Both of these sites are located within the northern portion of the Bison Range area, and at the southwestern portion of the observed dune formations within the overall GSDF area (Figure 5-2). Both sites are situated on reworked transverse dune sets overlaid by parabolic dunes.

#### *XMH-01520*

XMH-01520 is located in the far southwestern edge of the GSDF dune complex, at the transition between the lower lying sand sheet and the beginning of the dune formations (Figure 5-2). It consists of two discreet archaeological loci separated by over 50 m of unutilized space (Figure 5- 4 and Figure 5- 8). At both loci, the cultural materials are mainly comprised of waste flakes (n=127); however, lithic tools (n=31) are present in lower quantities. These tools will be discussed within Section 5.8: Lithic Analysis.

Within Locus 2, a potential hearth feature is present, located within a portion of the dune that has been deflated (Figure 5- 9). Radiocarbon dating of a charcoal fragment from the area of the feature provided a date of 1,715 to 1,865 Cal BP (UGAMS-25457, 1850 +/- 25 BP; Table 5-6). This date may indicate that occupation occurred during this time frame; however, extensive deflation has occurred at this portion of the site, and may have allowed for younger fragments of charcoal to have mixed with the contents of the hearth materials. Stratigraphy from test units at this location, and at nearby TRA-01, display alternating episodes of sand deposition and layers of charcoal after approximately 4,000 Cal BP. This indicates that during the late Holocene forest fire cycles occurred at least semi-regularly throughout the Bison Range portion of the GSDF, increasing the likelihood of mixture charcoal from multiple natural and cultural burning episodes (Figure 5- 10 and Figure 5- 19).

Unfortunately, due to more modern erosive events including bison wallowing and trail maintenance preformed on the area to allow hunting access, this site has become even more deeply disturbed, suggesting that XMH-01520 is likely a large palimpsest. At only one location, along the north side of Locus 1, a buried B horizon was located in direct association with lithic flaking debris (Figure 5- 5). This is the only known location within this site where in situ artifacts have been recovered and documented directly associated with soil development. Charcoal from this buried soil provided a date of 4,665 to 4,865 Cal BP (Beta-440127; 4250 +/- 30 BP; Table 5-6). This date suggests that at least one component of this potential palimpsest dates to the middle Holocene. Notched bifaces recovered from a deflated surface (Reuther 2010) suggest that Northern Archaic tradition populations used the XMH-01520 area during the middle or late Holocene.

*Figure 5- 4.* Blow out at loci 1 at XMH-01520.

*Figure 5- 5.* Positive test pit excavated into north area of XMH-1520 Loci 1 blowout. View north.

*Figure 5- 6.* Stratigraphy of positive test in Loci1 of XMH-01520. View north.

*Figure 5- 7.* Small flake in situ in from test pit.

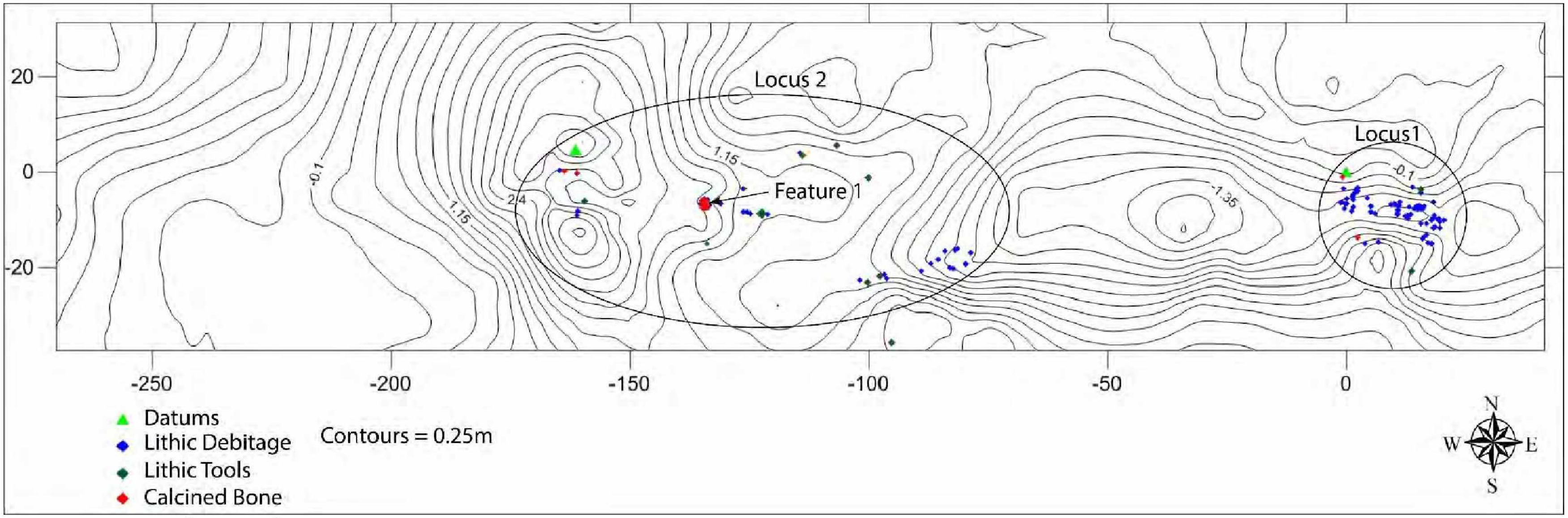


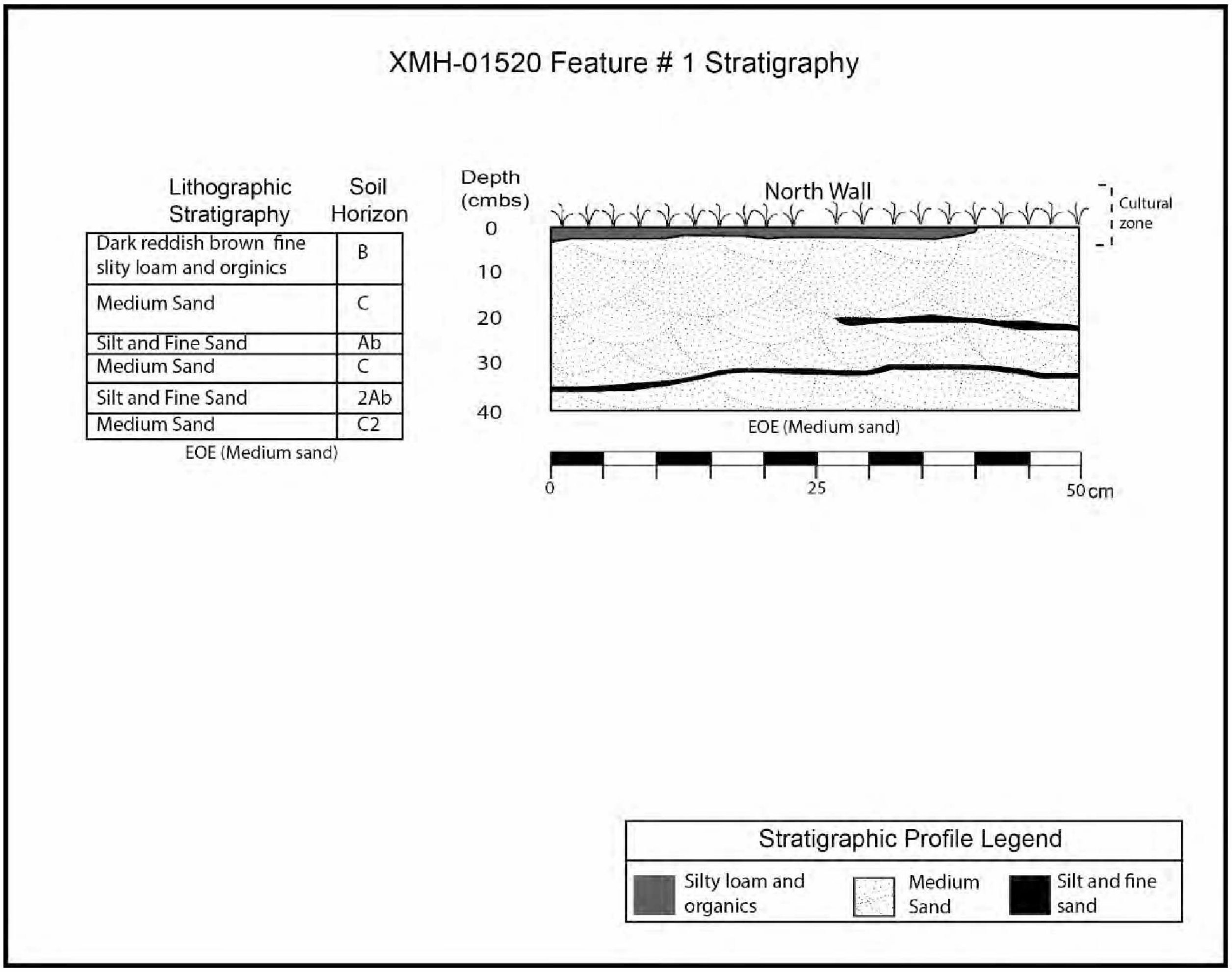
*Figure 5- 8.* Topographic map of XMH-01520.

*Figure 5- 9.* Potential hearth, XMH-1520, loci 2.

### *XMH-01520 Site Stratigraphy*

Due to the deflated nature of deposits at XMH-01520 it is mostly unknown to what extent cultural deposits relate to stratigraphy. However, at stated earlier, at least one component is related to an exhumed dark reddish brown fine silty loam (B horizon; 0-3cmBS) dating to 4,665 to 4,865 Cal BP (Beta-440127; 4250 +/- 30 BP), located in the northern deflated portion of Locus 1. This exhumed soil and associated organics most likely comprise the material associated with the B horizon observed in the stratigraphy at Feature 1 (Figure 5- 9). Below this mixture of lag material and exhumed soil are a series of thinner lesser developed buried soils and other lag deposits (Figure 5- 10 and Table 5-1). These deposits are separated by a yellow medium sand (10YR 8/6), likely deposited during the original transverse dune formation sourcing from the south, and then locally reworked parabolically as observed elsewhere in the GSDF.

Stratigraphy from the southern portion of the dune area (Figure 5- 11) displays a higher very dark gray silt and fine sand (Ab horizon; 10-20 centimeters below surface [cmBS]) that separates silt deposits from lower sands and lag deposits. It is likely that this soil and associated burned wood debris relate to later forest fire activity after the ubiquitous coverage of forests after approximately 4,000 Cal BP. Finer sediments above being deposited as local material was exposed and possibly newly introduced, potentially from alluvial actions or from local forest fire landscape degradation allowing for aeolian processes to give transport.



| Lithographic Stratigraphy | Soil Horizon |
|---|---|
| Dark reddish brown fine slity loam and orginics | B |
| Medium Sand | C |
| Silt and Fine Sand | Ab |
| Medium Sand | C |
| Silt and Fine Sand | 2Ab |
| Medium Sand | C2 |

EOE (Medium sand)

*Figure 5- 10.* XMH-01520 feature 1 north wall stratigraphy.

*Table 5- 1.* Feature 1 excavation stratigraphy.

| Strat descriptions | XMH-01520, Feature 1 | | |
|---|---|---|---|
| Unit (Soil Horizon) | General Depth (cmBS) | Maximum Thickness (cm) | Description |
| B | 0-3 | 3 | 5YR 3/2 dark reddish brown fine silty loam; fine partially decomposed organics; well sorted; abrupt, smooth boundary |
| C | 0-35 | 35 | 10YR 8/6 yellow medium sand; well sorted, clear, smooth boundary |
| Ab | 18-20 | 2 | 10YR 3/1 very dark gray silt and fine sand; fine partially decomposed organics; clear, smooth boundary |
| 2Ab | 30-35 | 2 | 10YR 3/1 very dark gray silt and fine sand; fine partially decomposed organics; clear, smooth boundary |
| 2C | 35-40 | 5 | 10YR yellow medium sand; well sorted, clear, smooth boundary |

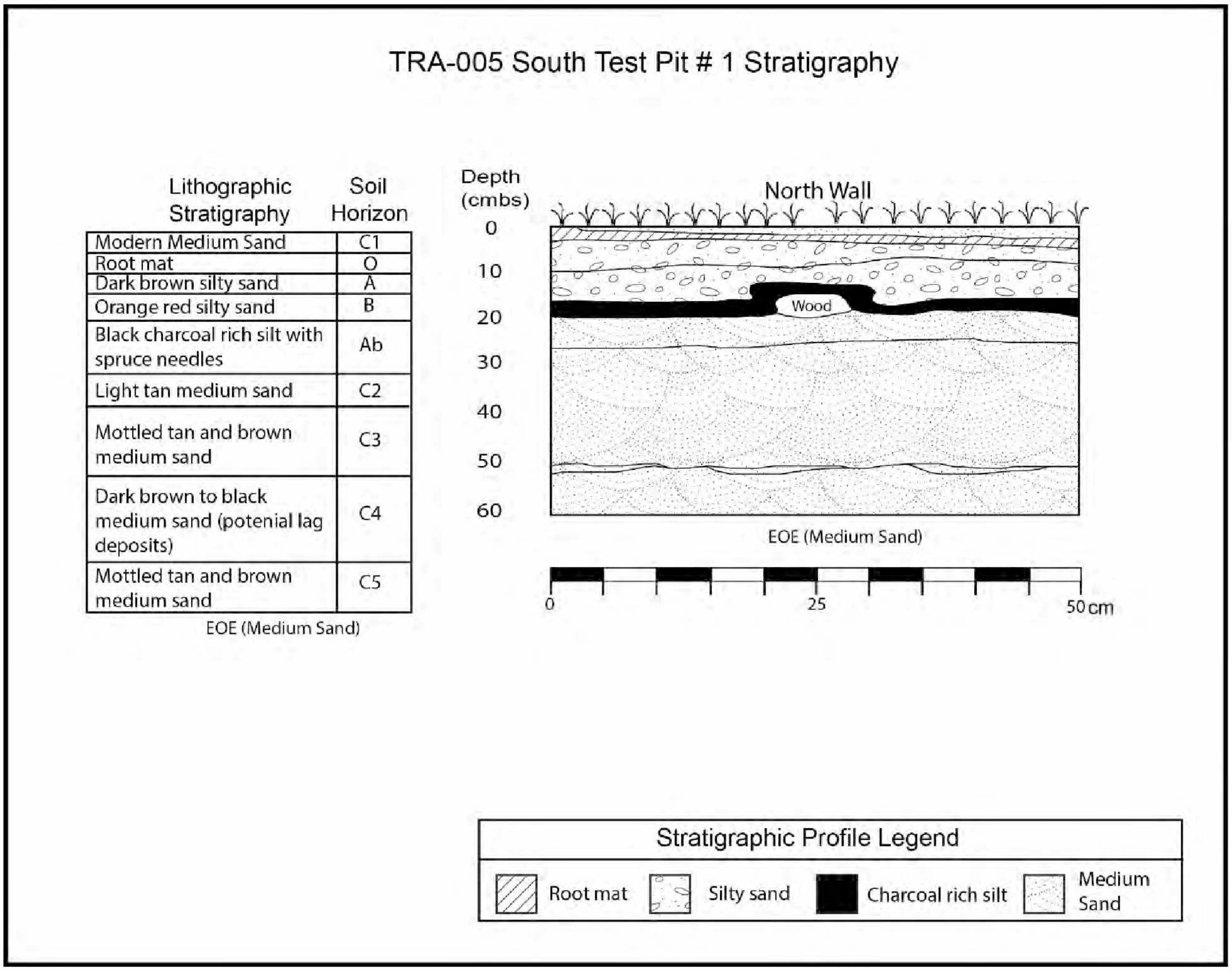


*Figure 5- 11.* XMH-01520 south test pit 1 stratigraphy, north wall.

### *XMH-01521*

XMH-01521 is located on a transverse dune formation within the southern portion of the GSDF. Evidence of sand deposition associated with parabolic reworking is present in a stratigraphic unit above the cultural deposit (Figure 5- 16 and Table 5-2). Cultural material from this site is directly associated with a dark reddish brown fine silty loam (Bb horizon; approximately 50 cmBS) (Figure 5-12, Figure 5- 13, and Figure 5- 14). This Bb horizon is approximately 5-8 cm thick at its thickest points, but is discontinuous and truncated in several locations across the landform. This lack of continuity is interpreted to reflect an erosive event after the period of reactivation that created the parabolic dune subset above the original transverse dune formations. Archaeological remains from this paleosol have been documented to be present within the paleosol and also in locations where the paleosol has been eroded away. Artifacts were also documented at the base of the paleosol and its erosive boundary (Figure 5- 14). This indicates that the archaeology at this site was in fact directly associated with the upper portion of the developed paleosol; however, some vertical displacement occurred during the later erosion and sediment mobilization at the site. Charcoal from this buried B horizon dated to 11,970 to 12,365 Cal BP (Beta-421547; 10290 +/- 40 BP) (Table 5-6). The presence of archaeological material in direct association with this paleosol indicates that this site was occupied while this soil was developing on the landscape. It also indicates that this site was occupied during the terminal Pleistocene and contemporaneous with the earliest occupations at Healy Lake (Cook 1969) and Linda's Point (Younie 2016).

Further testing on the sand dune where XMH-01521 is located picked up the Bb horizon across the landform (Figure 5- 15). However, no further archaeological remains were encountered. Artifacts from this site consist of a small collection of flakes of various materials (Figure 5- 14). Due to the deflated nature of the deposits at XMH-01520, it is unknown as to whether archaeological material located there coincide in time with the occupation (or occupations) at XMH-01521. It is also unknown as to whether the ~12,000 Cal BP paleosol represented at XMH-01521 extended to the GSDF edge where XMH-01520 is located, or if this soil's development was limited to in the interior areas of the dune field.

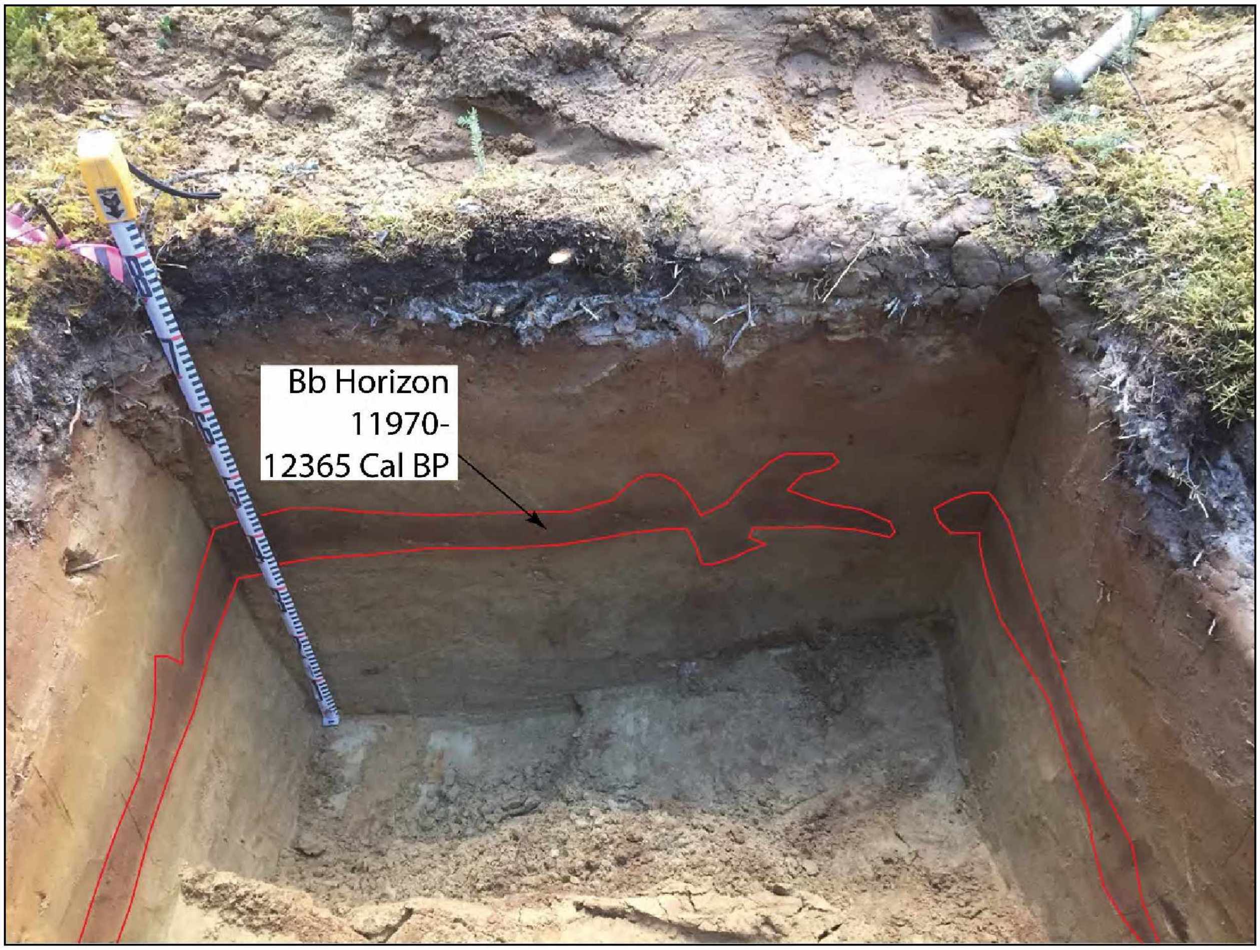


*Figure 5- 12. XMH-01521 excavation unit 1, south wall. Bb horizon outlined in red.*

*Figure 5- 13.* XMH-01521, excavation unit 1, north wall. Bb horizon outlined in red. Dashed lines indicate breaks in continuity.

*Figure 5- 14.* Close up on cultural zone within XMH-01521 Excavation Unit 1. Dashed lines indicate interpreted Bb horizon boundary.

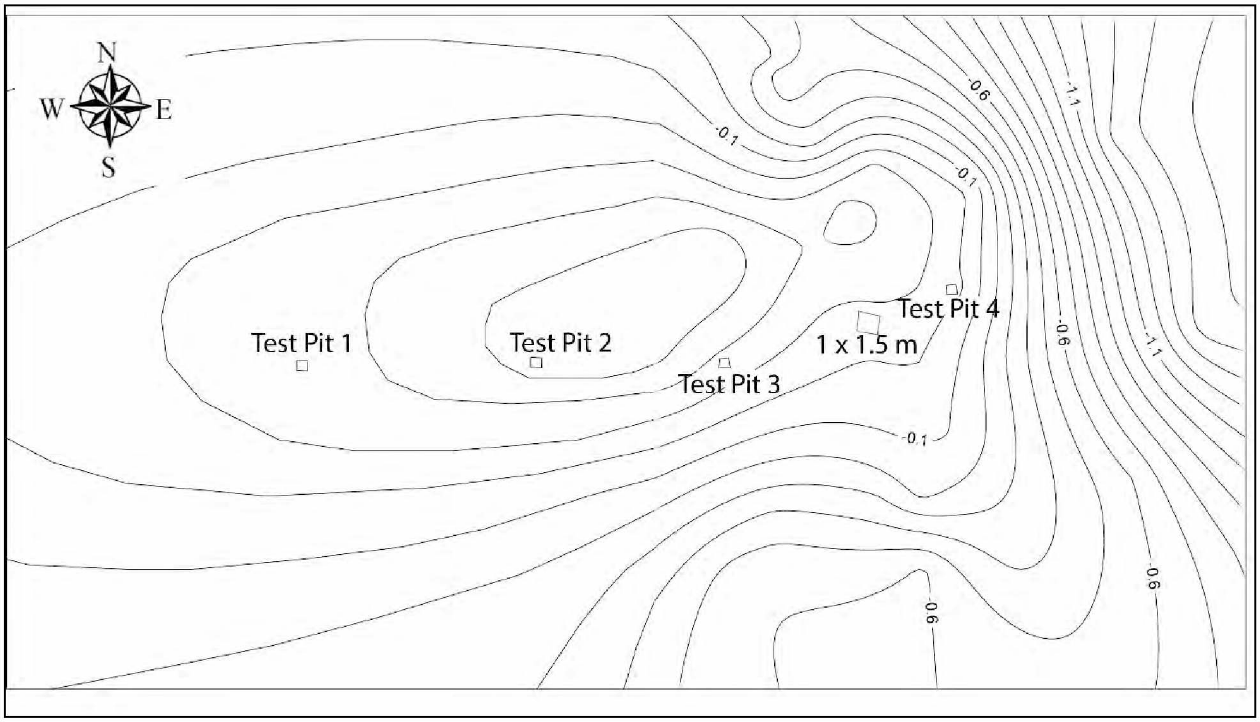


*Figure 5- 15.* Topographic map of XMH-01521.

### *XMH-01521 Site Stratigraphy*

XMH-01521 is far less disturbed than XMH-01520. Lower sands from this site are larger in clast size and likely represent the early morphologically transverse dune material. Archaeological material found at this site occurs in contact with the developed Bb horizon. The lack of continuity of this Bb horizon suggests that after its development an erosional period occurred leading to its exhumation. This erosional period is likely associated with a localized redeposition of sands associated with the B horizon materials after ~8,000 Cal BP, potentially correlative with the formation of parabolic dune morphologies spreading across the GSDF. A mixture of fine sand and silt deposition occurs after this shift from transverse to parabolic morphologies and until the development of the surficial forest soil. This suggests that lower wind energy than that necessary to move sand particles was present after the formation of the parabolic dunes, as well as relative landform stabilization on the local level.

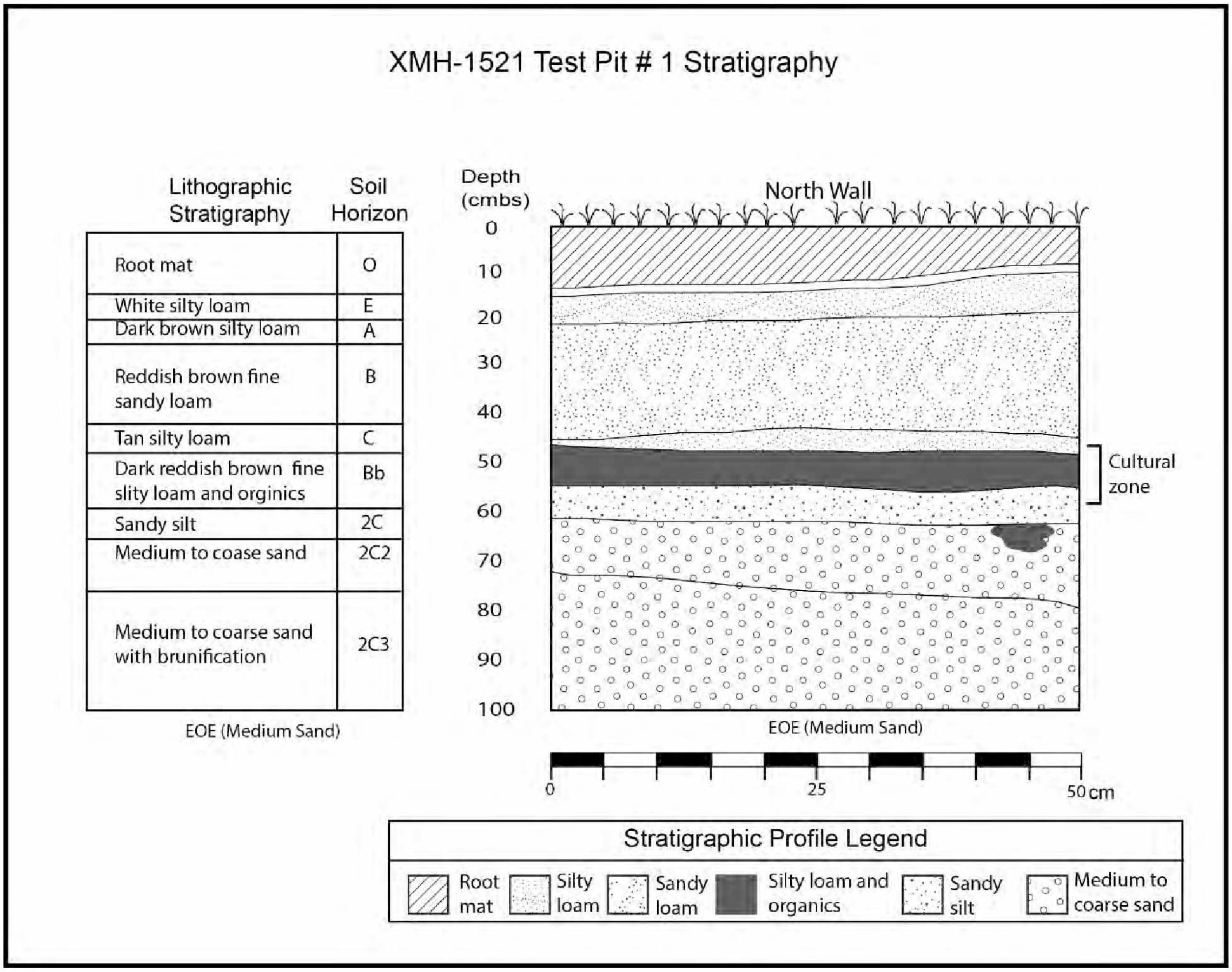


*Figure 5- 16.* XMH-01521 test pit 1, north wall.

*Table 5- 2.* XMH-01521 Excavation Unit 1 stratigraphy.

| Strat descriptions | XMH-01521 | | |
|---|---|---|---|
| Unit (Soil Horizon) | General Depth (cmBS) | Maximum Thickness (cm) | Description |
| O | 0-10 | 10 | Modern vegetative growth and forest litter (moss, lichen, spruce needles); silt loam; partially to moderately decomposed organics; minor roots present; abrupt, smooth boundary |
| E | 10-15 | 5 | 10YR 8/1 white silty loam; clear, smooth boundary |
| A | 15-22 | 7 | 10YR 3/3 dark brown silty loam; clear, smooth boundary |
| B | 22-45 | 23 | 5YR 5/3 reddish brown fine sand loam, higher percentages of sand are present at the base of this horizon, |

*Table 5- 2. Continued*

| | | | |
|---|---|---|---|
| | | | decreasing upwards (In some locations the B horizon does not fully extend through the sand deposit); clear smooth boundary, in some locations more diffuse |
| C | 45-50 | 5 | 10YR 8/6 yellow silty loam; clear, smooth to partially wavy boundary |
| Bb | 48-55 | 7 | 5R 3/2 dark reddish brown fine silty loam; fine partially decomposed organics; well sorted; abrupt, smooth boundary |
| 2C | 55-62 | 7 | 10YR 4/3 brown sandy silt; clear, smooth boundary |
| 2C2 | 62-75 | 13 | 10YR 6/3 pale brown medium to coarse sand; moderately sorted, clear, smooth boundary |
| 2C3 | 75-100 | 25 | 10YR 6/3 pale brown medium to coarse sand; intensely mottled with sequioxides; moderately sorted; test excavation ended at 100 cmBS |

### 5.2.2 Sawmill Creek Dunes

Four archaeological sites are present within the Sawmill Creek portion of the GSDF. The Sawmill Creek area is located north of the Bison Range portion, spanning from the Alcan Highway at its southern most point, northward to the northern extent of the dune field. Eastward, this portion of the GSDF extends until the boundary of the more ancient alluvial escarpment is encountered, peripheral to the area where sand deposits give way to longitudinal flood bar alluvial structures further east (Figure 5-2, Figure 5- 17, and Figure 5- 18). These four sites are XMH-01408, XMH-01409, XMH-01411, and XMH-00251 (also known as the Walk-in Site). Each one of these sites is located on the top of transverse dune formations that were reworked by parabolic dune activity. XMH-01411 and XMH-01409 are located near where the transverse sand dunes are truncated by the alluvial escarpment to the east.

In general, archaeology at these Sawmill Creek sites is associated directly with paleosol development dating either to approximately 10,000 Cal BP (XMH-01408) or 4,000 Cal BP (XMH-1409).

Stratigraphy across this limited area is relatively consistent and provides a basic system for generalizing the chronology of the occupations (Figure 5- 19 and Table 5-3). In general, the soil associated with the 10,000 Cal BP period (and previous soil formations [see Figure 5- 19]) appears far more patchy across this portion of the GSDF, whereas soil formation at 8,000 Cal BP (containing no known archaeological deposits) and the soils dating to approximately 4,000 Cal BP are far more ubiquitous across the entire GSDF area.

Archaeological remains associated with these sites consist of a series of lithic debris scatters that are spatially limited and numerically sparse in artifact quantities. However, a few collections contain some larger tools.

### *XMH-01408*

XMH-01408 is a site that contains stratigraphy generally consistent with that observed across the Sawmill Creek portion of the GSDF, particularly like XMH-01409 (see below for description) (Figure 5- 19 and Table 5-3). Archaeological material observed at this site was recovered at approximately 70 cmbs in association a very dark brown silty sand (Ab horizon). Charcoal dated from this horizon produced a date of 10,810 to 11,260 Cal BP (Beta-272008; 9740 +/- 60 BP) (Reuther 2010) (Table 5-6). An earlier discontinuous reddish brown fine to medium sand soil patch (Bwb horizon) was also dated from below this layer at 94-96 cmbs. Charcoal from this layer yielded a date of 12,940 to 13,290 Cal BP (Beta-272009; 11240 +/- 60 BP) (Reuther 2010) (Table 5-6). Other discontinuous soil patches close in age, and likely containing similar vegetative material, to this one are present in other portions of the Sawmill Creek area and the Bison Range; however, no other dates in either area fall within the same statistical range.

*XMH-01409*

XMH-01409 is present on a dune crest that was cross-cut during events associated with the construction of the Haines Pipeline (built from 1953 to 1955 [Hollinger 2003]). This man-made cut is located at the landform's southern edge (Reuther 2010). During fieldwork conducted by Reuther (2010) in 2009 excavation was conducted in order to locate buried archaeological material in stratigraphic context. Stratigraphy reported at this time consisted of:

> *A 2 cm thick root mat (O horizon; 0-2 cmBS) with a 3 cm thick redeposited sediment and organics (Ap horizon; 2-5 cmBS) due to blading of heavy machinery at the southern edge of the dune; the original modern surface (Ab1 horizon; 5-20 cmBS) grades into relatively unaltered sand (C hoz; 20-38 cmBS); and a series of buried soils are interspersed in over 1 m of fine sands. A reddish brown sandy loam, ~10-17 cm thick (Bwb horizon) is situated between 38- 55 cmBS, a 2-3 cm thick buried incipient soil (Ab horizon) is present at ~75 cmBS, and 1 cm thick faint incipient buried soils (paleosol stringers) occur at least beyond 110 cmBS.*

Archaeological deposits observed later during limited field excavation in 2015 were recovered in association with light reddish brown fine sand (B horizon; 20-25 cmBS). In some locations at this site the surficial B horizon appears to have welded on top of the Bwb horizon below, but remains visibly separated at other locations at the site. Due to archaeological materials only being present in the Bwb horizon at places within the site where these two horizons are separate it has been inferred that the prehistoric material was originally associated with the Bwb horizon (Bowman 2016).

### *XMH-01411*

XMH-01411 is located on a dune crest within the Sawmill Creek dune locality of the GSDF (Reuther 2010). Activities related to the construction of the Haines-Fairbanks Pipeline and the Alaska Highway destroyed portions of the landform at its southern and northern ends. Artifacts recovered from this site were located within the top 10 cmBS at the dune crest surface. Material located here by Reuther (2010) consists of an ephemeral, spatially small and containing only a few artifacts, scatter of gray chert. Fieldwork conducted in association with this thesis recovered no further material from this site.

### *XMH-00251 (Walk-in Site)*

Reuther (2010) took Dr. Charles Holmes in 2010 to the Walk-in site in order to discuss the actual location of the material Holmes found at this site in 1977, which included two larger rough bifaces and several expedient tools. Reuther (2010) reported that:

> *Dr. Chuck Holmes visited this area with Mr. Reuther to discuss the actual location of where the 1977 cultural materials of XMH-251 were found. As noted above, the AHRS coordinates for XMH-251 place the site on low-lying terrain at the eastern edge of a gravel pit. 2008 testing included a dune crest to the ~50 m north of the AHRS coordinates and situated at the northeastern corner of the gravel pit. Dr. Holmes indicated that the AHRS coordinates placed the area where he recovered the 1977 materials in the wrong location. The proper location of the 1977 XMH-251 materials is in the vicinity of a blowout at the southern end of the crest at XMH-1409. This blowout is located within the intersection of the pipeline and agricultural access corridors at XMH-1409.*

Dating conducted by Reuther (2010) on charcoal recovered from an Ab horizon produced an age of 10,240-10,515 Cal BP (Beta-272012; 9210 +/- 60 BP). Cultural materials were found within this buried soil at the same depth and a few centimeters away from the charcoal. The presence of this paleosol is patchy across the Sawmill Creek area, but has some potential correlates at other locations across the GSDF (Figure 5- 24). During a field examination associated with this thesis no further material was located at XMH-00251. However, a high degree of modern site disturbance is still currently occurring at this site location associated with local recreation and hunting activities.

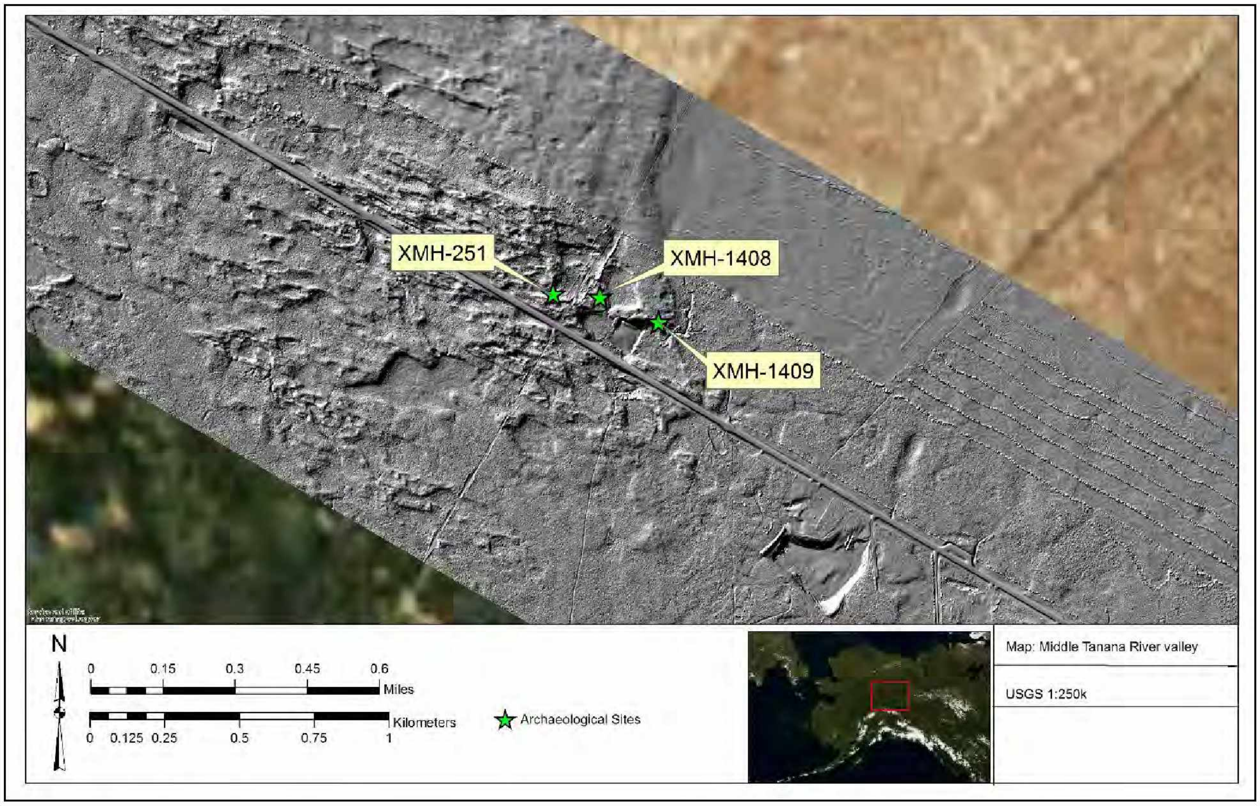


*Figure 5- 17.* LIDAR maps of Sawmill Creek area.

*Figure 5- 18.* Sawmill Creek dunes, view north.

### *Sawmill Creek Generalized Area Stratigraphy*

General trends in stratigraphy and correlations across landforms were noticed between excavations associated with work conducted by Reuther (2010) and those conducted in associated with this thesis project (Bowman 2016). In general, the lower medium sand observed within this area contains thin ephemeral patchy paleosol development and lag depositing. More uniform coverage occurs in association with Ab and Bwb horizons dating to approximately 8,000 to 9,000 Cal BP and at 10,000 to 11,000 Cal BP with Ab and Bwb horizons above the initial medium sand. Above those, fully ubiquitous Bwb horizon coverage occurs in association with a soil dating to approximately 4,000 Cal BP

(Figure 5- 19and Table 5-3). Archaeological material across the Sawmill area has been observed in close association with the paleosols dating to 4,000 Cal BP and the 10,000 to 11,000 Cal BP.

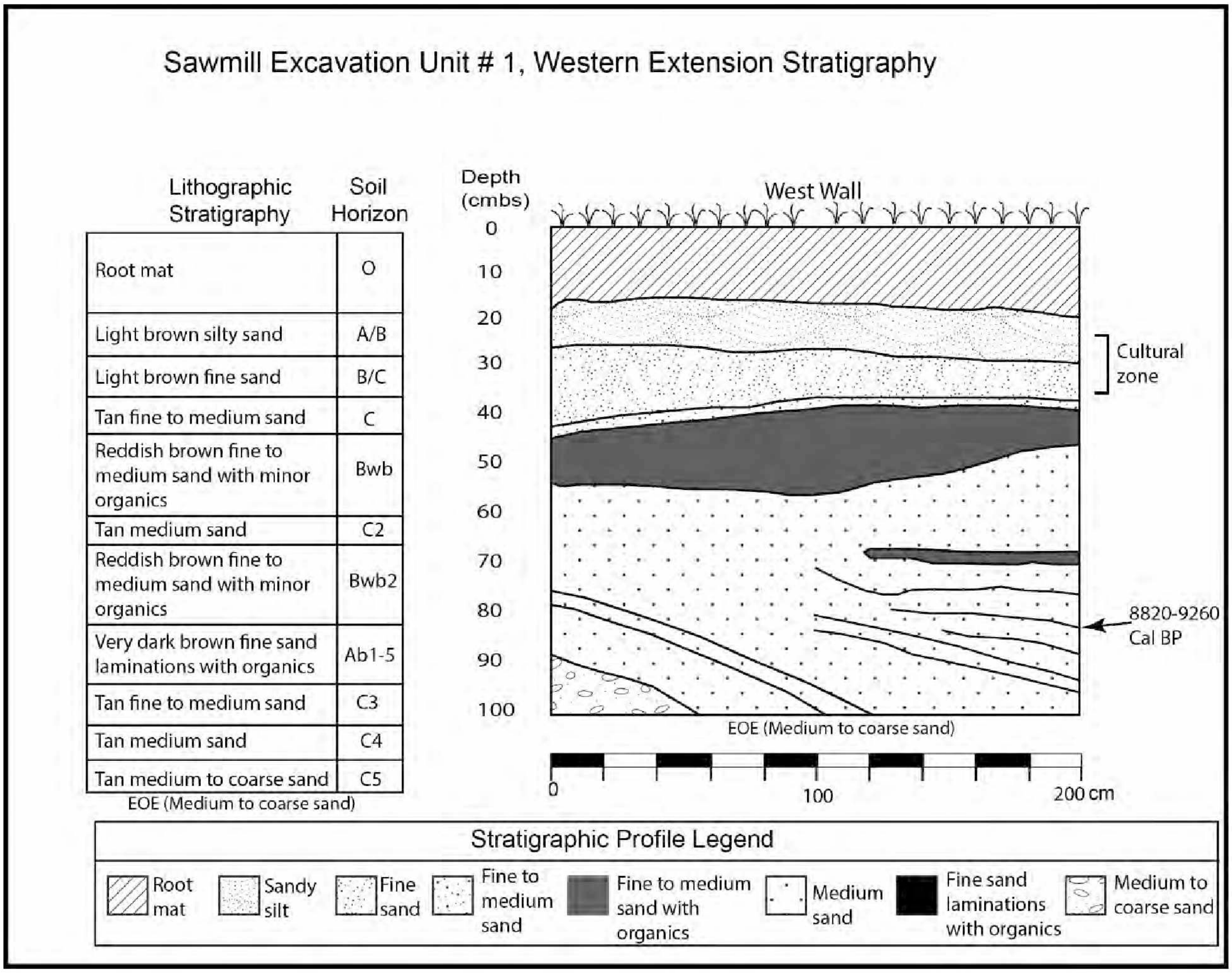


*Figure 5- 19.* Sawmill Excavation Unit 1, west wall.

*Table 5- 3.* Sawmill Excavation Unit 1 stratigraphy.

| Strat descriptions | Sawmill Creek Dunes | | |
|---|---|---|---|
| Unit (Soil Horizon) | General Depth (cmBS) | Maximum Thickness (cm) | escription |
| O | 0-10 | 10 | Modern vegetative growth and forest litter (moss, lichen, spruce needles, grasses, sedges); silt loam; partially to moderately decomposed organics; minor roots present; abrupt, smooth boundary |
| A | 10-20 | 10 | 10YR 3/3 dark brown silty sand; clear, smooth to partially wavy boundary |

*Table 5- 3. Continued*

| | | | |
|---|---|---|---|
| B | 20-25 | 5 | 5YR 6/3 light reddish brown fine sand; well sorted; clear, smooth to partially wavy boundary |
| Ab | 25-30 | 5 | 10YR 2/2 very dark brown silty sand; clear, smooth boundary |
| Bb | 30-40 | 10 | 5YR 4/3 reddish brown fine to medium sand; minor partially decomposed organics; clear, smooth to partially wavy boundary |
| C | 40-48 | 8 | 10YR 7/6 yellow medium sand; well sorted; gradual, smooth boundary |
| Bwb | 48-55 | 7 | 5YR 5/3 reddish brown fine to medium sand; minor partially decomposed organics; abrupt, partially wavy boundary |
| 2C | 55-65 | 10 | 10YR 7/6 yellow medium sand; well sorted; gradual, smooth boundary |
| 2Bwb | 65-70 | 5 | 5YR 5/3 reddish brown fine to medium sand; minor partially decomposed organics; abrupt, partially wavy boundary |
| 3C | 70-125 | 55 | 10YR 7/6 yellow medium sand; well sorted; test excavation ended at 125 cmBS |

## 5.3 Geological Test Locations

Several locations were tested during this thesis in order to determine the spatial ranges of different stratigraphic horizons across the GSDF and also to potentially locate unknown archaeological sites. Sites described below were tested locations where no archaeological material was observed but sedimentological and soil data provide key insights into landform evolution, and paleoenvironmental conditions and changes across the area. In this section each location will be described both morphologically and stratigraphically, in terms of change through time.

### 5.3.1 TRA-01

TRA-01 was originally tested in 2010 and reported by Reuther (2010). This location consists of a low lying deflated transverse dune at the northernmost edge of the low lying sand sheet area and the southern edge of the transverse dune area within the Bison Range portion of the GSDF (Figure 5-1 and

Figure 5-2). Originally noted by Reuther (2010), TRA-01 consists stratigraphically of a series of yellow fine and medium sand with dark reddish brown fine sand (Ab horizons) developed dividing C horizons (Figure 5- 20 and Table 5-4). $^{14}$C dates provided from paleosols from this location are presented in Table 5-6.

The earliest dated paleosol at this location provided a date of 5855 to 5645 Cal BP (UGAMS-25452; 4980 +/- 25 BP), followed by 3925 to 4090 Cal BP (UGAMS-25456; 3680 +/- 25 BP), and then 3635 to 3480 Cal BP (UGAMS-25455; 3330 +/- 25 BP), respectively. The rapidity of these reported dates in chronological sequence becoming older with depth at this location with fully mineralized sediments between suggests a series of periods during the middle Holocene of frequent soil development with periodic aeolian reactivation. The reason for these rapid changes between episodes of stability and dynamic sediment deposition is probably due to frequent local fires in the middle Holocene, likely associated with the presence of the spruce forest (Hu et al. 2006; Kelly et al. 2013; Lynch et al. 2004).

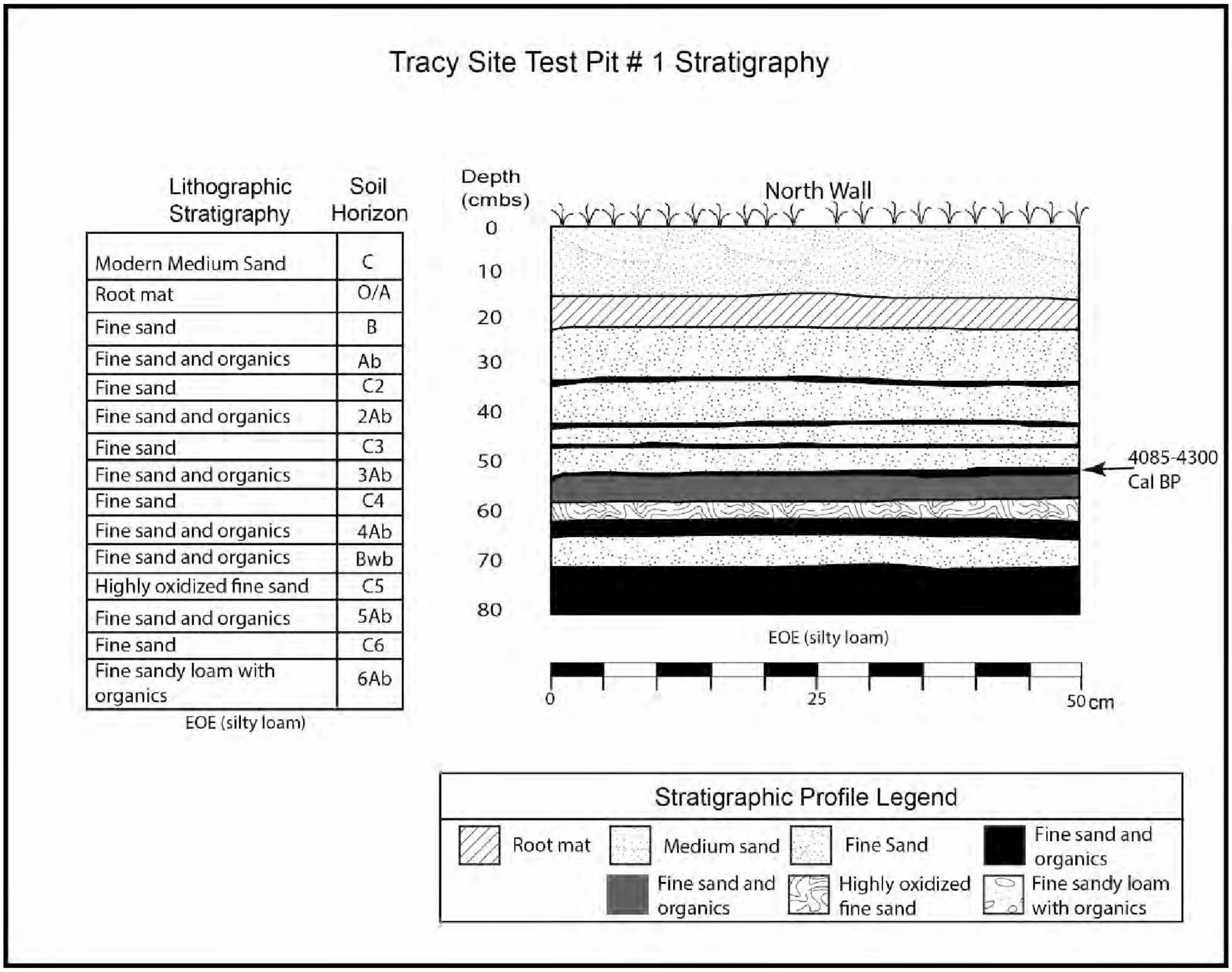


*Figure 5- 20.* Tracy Site test pit 1, north wall.

*Table 5- 4.* Tracy Site Test Pit 1 stratigraphy.

| Strat descriptions | Tra-01 | | |
|---|---|---|---|
| Unit (Soil Horizon) | General Depth (cmBS) | Maximum Thickness (cm) | Description |
| C | 0-15 | 15 | 10YR 7/6 yellow modern reactivated medium sand; well sorted, clear, smooth boundary |
| O/A | 15-22 | 7 | Modern vegetative growth and light forest litter (spruce needles, broad leaf litter, grasses, sedges); silt loam; partially to moderately decomposed organics; minor roots present; abrupt, smooth boundary |

*Table 5- 4. Continued*

| | | | |
|---|---|---|---|
| B | 22-35 | 13 | 5 YR5/3 reddish brown fine sand; well sorted; clear, smooth boundary |
| Ab | 35-36 | 1 | 5YR 3/2 dark reddish brown fine sand; well sorted; partially decomposed organics; abrupt, smooth boundary |
| 2C | 36-42 | 6 | 10YR 7/6 yellow fine sand; well sorted; clear, smooth boundary |
| 2Ab | 42-43 | 1 | 5YR 4/3 reddish brown fine sand; well sorted; partially decomposed organics; abrupt, smooth boundary |
| 3C | 43-45 | 2 | 10YR 7/6 yellow fine sand; well sorted; clear smooth boundary |
| 3Ab | 45-46 | 1 | 5YR 4/3 reddish brown fine sand; well sorted; partially decomposed organics; abrupt, smooth boundary |
| 4C | 46-54 | 8 | 10YR 7/6 yellow fine sand; well sorted; clear smooth boundary |
| 4Ab | 54-55 | 1 | 5YR 4/4 reddish brown fine sand; well sorted; partially decomposed organics; abrupt, smooth boundary |
| Bwb | 55-60 | 5 | 5YR 6/3 light reddish brown fine sand; well sorted; partially decomposed organics; gradual, smooth boundary |
| 5C | 60-64 | 4 | 10YR 7/6 yellow fine sand; well sorted; clear, smooth boundary |
| 5Ab | 64-66 | 2 | 5YR 4/3 reddish brown fine sand; well sorted; partially decomposed organics; abrupt, smooth boundary |
| 6C | 66-74 | 8 | 10YR 7/6 yellow fine sand; well sorted; clear, smooth boundary |
| 6Ab | 74-80 | 6 | 5YR 3/3 dark reddish brown fine sand; well sorted; partially decomposed organics; test excavation ended at 80cmBS |

### 5.3.2 Gerstle River Dunes

Limited testing was conducted at the Gerstle Dunes portion of the GSDF at two locations, GD-RCB-002 and GD-RCB-003. GD-RCB-002 is a transverse dune situated parallel to and truncated at its most eastern edge by the Gerstle-Clearwater escarpment (Figure 5-2 and Figure 5- 21). Excavation at this location terminated in loess at 100 cmBS. Two paleosols were encountered at this location, a very dark brown silt (Ab horizon; 63-70 cmBS) and a reddish brown silt (Bwb horizon; 78-88 cmBS). Dates on charcoal from these paleosol provides minimum ages on their development from 3,250 to 3,395 (UGAMS-25453; 3120 +/- 25 BP) and 3,935 to 4,090 Cal BP (UGAMS-25454; 3700 +/- 25 BP), respectively (Table 5-6).

At GD-RCB-003, a much thinner loess mantle is present over transverse dune sands. At this location a reddish brown silt (Bwb horizon) was observed to have developed just above the dune sands, prior to roughly 75 cm of silt deposition (Figure 5- 22 and Table 5-5). Charcoal from this paleosol produced a date of 8,635 to 8,980 Cal BP (Beta-421546; 7930 +/- 30 BP) (Table 5-6). This date is interpreted to be the maximum date of transverse dune deposition within the Gerstle Dune portion of the GSDF.

*Figure 5- 21.* Dune topography at GD-RCB-002. View north.

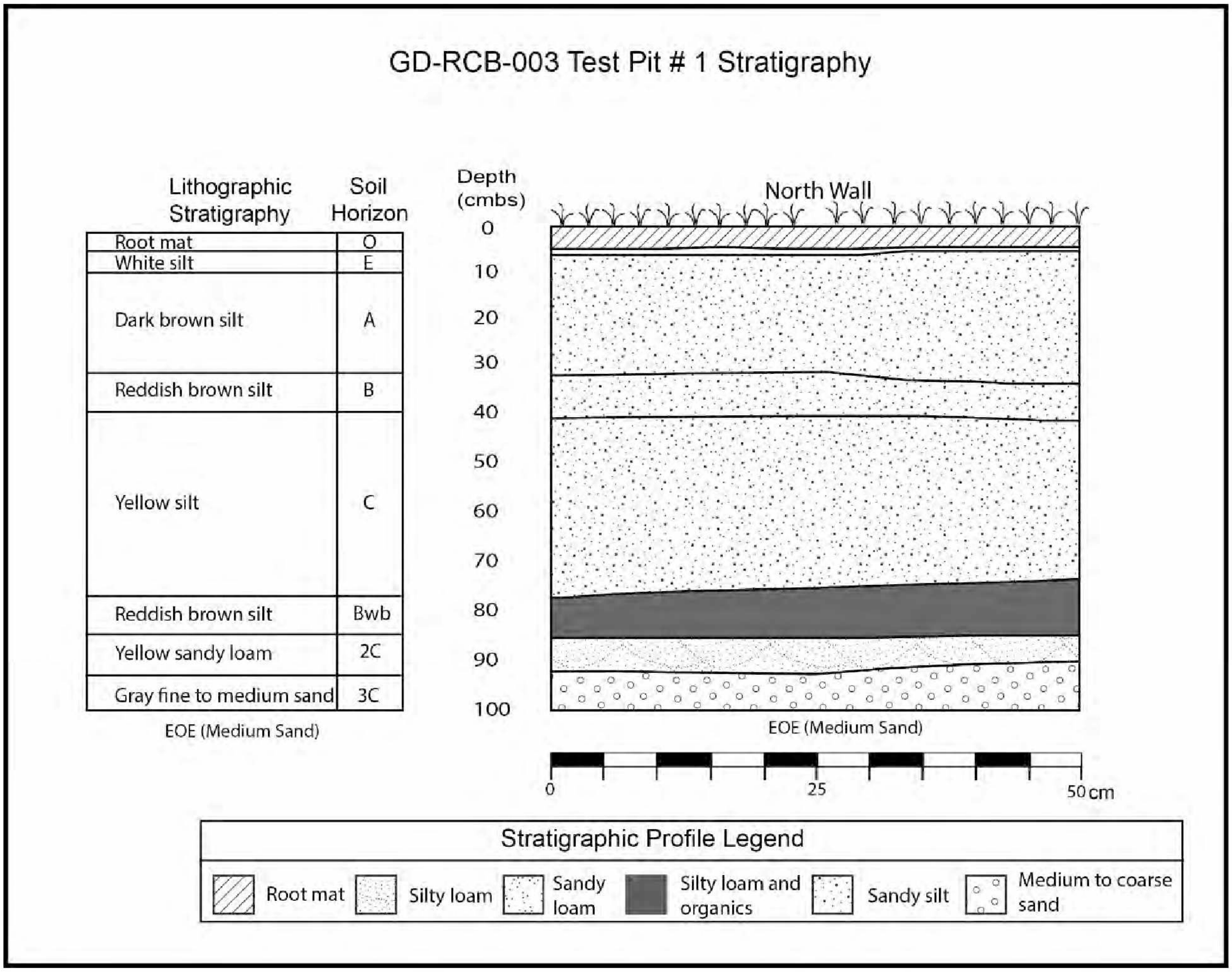


*Figure 5- 22.* GD-RCB-003 Test Pit 1, north wall.

*Table 5- 5.* GD-RCB-003 test pit 1 stratigraphy.

| Strat descriptions | Gerstle Dunes | | |
|---|---|---|---|
| Unit (Soil Horizon) | General Depth (cmBS) | Maximum Thickness (cm) | Description |
| O | 0-5 | 5 | Modern vegetative growth and forest litter (moss, lichen, spruce needles, grasses, sedges); silt loam; partially to moderately decomposed organics; minor roots present; abrupt, smooth boundary |
| E | 5-6 | 1 | 10YR 8/1 white silty loam; clear, smooth boundary |
| A | 6-35 | 29 | 10YR 3/3 dark brown silt; well sorted; clear, smooth boundary |
| B | 35-42 | 7 | 5YR 5/4 reddish brown silt; well sorted; clear, smooth boundary |
| C | 42-80 | 38 | 10YR 7/8 yellow silty loam; clear, smooth boundary |
| Bwb | 80-85 | 5 | 5YR 5/4 reddish brown silt; minor fine partially decomposed organics; clear, abrupt boundary |
| 2C | 85-95 | 10 | 10YR 7/8 yellow sandy loam; clear, smooth boundary |
| 3C | 95-100 | 5 | 10YR 5/1 gray fine to medium sand; moderately sorted; test excavation ended at 100 cmBS |

## 5.4 Radiocarbon Analysis and Stratigraphic Correlations

### 5.4.1 Radiocarbon Analysis

Table 5-6 lists the dates associated with archaeological occupations and periods of soil development throughout the GSDF. Most dates listed below appear to be clearly associated within the appropriate time frame for vegetation development and human occupation based on stratigraphic correlations across the GSDF area. In general, most dates correspond closely to one another and statistically overlap to form a timeframe for human habitation and soil stability for the GSDF area (Figure 5- 23). These timeframes appear to range chronologically between the periods of roughly 11,000 to 8,000 Cal BP, 8,000 to 4,000 Cal BP, and 4,000 to 0 Cal BP across the GSDF area (Table 5-7 and Figure 5-23). Periods where ages are not represented in radiocarbon ages correspond stratigraphically with time periods where active dune development was taking place (Figure 5- 23). Soil development may have occurred during these times, however no visible remains were encountered during field examination, potentially because these possible soils may have been short lived on the landscape and/or likely owed to local and regional preservation issues at sites and across the area. The lower time range of the transverse dune development likely dates to the primary context of ancient carbon redeposited at XMH-01408 and XMH-00251. As such, an aforementioned redeposited more ancient carbon contamination (date produced from soil organics), associated with the original Beta-Analytic date of 24,330 to 28,205 Cal BP (Beta-272818; 20500 +/- 80 BP and AA98000; 23780 +/- 160 BP), appears to have had an influence on dates associated with XMH-01409 at a depth of 82-86 cmBS and at XMH-00251 at a depth of ~110 cmBS.

In order to mitigate this issue, sub-samples of soil organics from this layer were heated to different temperatures in order to release different ages of carbon into fractions of ancient, excepted, and younger percolation carbon for radiometric analysis. Recent studies suggest that volatile soil organic constituents can be separated by varying combustion temperatures between 200 and 800 °C (Brock et al. 2010; Cheng et al. 2013; Mayer et al. 2008; McGeehin et al. 2001; Wang et al. 2003). Most of these studies suggest that older dates occur with higher combustion temperatures because older diagenetically derived clays containing humin are combusted at these temperatures, effectively contaminating the sample after high temperature combustion into a gas for analysis and producing an older than expected age (McGeehin et al. 2001), while temperatures between 400 and 800 degrees Celsius provide the most consistent ages with charcoal from the same context, since at these temperatures the clays do not combust (the expected ages). Based on these divisions an expected date of 8,820 to 9,260 Cal BP (Beta-272817; 8120 +/- 50 BP) was obtained, as well as a date from younger soil carbon of 1,390 to 1,570 Cal BP (Beta-272011; 1600 +/- 40 BP). The ancient date of residual carbon associated with this paleosol was then determined based on its temperature range (>800°C) to be 27,580 to 28,205 Cal BP (AA98000; 23780 +/- 160 BP).

The presence of this older than expected date is striking at this location for many reasons. First, the older contamination issues only appear to occur at XMH-1408 and XMH-00251, sites situated near the edge of the ancient alluvial escarpment dividing the alluvial floodplain east of the escarpment in the south east of the GSDF from the dune forms in the west. Contamination from older pedogenic clays may occur at other locations within the GSDF however, only these locations produced dates significantly older than the expected time frames and out of stratigraphic correlative sequence with other radiocarbon ages within the area. Second, this contamination only appears to occur within the time frame of approx. 8,000 Cal BP, making the redeposition of this ancient carbon from its primary context an event or process isolated to a distinctive time period where abrupt depositional changes took place.

*Table 5- 6.* Radiocarbon dates from the GSDF.

| **Sample No.** | **Lab No.** | **Material** | **Site** | **Provenance** | **Strat Unit** | **Measured Age (BP)** | **Conventional Age (BP)** | **13C** | **Calibrated at 2-sigma (Cal BP)** | **Notes** |
|---|---|---|---|---|---|---|---|---|---|---|
| B15JDR01-01 | Beta-272008 | charred material (charcoal) | XMH-1408 | 495N/510E, North Wall, ~70 cmBS | Ab Hoz | NA | 9740+/-60 | NA | 10,810-11,260 | |
| B15JDR01-02 | Beta-272009 | charred material (charcoal) | XMH-1408 | 490N/510E, East Wall, ~94-96 cmBS | Bwb Hoz | 11260+/-60 | 11240+/-60 | -26.2 | 12,940-13,290 | |
| B15JDR02-02 | Beta-272011 | sediment (alkali soluble) | XMH-1409 | 500N/510E, ~82-86 cmBS | Ab Hoz | 1600+/-40 | 1600+/-40 | -25.3 | 1,390-1,570 | (Combusted below 400°C) percolated younger carbon; rejected |
| B15JDR02-02 | Beta-272817 | sediment (alkali insoluble) | XMH-1409 | 500N/510E, ~82-86 cmBS | Ab Hoz | 8120+/-50 | 8120+/-50 | -24.9 | 8,820-9,260 | (Combusted between 400 and 800°C) accepted age |
| B15JDR04-01 | Beta-272012 | charred material (charcoal) | XMH-251 | N495/E505, 60-70 cmBS | Bwb Hoz near contact with C Hoz | 9200+/-60 | 9210+/-60 | -24.1 | 10,240-10,515 | |
| B15JDR04-02 | Beta-272818 | sediment (alkali insoluble) | XMH-251 | N495/E505, ~110 cmBS | Ab Hoz | 20470+/-80 | 20500+/-80 | -22.9 | 24,330-24,980 | (Combusted above 800°C) redeposited ancient |

*Table 5- 6. Continued*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | carbon; rejected |
| CS-TRA-10-01 | AA96865 | charred material (charcoal) | TRA-01 | Tra-01,Test 3 (road test), Ab Hoz, ~33 cmBS | Ab Hoz | 0.2434+/-0.0018 pMC | 11352+/-61 | -26.00 | 13,000-13,240 | (Combusted above 800°C) redeposited ancient carbon; rejected |
| CS-TRA-10-05 | AA96869 | charred material (charcoal) | TRA-01 | Tra-01, Test 1 on top of blowout, ~50-55 cmBS | Ab/Bwb Hoz | 0.6223+/-0.0030 pMC | 3811+/-39 | -26.20 | 4,085-4,300 | |
| B15JDR02-02H | AA98001 | sediment (alkali soluble) | XMH-1409 | 500N/510E, ~82-86 cmBS | Ab Hoz | 0.8692+/-0.0028 pMC | 1126+/-26 | -26.9 | 985-1,170 | (Combusted below 400°C) percolated younger carbon; rejected |
| B15JDR02-02 | AA98000 | sediment (alkali insoluble) | XMH-1409 | 500N/510E, ~82-86 cmBS | Ab Hoz | 0.8692+/-0.0028 pMC | 1366+/-31 | -25.8 | 1,190-1,340 | (Combusted below 400°C) percolated younger carbon; rejected |
| B15JDR02-02 | AA98000 | sediment (alkali insoluble) | XMH-1409 | 500N/510E, ~82-86 cmBS | Ab Hoz | 0.0518+/-0.0010 pMC | 23780+/-160 | -22.9 | 27,580-28,205 | (Combusted above 800°C) redeposited ancient carbon; rejected |
| GSDF-C-15-001 | Beta-421546 | charred material | GD-RCB-003 | GD-RCB-003, TP1, | Bwb Hoz | 7920 +/- 30 | 7930 +/-30 | -24.5 | 8,980-8,635 | |

*Table 5- 6. Continued*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 76-82 cmBS, Sample 29 | | | | | | |
| GSDF-C-15-002 | Beta-421547 | charred material | XMH-1521 | XMH-1521, TP1, 40-45 cmBS, Sample 8 | Bb Hoz | 10300 +/-40 | 10290 +/-40 | -25.5 | 12,365-11,970 | |
| GSDF-RB-001 | UGAMS-25452 | charcoal | TRA-01 | Tra-01, TP2, 55-60cmBS | Bwb Hoz | 53.8 +/-.17 pMC | 4980 +/- 25 | -29.62 | 5,855-5,645 | |
| GSDF-RB-002 | UGAMS-25453 | charcoal | GD-RCB-002 | GD-RCB-002, TP2, 63-70cmBS | Ab Hoz | 67.85 +/-.20 pMC | 3120 +/- 25 | -24.13 | 3,395-3,250 | |
| GSDF-RB-003 | UGAMS-25454 | charcoal | GD-RCB-002 | GD-RCB-002, TP2, 78-88cmBS | Bwb Hoz | 63.12 +/-.20 pMC | 3700 +/- 25 | -25.83 | 4,145-3,935 | |
| GSDF-RB-004 | UGAMS-25455 | charcoal | TRA-01 | Tra-01, TP2, 45-48cmBS | Ab/Bb Hoz | 66.1 +/-.20 pMC | 3330 +/- 25 | -23.72 | 3,635-3,480 | |
| GSDF-RB-005 | UGAMS-25456 | charcoal | TRA-01 | Tra-01, TP2, 45-50cmBS | Ab Hoz | 63.23 +/-.19 pMC | 3680 +/- 25 | -23.13 | 4,090-3,925 | |
| GSDF-RB-006 | UGAMS-25457 | charcoal | XMH-1520 | Tra-05, Feature 1, 0-10cmBS | Feature 1 | 79.41 +/-.23 pMC | 1850 +/- 25 | -24.67 | 1,865-1,715 | modern charcoal contamination via deflation; rejected |
| GSDF-C-16-01 | Beta-440127 | charcoal | XMH-1520 | Locus 1, north side of blowout, ~55-65 cmBS | Bb Hoz | 4250 +/- 30 | 4250 +/- 30 | -24.8 | 4,665-4,865 | accepted |

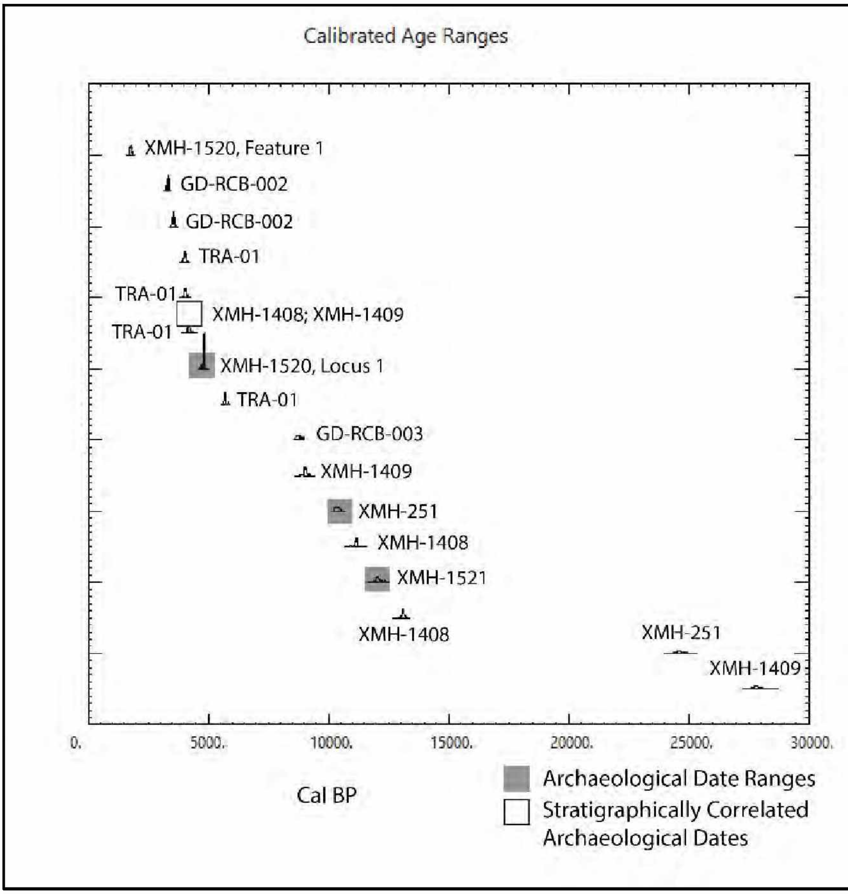
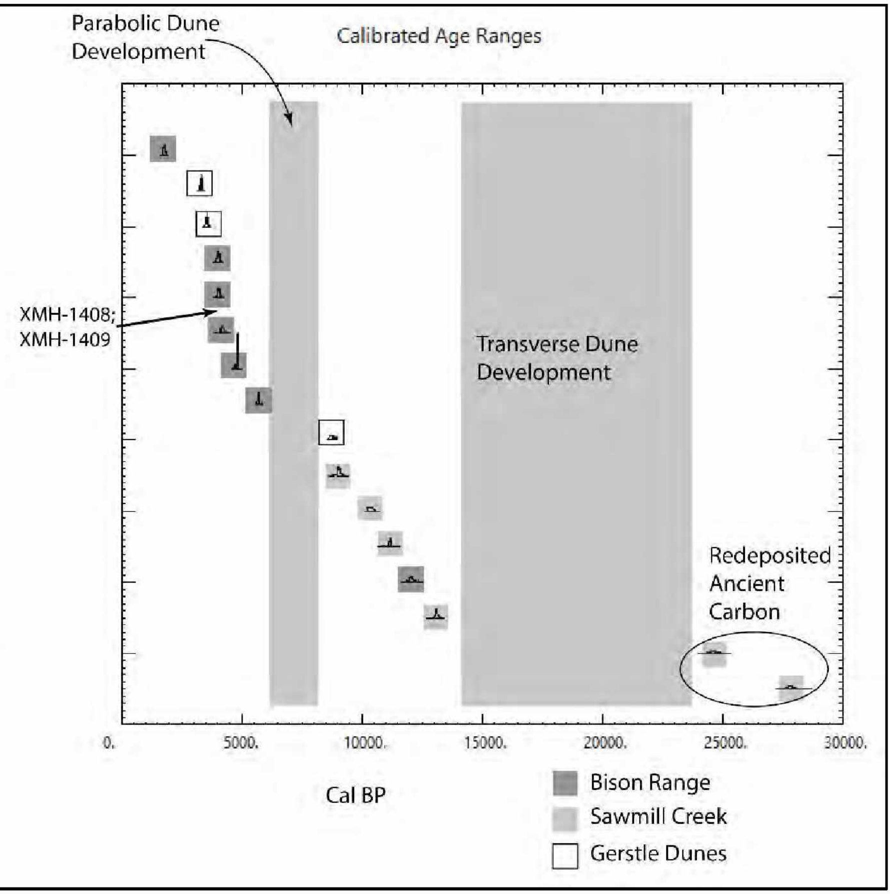


*Figure 5- 23.* GSDF Radiocarbon ages.


Parabolic Dune Development
Calibrated Age Ranges
XMH-1408;
XMH-1409
Transverse Dune Development
Redeposited Ancient Carbon
0.
5000.
10000.
15000.
20000.
25000.
30000.
Cal BP
Bison Range
Sawmill Creek
Gerstle Dunes

### 5.4.2 Stratigraphic Correlation

Stratigraphic correlations across the GSDF, and nearby by Gerstle River Quarry and North Gerstle Point and sites, are presented in Figure 5- 24 through Figure 5- 26. Stratigraphy across the GSDF correlates with dates presented in the previous radiocarbon section. In the Sawmill Creek area, patchy soils dating to approximately 10,000 Cal BP and 13,000 Cal BP are present. In the Bison Range, an approximately 12,000 Cal BP paleosol is present. Older paleosol dates from across the GSDF correlate chronologically with soil development at peripheral sites (North Gerstle Point site and Gerstle River site) as well. In the eastern portion of the GSDF, ranging from the Gerstle Dune area to the Sawmill Creek area, an approximately 8,000 Cal BP paleosol is present. Above this, in most locations a fine to medium sandy loam is present (Figure 5- 24 through Figure 5- 26), this layer is interpreted to be redeposited local sands associated with parabolic dune formations across the western portion of the GSDF. In most areas, the approximately 4,000 Cal BP soils are ubiquitous across the GSDF area and its peripheral zones. The current modern forest soil is also ubiquitous across the GSDF area (Figure 5- 24 through Figure 5- 26), and appears to have welded on to soils dating to approximately 4,000 Cal BP, while in other areas a thin layer of loess separates these two soils.

In general the degree of correlation across the GSDF and peripheral sites suggests that just after 13,400 to 10,200 (Ka) years ago, a date from an IRSL sample near the contact of the transverse dune sands and the mantling loess, forest soils develop across the area from between approximately 12,000 Cal BP and 10,000 Cal BP. Forest then appear to cover the area by approximately 8,000 Cal BP, everywhere but in the Bison Range portion of the GSDF. After that a destabilizing event or process allowed for parabolic dune reworking to occur, in combination with a wind direction change from northward to westward, with the remaining patches of stabilized forest soils  likely acted as catchment points. At 4,000 Cal BP the system appears to have again stabilized across the GSDF, now including the Bison Range area and peripheral sites. However, in the Bison Range area minor destabilization events continue to persist throughout the area, allowing for the deposition of fine to medium sand sheets in the TRA-01 locality, appearing to occur semi-regularly. The area was then covered by a ubiquitous surficial forest soil at a later date, again, in some areas overriding the apparent 4,000 Cal BP forest soil.

Known archaeological occupation across the GSDF appears consistent with developed soil patches prior to 8,000 Cal BP (XMH-01521, XMH-00251, and possibly XMH-01520) and with the ubiquitous 4,000 Cal BP forest soil after (XMH-1408, XMH-01409, and XMH-01520). In the peripheral zones associated with the GSDF archaeological occupation also occurs during those time frames at both the North Gerstle Point site (Vanderhoek et al. 1992) and the Gerstle River site (Potter 2005). However, where the North Gerstle Point site does display the same corresponding paleosols developing during these time frames, the Gerstle River site displays an inverse relationship between paleosol development during archaeological occupation prior to the 8,000 Cal BP, but a positive relationship between archaeological occupation and soil development at the 4,000 Cal BP.

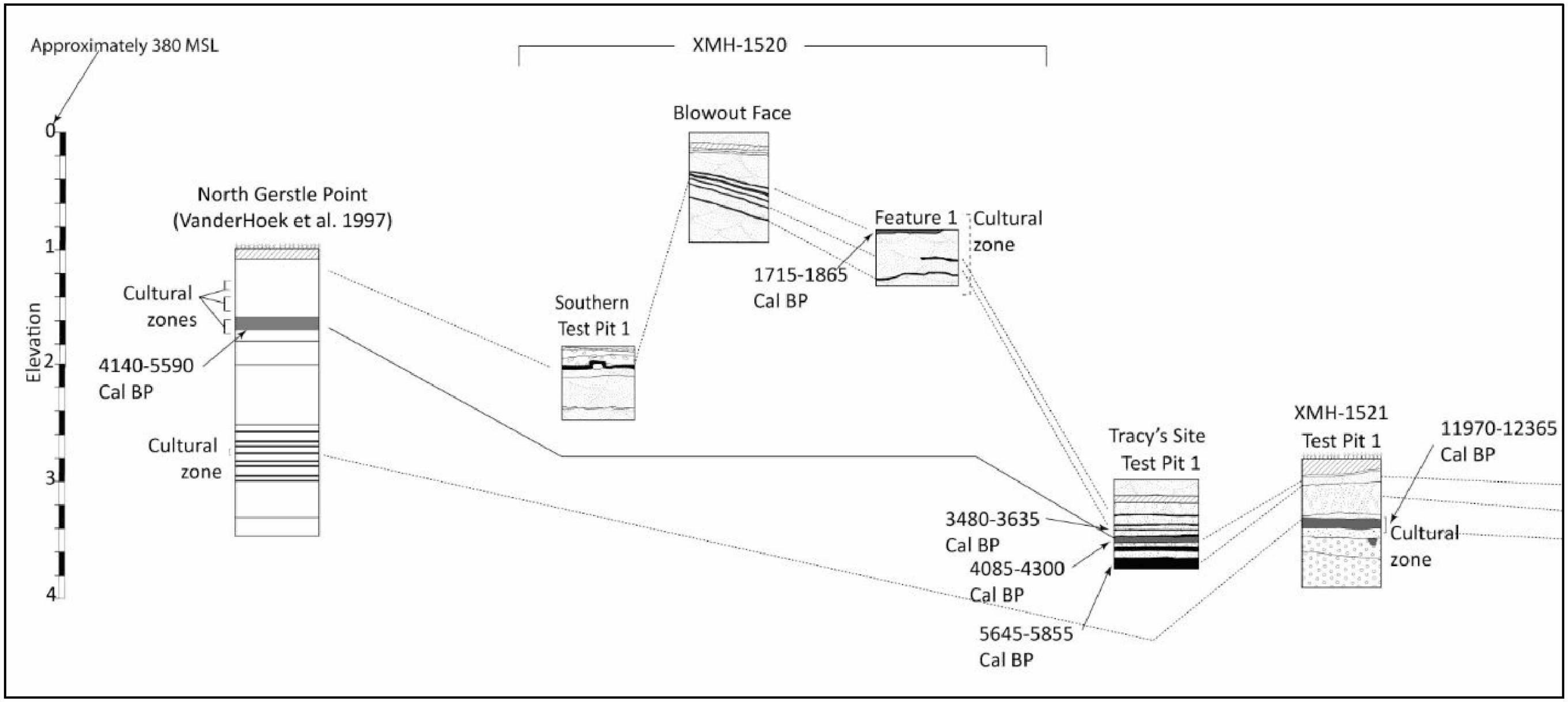


*Figure 5- 24. Close up of North Gerstle Point and Bison Range Stratigraphy.*

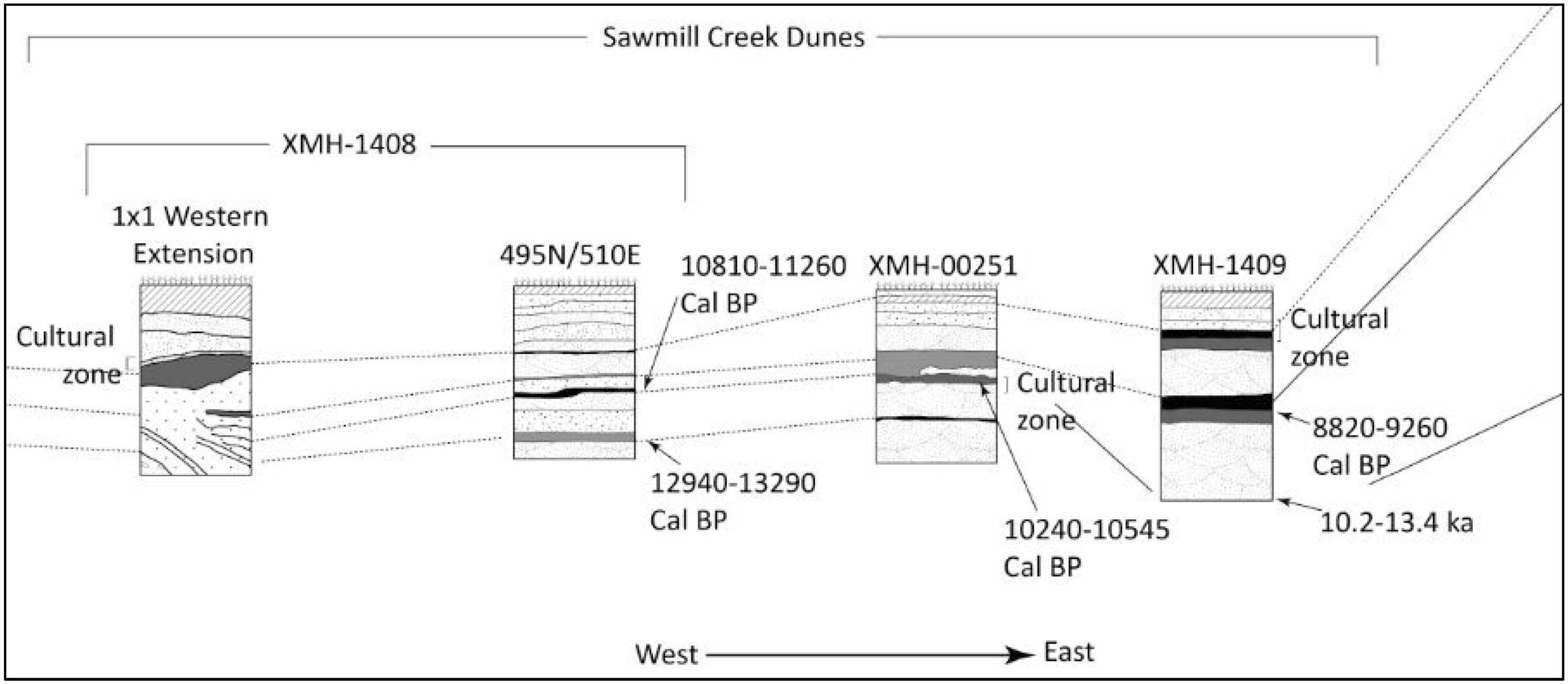


*Figure 5- 25. Close up of Sawmill Creek Stratigraphy.*

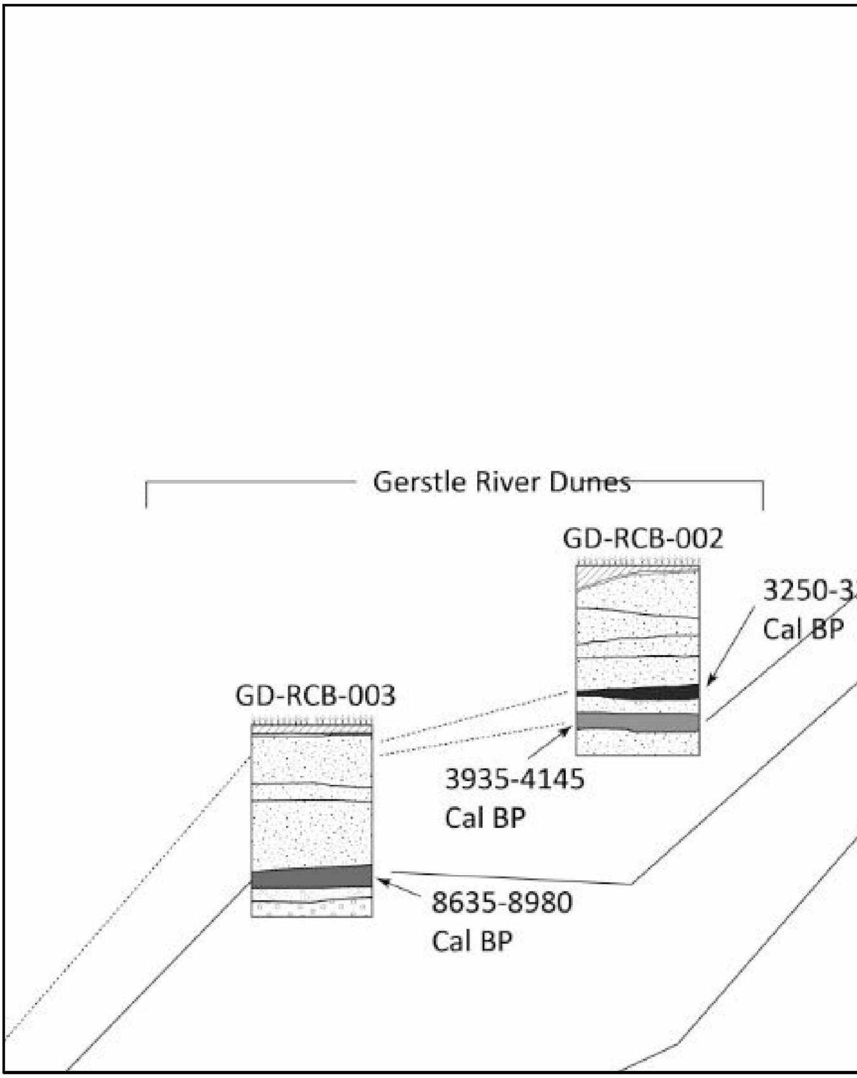
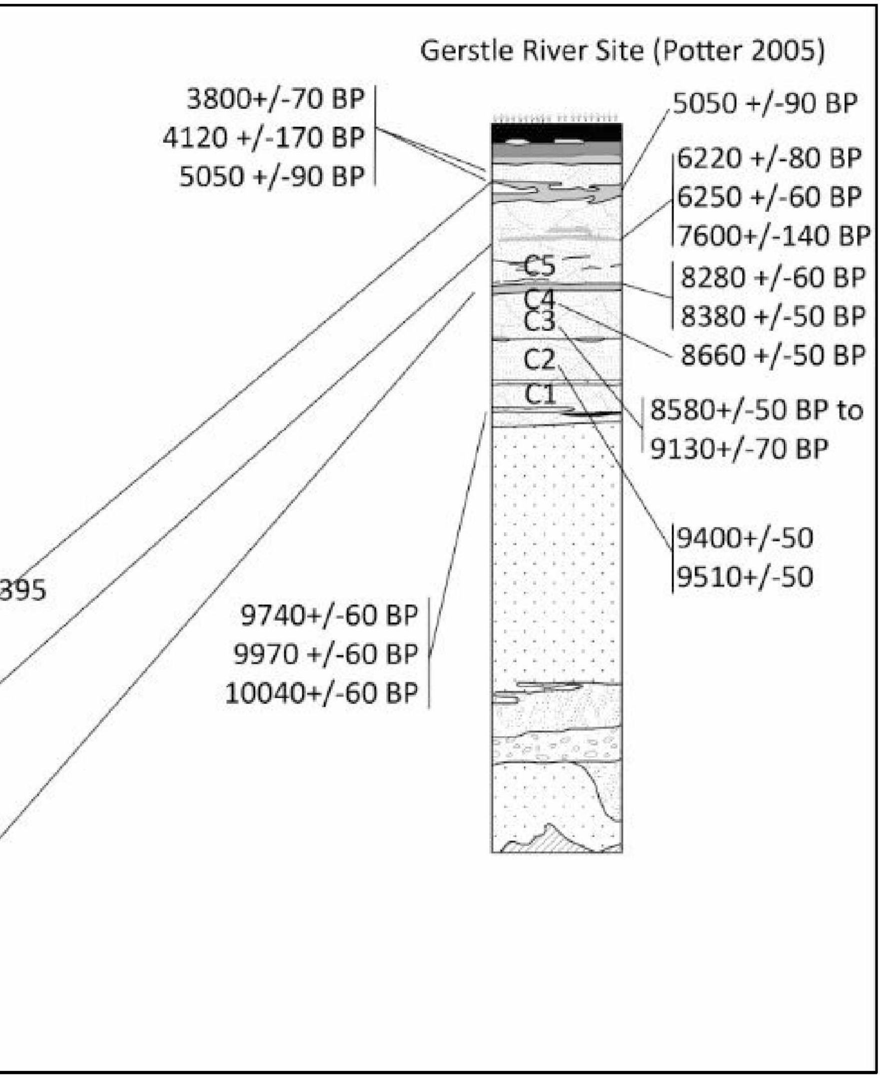


*Figure 5- 26. Close up of Gerstle Dunes and Gerstle River Site Stratigraphy.*


Gerstle River Site (Potter 2005)
3800+/-70 BP
4120 +/-170 BP
5050 +/-90 BP
5050 +/-90 BP
6220 +/-80 BP
6250 +/-60 BP
7600+/-140 BP
C5
8280 +/-60 BP
8380 +/-50 BP
C4
C3
8660 +/-50 BP
C2
C1
8580+/-50 BP to
9130+/-70 BP
9400+/-50
9510+/-50
395
9740+/-60 BP
9970 +/-60 BP
10040+/-60 BP

## 5.5 Geoarchaeological Analyses

### 5.5.1 Particle Size

XMH-01521, XMH-01409, and GD-RCB-003 were chosen for particle size analysis in order to capture the range of sedimentation history across the GSDF area (Figure 5- 27). Sand sizes and amounts at the base of excavations from each dune sampled are consistent across the GSDF area correlating to the transverse dunes. Particle size shifts occur after 12,000 Cal BP in the Bison Range area to 8,000Cal BP in the Sawmill and Gerstle Dune areas. After 12,000 Cal BP in the Bison Range area increases in silt and clay occur. This period also correlates with the development of a localized buried soil (Bb horizon) and human occupation.

The intensity of sand deposition appears to decrease at the Sawmill Creek and Gerstle Dune areas around 8,000 Cal BP. Soil development and increases in silt and clay are consistent across the eastern portion of the GSDF. Sand percentages increase after 8,000 Cal BP within the western portion of the GSDF (Bison Range and Sawmill Creek areas) indicating localized reactivation of dune sands, this correlates with the development of the local parabolic dune morphology in the area. Parabolic dune morphology is absent from the Gerstle Dune area as in the increase in sand concentration within that area. From this point forward in the Gerstle Dune area deposition is dominated by silt, excepting the more modern time frame, in which we see a sharper increase in clay deposition and sands.

After sand concentration increases in the western GSDF associated with the 8,000 Cal BP time period, another sharp decrease in sand amounts occurs within the western portion of the GSDF with the development of a the 4,000 Cal BP soil development across the GSDF. This low wind intensity time frame is also associated with human occupation within the western portion of the GSDF. After 4,000 Cal BP, increases in sand concentration occur locally in the Bison Range and the Gerstle Dune areas, likely associated with localized reactivation with more recent human industrial and recreational development. No such increase occurs within the Sawmill Creek area.

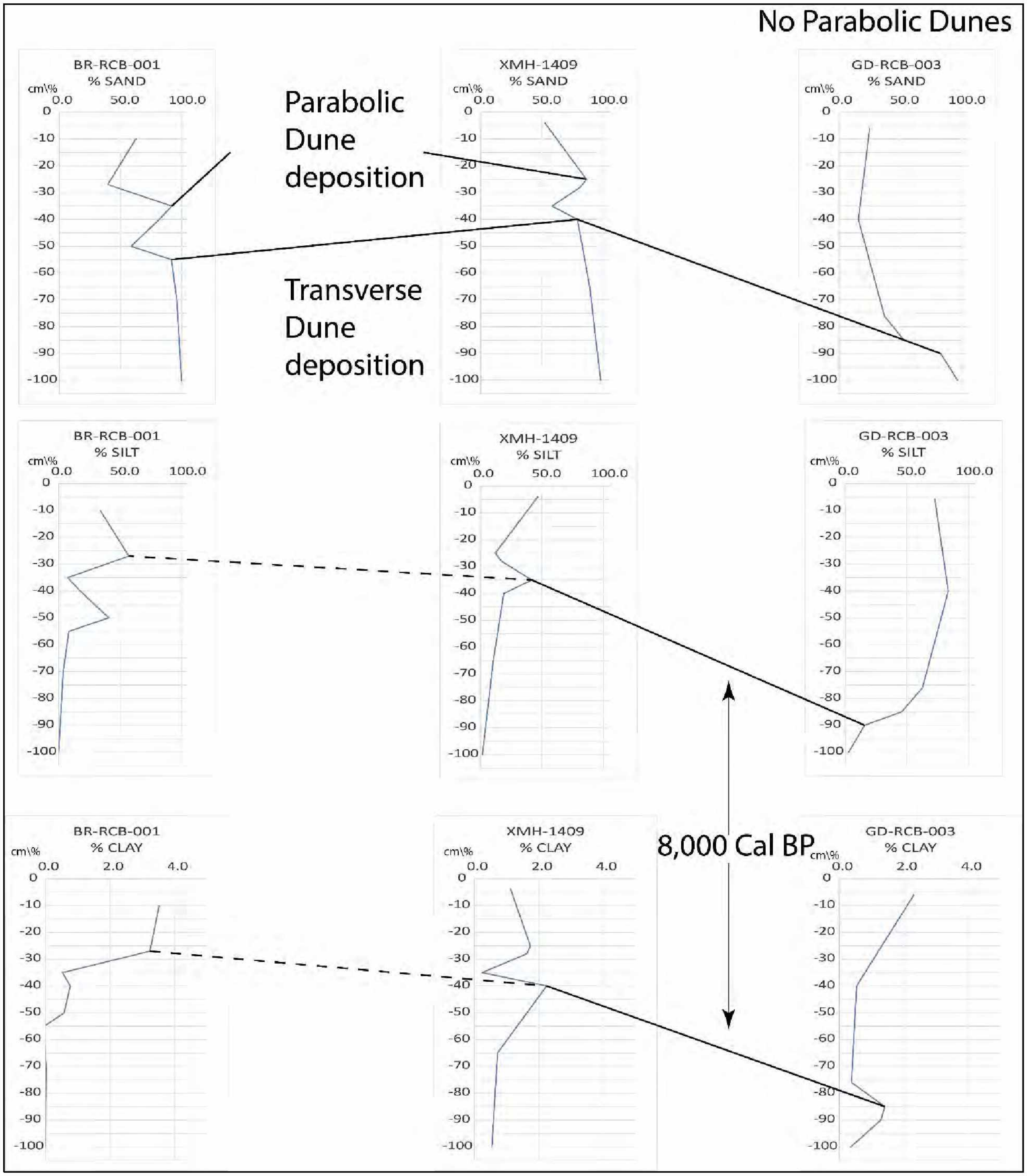


*Figure 5- 27.* Particle size analysis and correlations across the GSDF.

### 5.5.2 Organic/Inorganic Carbon

Organic and Inorganic carbon values in general mimic those of the particle size data (Figure 5-28). Peaks of both carbon types correlate with the development of paleosols across the tested areas. In general, levels of both organic and inorganic carbon are quite low across the GSDF. The exception to this general trend is that elevated levels of inorganic carbon are present in the Gerstle Dunes area when compared to the rest of the GSDF throughout. This is likely due the thicker deposits of loess, which are much more calcareous in nature than the underlying sand (Reger et al. 2008), present in the Gerstle Dunes and their proximity to the Gerstle River. Inorganic carbon values for loess from the Sawmill Creek and Bison Range are relatively similar however, the loess mantling at these locations is much thinner than at the Gerstle Dunes.

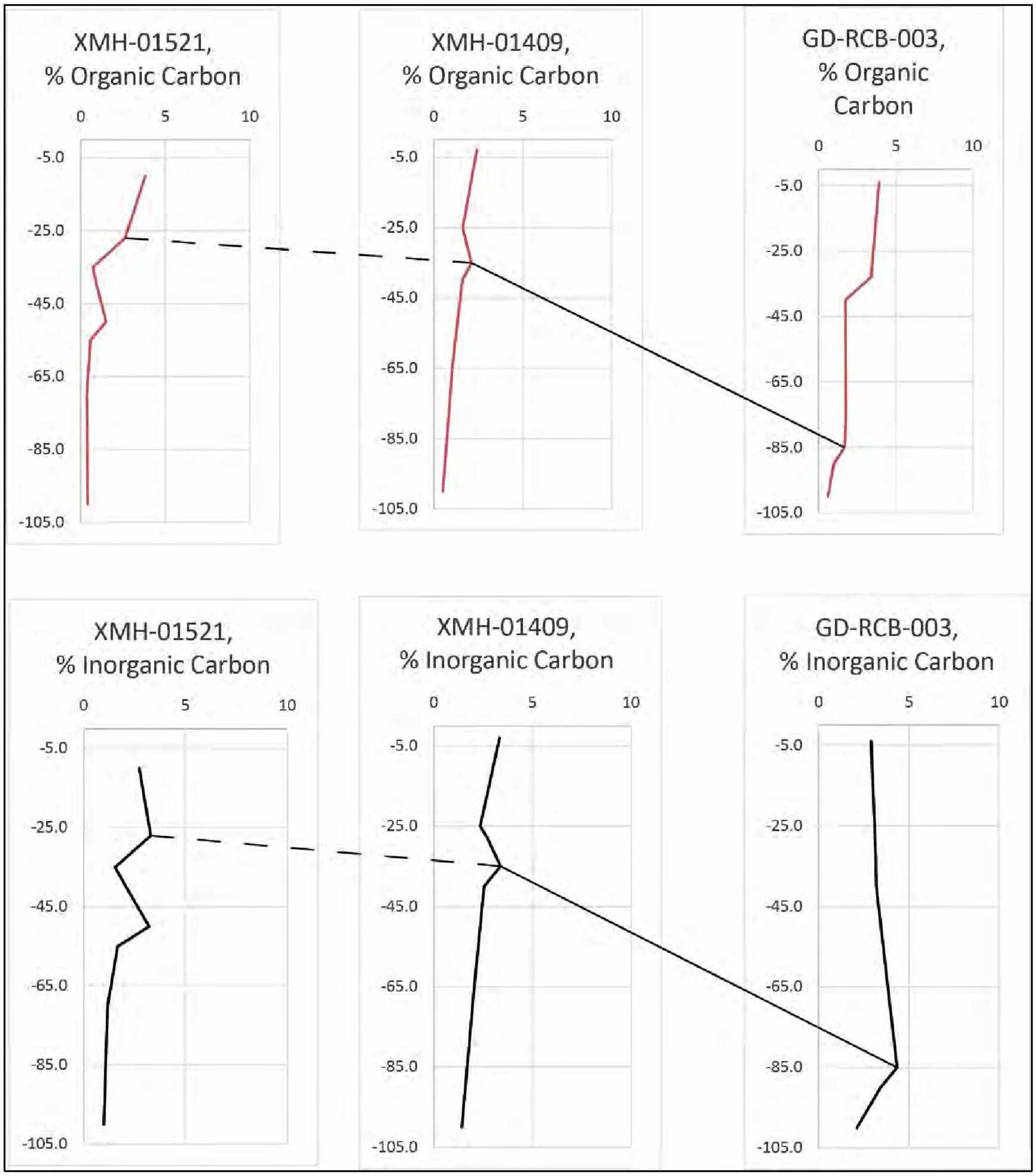


*Figure 5- 28.* Organic and inorganic carbon analysis and correlations across the GSDF.

### 5.5.3 Sediment Acidity

Sediment acidity and conductivity values across the GSDF appear to correlate with values of inorganic carbon (Figure 5- 29). For the purposes of comparison across the GSDF area, the test locations of TRA-001, XMH-01521, XMH-01409, and GD-RCB-003 were chosen for comparative purposes. These values were also compared against sediment samples taken from the Gerstle River site, east across the Gerstle River. In general, more acidic sediments are present through time within the western portion of the GSDF, whereas in the eastern portion (as shown through the values at GD-RCB-003) sediments are more basic. This more basic trend also persists across the Gerstle River valley and is present at the Gerstle River to the east. In all locations, as the modern era approaches, each location appears to trend toward the more acidic side of the pH scale.

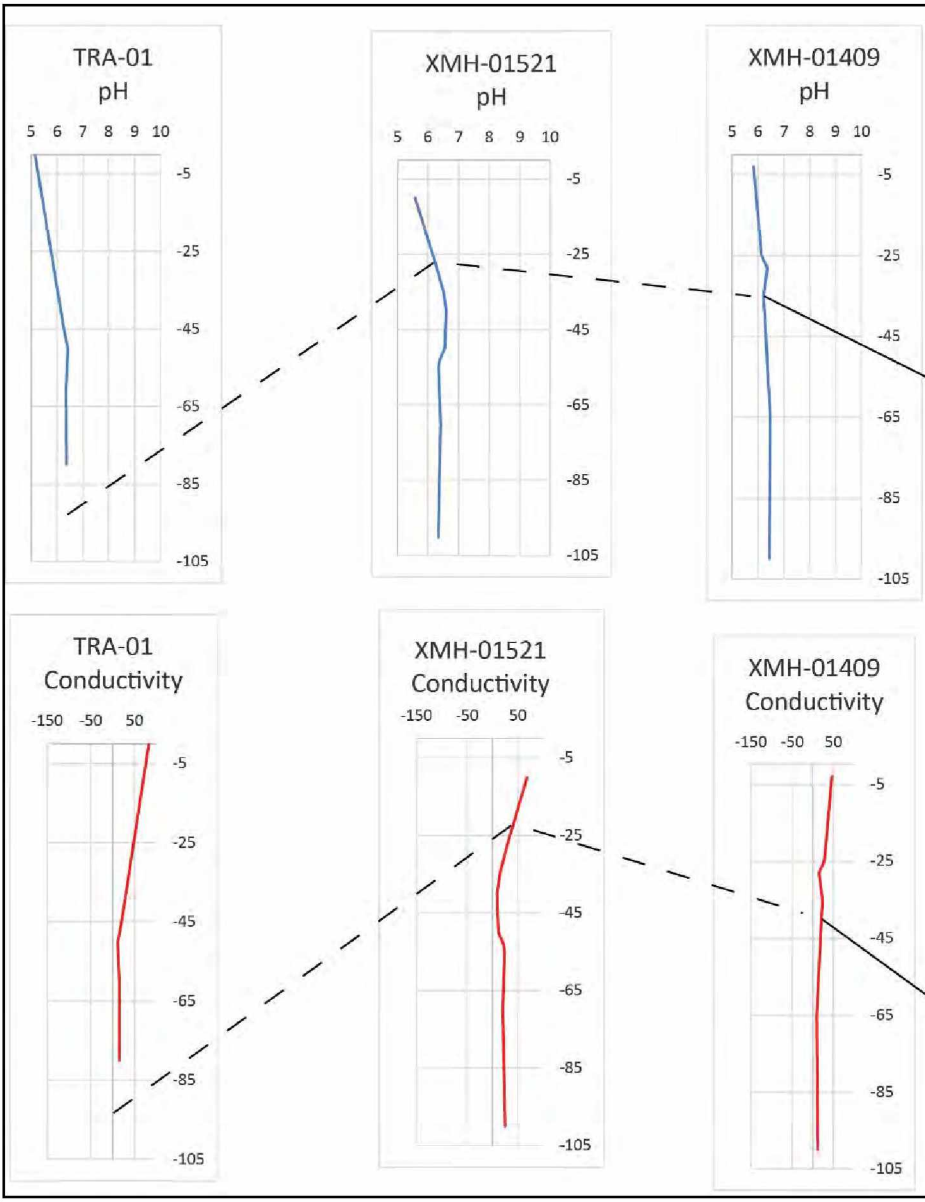
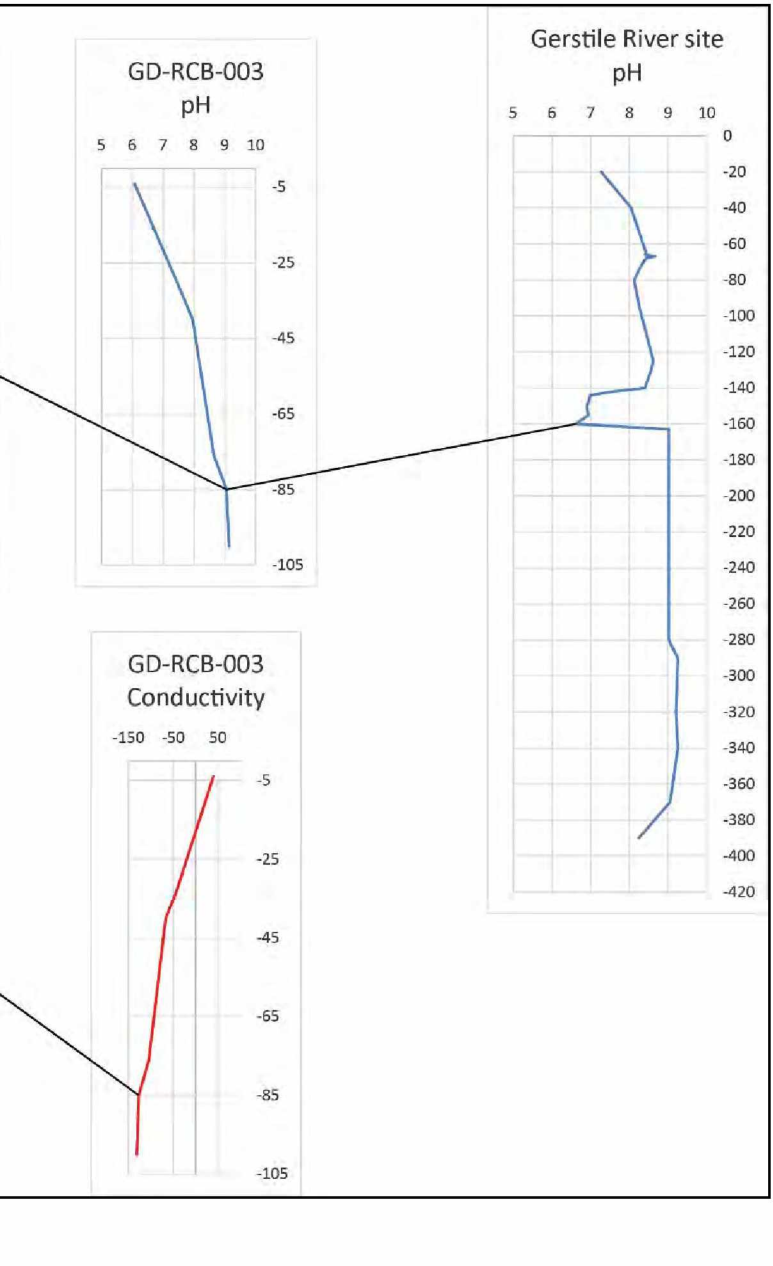


*Figure 5- 29.* pH analysis and correlations across the GSDF.


GD-RCB-003
pH
5 6 7 8 9 10
-5
-25
-45
-65
-85
-105
GD-RCB-003
Conductivity
-150 -50 50
-5
-25
-45
-65
-85
-105
Gerstile River site
pH
5 6 7 8 9 10
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
-320
-340
-360
-380
-400
-420

### 5.5.4 Micromorphology

Micromorphological analysis was conducted on samples from XMH-1408 and XMH-01409 within the Sawmill Creek portion of the GSDF. The primary focus of this analysis was to determine the mineral composition of the sediment in each sample. Results from this analysis are given in percentages and were used to create a tertiary graph displaying the different level of mineral concentration within each selected sample area (Figure 5- 30). Samples in this graph were separated by chronology based on their stratigraphic position and calibrated radiocarbon ages. Other attributes collected from this analysis include sample microstructure, granularity, void concentration and structure, as well as pedological and organic features in each sample (Stoops 2003). Results of the analysis are presented in Appendix A.

Mineral composition from examined samples are remarkably similar to one another displaying higher percentages of plagioclase feldspar and quartz throughout the sediment columns at both locations. Only one exception is presented from sample XMH-01409-01, which displays a much higher concentration of schistose lithic fragments at approximately 80% of the mineral constituency of the sample. Quartz and feldspar are harder minerals and are resistant to weathering over longer travel distances. However, schistose material, from the local bedrock Schist package is typically comprised of a mixture of gneiss, agen gneiss, amphibolite, quartzite, and minor marble, typically with a high muscovite content (Dusel-Bacon et al. 1993). These types of minerals are highly friable and break down quickly during transport. Temporally, this sample corresponds with the 9,300 Cal BP timeframe. It also corresponds with the reactivation of sand within the GSDF area and the formation of the parabolic dune sets locally at Sawmill Creek and the Bison Range.

On the whole the rest of the micromorphological characteristic from collected samples was remarkably similar across the other fields of data collection. Microstructure within samples typically ranged from subangular blocky to angular blocky. Granularity of samples generally displayed sediments packages consisting of fine to medium sand particles with minor lithic fragment content (including the

XMH-01409-01 sample with schistose lithic fragments presenting fine sand particles). Void patterning typically occurred from the degradation of root material as well as minor vughs, irregular in shape, consistent with water percolation patterns (Stoops 2003). Pedological patterning displayed iron oxide quasicoating and hypocoating only in association with paleosol development and the introduction of iron-rich organics (Stoops 2003). Organic structures present typically consisted of root penetrations, soil fungi, and charcoal fragments (Stoops 2003). No phytoliths were detected or other identifiable biological features that could present an opportunity to determine plant life within the area or exactly what floral biological niches were present through time within the Sawmill Creek area.

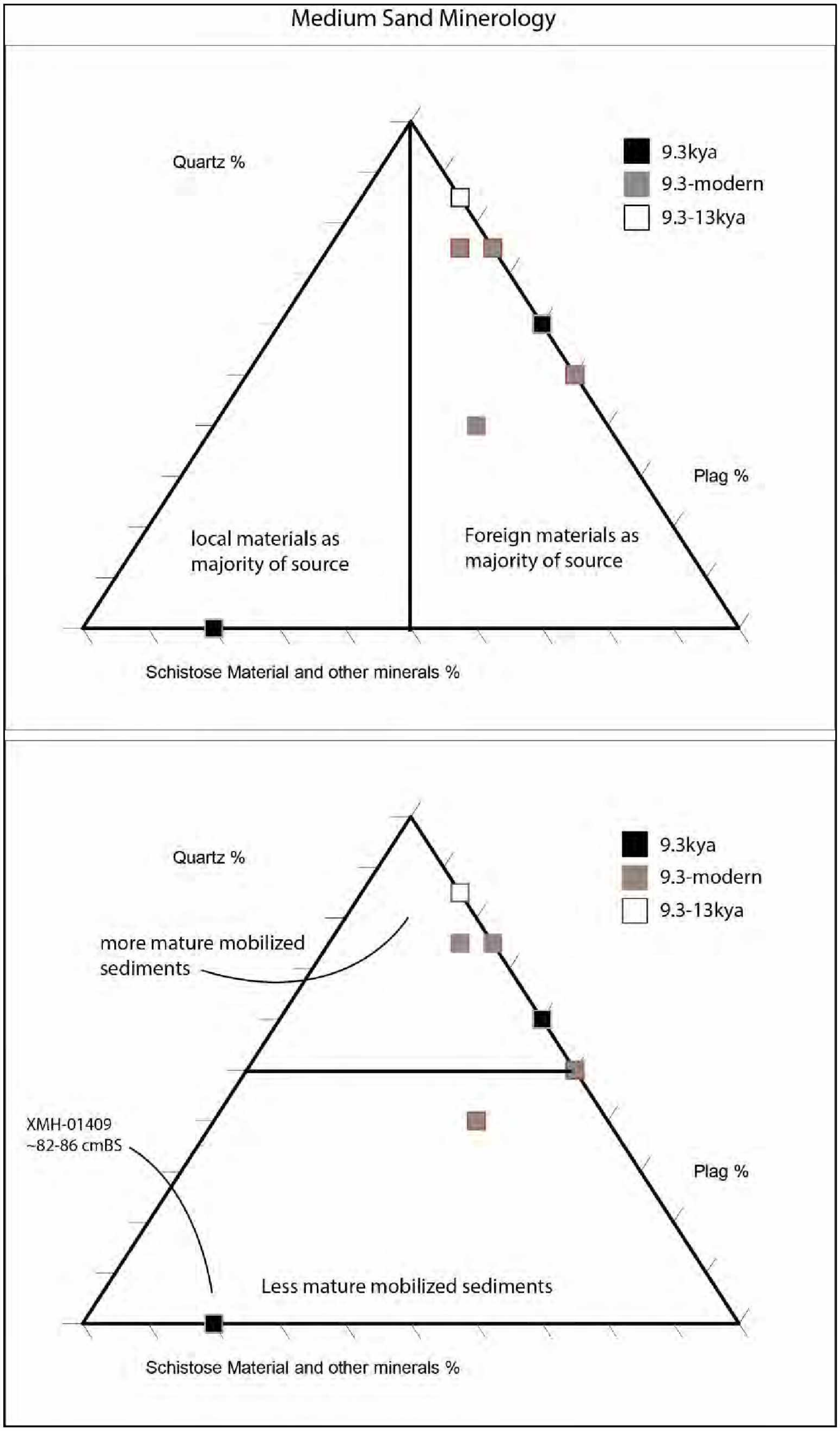


*Figure 5- 30.* GSDF sediment minerology.

### 5.5.5 Wave Dispersive X-ray Florescence

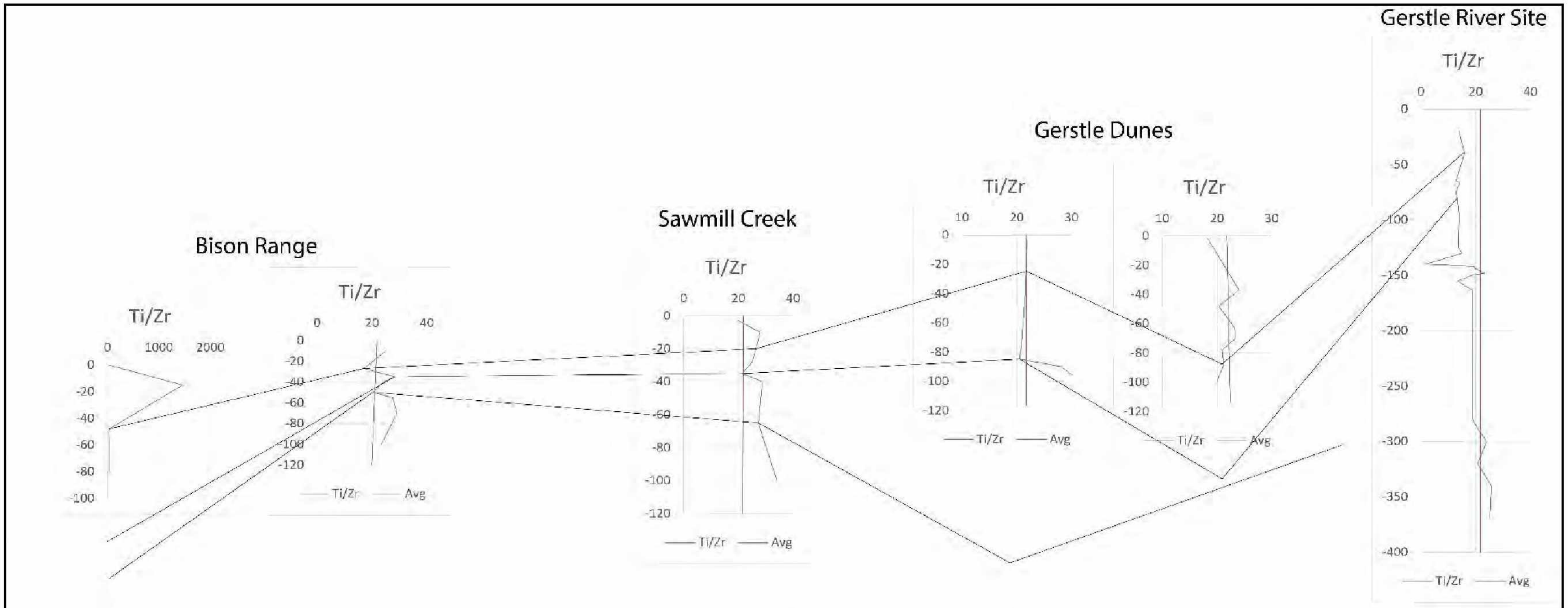
Results from WDXRF analysis are reported visually in Figure 5-31 and Figure 5-32, as well as numerically in Appendix B. Figure 5- 32 displays a stability index based on the ratio of lighter over heavier elements, in this case Ti/Zr. Figure 5- 33 displays values for sodium across the GSDF, used as an indicator of aridity (Sheldon and Tambor 2009). Averages were calculated based on values across the GSDF. Dramatic swings away from the local GSDF average during particular periods and through time are used to determine deviation into ranges of stable and dynamic and wetter versus drier. In such a way, given some level of overall change to both the local landscapes weathering patterns and aridity, a proxy can be created for change through time. Results are described in the following subsections and divided generally by radiocarbon dated periods.

Prior to 11,000 Cal BP the entirety of the GSDF was more dynamic than the calculated elemental local average. This also correlates chronologically with the deposition of the lower sands at the Gerstle River site (Potter 2005). This period is also indicated to be generally drier than average, with the exception of within the Gerstle Dune portion of the GSDF, due to its proximity to the Gerstle River. The 11,000 Cal BP period ends with the development of the paleosol associated with XMH-01521, which has for this study been conservatively lumped into the post- and during 11,000 Cal BP time frame for comparative purposes.

During this timeframe the Sawmill Creek and Gerstle Dune areas remain in a state of dynamic dune development while a shift toward stability occurs within the Bison Range dune area as well as at the Gerstle River site. Overall drier conditions are observed at the Bison Range and Gerstle Dune areas. Sawmill Creek transitions from drier to wetter during this timeframe, and the Gerstle River site appears wetter than the GSDF average.

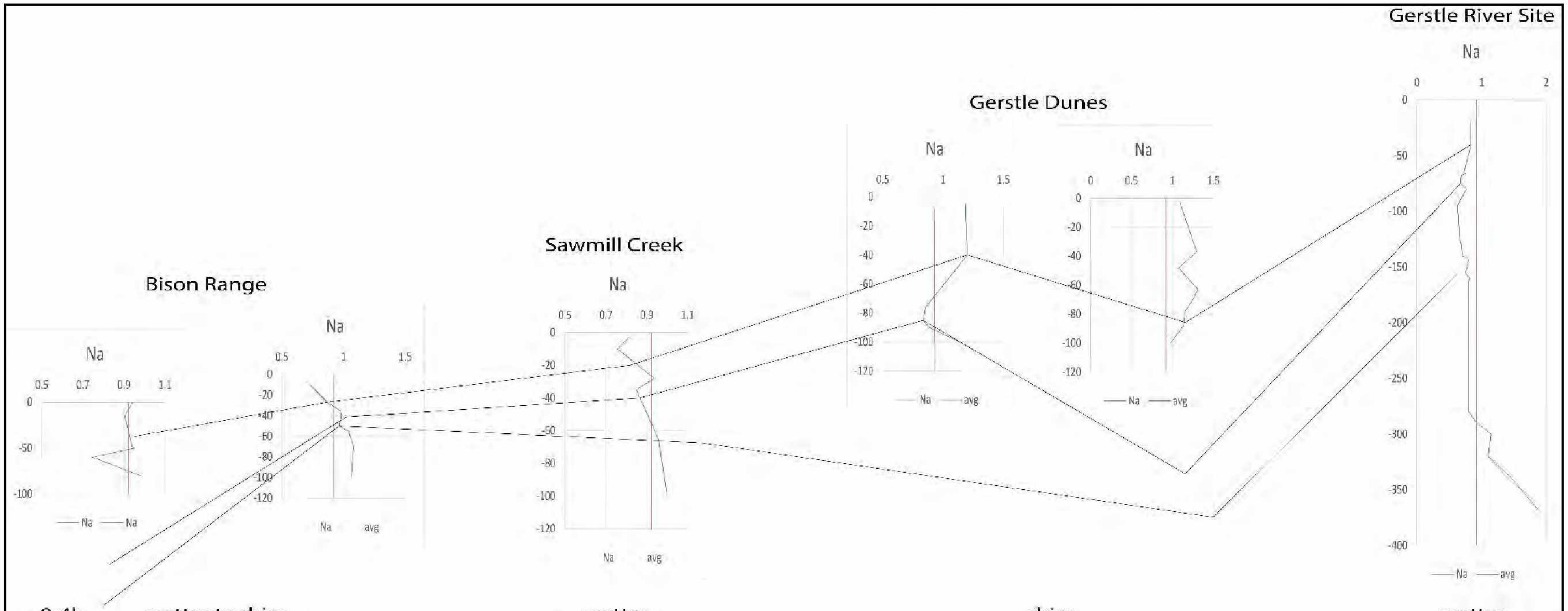
Within this timeframe in the Bison Range an oscillation from stable to dynamic and back to stable occurs. The Sawmill Creek section shifts for the first time from dynamic dune development to stable landforms. At this timeframe the Gerstle Dunes and, display a greater shift to overall stability. At the Gerstle River site many thin Ab horizon developed between 9,600 Cal BP to 6,000 Cal BP generally correlating to this time frame (Potter 2005). In terms of moisture conditions in the Bison Range a shift from drier to wetter occurs and the Sawmill Creek area becomes wetter, as well. The Gerstle Dunes shift during this time frame from wetter to drier and the wetter than average trend observed at the Gerstle River site continues.

From 0 to 4,000 Cal BP, Ti/Zr ratios across the GSDF are closer to their average trend lines (Table 5-8). Wetter conditions are apparent within the Bison Range, Sawmill Creek area, and at the Gerstle River site, the Gerstle Dunes appear to have drier conditions than the local average, likely tied to their location at the highest point on the Gerstle Clearwater escarpment and higher elevation away from the local water table.



| | | | | |
|---|---|---|---|---|
| 0-4k | Stable to Dynamic | Stable to Dynamic to Stable | Stable/Dynamic | Stable |
| 4-8k | Stable to Dynamic to Stable | Dynamic to Stable | Stable | Stable |
| 8-11k | Dynamic to Stable | Dynamic | Dynamic | Stable |
| 11k+ | Dynamic | Dynamic | Dynamic<br>(Inferred) | Dynamic to Stable |

*Figure 5- 31.* Ti/Zr elemental ratios and correlations across the GSDF.



| | | | | |
|---|---|---|---|---|
| 0-4k | wetter to drier | wetter | drier | wetter |
| 4-8k | drier to wetter | wetter | wetter to drier | wetter |
| 8-11k | drier | drier to wetter | drier | wetter |
| 11k+ | drier | drier | drier<br>(inferred) | drier to wetter |

*Figure 5- 32.* Na elemental concentrations and correlations across the GSDF.

## 5.6 Prey Rank Analysis

The analyses reported below in Table 5-7, Table 5-8, Table 5-9, and Table 5-10 are intended as a heuristic attempt to display optimal faunal resources for prehistoric food acquisition and choice making. The rankings presented below are based on human behavior ecology theories and ethnographic acquisition choice data gathered on the Upper Tanana (McKennan 1959). Acquisition through capture of multiple faunal resources at once (such as through communal hunting or the use of technology allowing capturing multiple creatures at the same time) is based on ethnographic acquisition data from the Upper Tanana (McKennan 1959). Nothing is mentioned here about herd tendencies beyond those of seasonal aggregation and congregation. Faunal population collapses are not taken into account throughout time periods, nor have such processes been realistically documented in such a way to effect this analysis. Resource availability is defined based on proximity of species to the GSDF based on modern seasonal movement and migration data (Coates 1997). In cases where species move outside of the GSDF area or are not being accessed by logistical teams traveling through the GSDF area species are omitted (i.e. bison and wapiti in the spring and summer months). Proximity was defined as being located within the GSDF or if a logistical group may have to travel through the GSDF in order to acquire a resource (i.e. dall sheep). Seasonal use is based on ethnographic behaviors as described by McKennan (1959).

It is assumed, based on the faunal evidence from middle Tanana River Valley sites, that the species represented here were present up until at least 4,000 Cal BP. Species presented here are given caloric values based on modern species proxies. In the case of bison, *bison bison* was used as a proxy for *bison priscus*, given that no current *bison priscus* caloric values could be obtained. In the case of wapiti, modern wapiti caloric values were used in place of ancient wapiti, despite the larger sizes of the more ancient populations of the species (Guthrie 2006; Potter 2005). In both cases, for bison and wapiti, these differences are considered negligible for the purposes of this heuristic ranking.

Given these stipulations the results from this brief analysis likely reflect some of the seasonal choices prehistoric hunter gatherers may have made in faunal resource acquisition. All recommendations are suggested by an interpreted rank, based on the criteria described in more detail in Chapter 4.

### Fall

During the autumnal season fish (salmon) are the highest ranked resource on the landscape due to their ability to be take enmasse, low handling time, and their high caloric yield. Bison and wapiti rank the second highest because of their high caloric yield, their presumed nearby location on the landscape, and their ability to be acquired as herd animals enmasse. Ethnographically, McKennan (1959) reports that while logistical teams were sent out acquire large mammals, some remained to continuing acquiring fish resources close to the residential occupation. Caribou ranks third due to its congregate population but lower than bison and caribou because of its lower caloric yield. Moose ranks next, mainly because of its limited degree of congregation on the landscape, environmental constraints (Bigelow 1997), and the search time that would be needed to find moose in locations where they do congregate in small groups, followed by Dall sheep, because of its lack of proximity.

### Winter

During winter months bison and wapiti again rank first because of the reasons listed above. This is followed by caribou and moose. Both again because of the reasons listed in the paragraph above.

Spring

In the spring, when wapiti and bison begin to move out of the GSDF area search times increase for them, dropping their ranking. As a result caribou and ducks/geese replace them as the most highly ranked resources in the local area. While it is still very likely that logistical groups would be dispatched out of the area to search for bison and wapiti if the need existed, the abundance of waterfowl during this time period may have offered another, more easily acquired food choice, if the necessary technology for capture was in place, with negligible handling time. Again, moose is ranked last due to its relative unpredictability on the landscape.

Summer

During summer fish (salmon) are the highest ranked resource on the landscape due to their ability to be take enmasse, low handling time, and their high caloric yield. This is followed by ducks/geese for the same reason. Moose, again is ranked last amongst the species listed here.

*Table 5- 7.* Fall GSDF prey rank analysis.

| | species | | | | | |
|---|---|---|---|---|---|---|
| Fall | Moose | Bison | Dall Sheep | Wapiti | Caribou | Fish (Salmon) |
| Caloric Mean | 11950 | 20000 | 11280 | 11950 | 11950 | 3790 |
| Group Modifier | 1 | 3 | 2 | 2 | 3 | 4 |
| search time | 4 | 2 | 10 | 2 | 6 | 0.5 |
| handling time | 2 | 5 | 5 | 1 | 1 | 0.5 |
| Kcal/search | 2987.5 | 10000 | 1128.0 | 5975.0 | 1991.7 | 7580 |
| Kcal/handling | 5975.0 | 4000.0 | 2256 | 11950 | 11950 | 7580 |
| Kcal/total time | 1991.7 | 8571.4 | 1504 | 7966.7 | 5121.4 | 15160 |
| Rank | 5 | 2 | 6 | 3 | 4 | 1 |

*Table 5- 8.* Winter GSDF prey rank analysis.

| | species | | | |
|---|---|---|---|---|
| Winter | Moose | Bison | Caribou | Wapiti |
| Caloric Mean | 11950 | 20000 | 11950 | 11950 |
| Group Modifier | 1 | 3 | 3 | 2 |
| search time | 4 | 2 | 6 | 2 |
| handling time | 2 | 5 | 1 | 1 |
| Kcal/search | 2987.5 | 10000 | 1991.7 | 5975.0 |
| Kcal/handling | 5975.0 | 4000.0 | 11950 | 11950 |
| Kcal/total time | 1991.7 | 8571.4 | 5121.4 | 7966.7 |
| Rank | 4 | 1 | 3 | 2 |

*Table 5- 9.* Spring GSDF prey rank analysis.

| | species | | |
|---|---|---|---|
| Spring | Moose | Caribou | Duck/Geese |
| Caloric Mean | 11950 | 11950 | 720 |
| Group Modifier | 1 | 3 | 4 |
| search time | 4 | 6 | 0.5 |
| handling time | 2 | 1 | 0.5 |
| Kcal/search | 2987.5 | 1991.7 | 1440 |
| Kcal/handling | 5975.0 | 11950 | 1440 |
| Kcal/total time | 1991.7 | 5121.4 | 2880 |
| Rank | 3 | 1 | 2 |

*Table 5- 10.* Summer GSDF prey rank analysis.

| | species | | |
|---|---|---|---|
| Summer | Moose | Duck/Geese | Fish |
| Caloric Mean | 11950 | 720 | 3790 |
| Group Modifier | 1 | 4 | 4 |
| search time | 4 | 0.5 | 0.5 |
| handling time | 2 | 0.5 | 0.5 |
| Kcal/search | 2987.5 | 1440 | 7580 |
| Kcal/handling | 5975.0 | 1440 | 7580 |
| Kcal/total time | 1991.7 | 2880 | 15160 |
| Rank | 3 | 2 | 1 |

## 5.7 Spatial Analysis/Patch Choice Model

Analysis of space and chronology from the GSDF area are displayed for four time frames; prior to 11,000 Cal BP, 11,000 to 8,000 Cal BP, 8,000 to 4,000 Cal BP, and 4,000 to 0 Cal BP (Figure 5- 33 through Figure 5- 36). During this earlier time frame, prior to 11,000 Cal BP, the Bison Range appears to be utilized more within the GSDF, with land use occurring at XMH-01521 and at XMH-01520. This area of use is largely toward the edge of the dune field area and overlooks the lower elevated sand sheet to the south and west. From 11,000 to 8,000 Cal BP XMH-1521 is no longer in use however, occupation occurs at XMH-251 within the Sawmill Creek area. From 8,000 to 4,000 Cal BP, no land use has been discovered within the GSDF. From 4,000 to 0 Cal BP a shift occurs toward a higher degree of landscape use of the Sawmill Creek area with higher numbers of dated sites and closer site proximity to one another in the Sawmill Creek area, while only limited use of the Bison Range area occurs only at XMH-01520.

While these patterns are correct for the data presented in this thesis it must be stated that the overall sampling strategy used to collect data for these examination was not presumably totally error free and sample size within the areas described above is quite small (n=7, for the total area including potential residential bases and logistical spike camps in proximity to the GSDF). As a result, such shifts in land use patterning through time may be a function of inherent biases within the strategy used in this examination to collect data regarding environmental change and human land use. Potentially, if another testing strategy was put in place to examine other aspects of human behavior in the area such patterns may prove to be ill defined or non-existent.

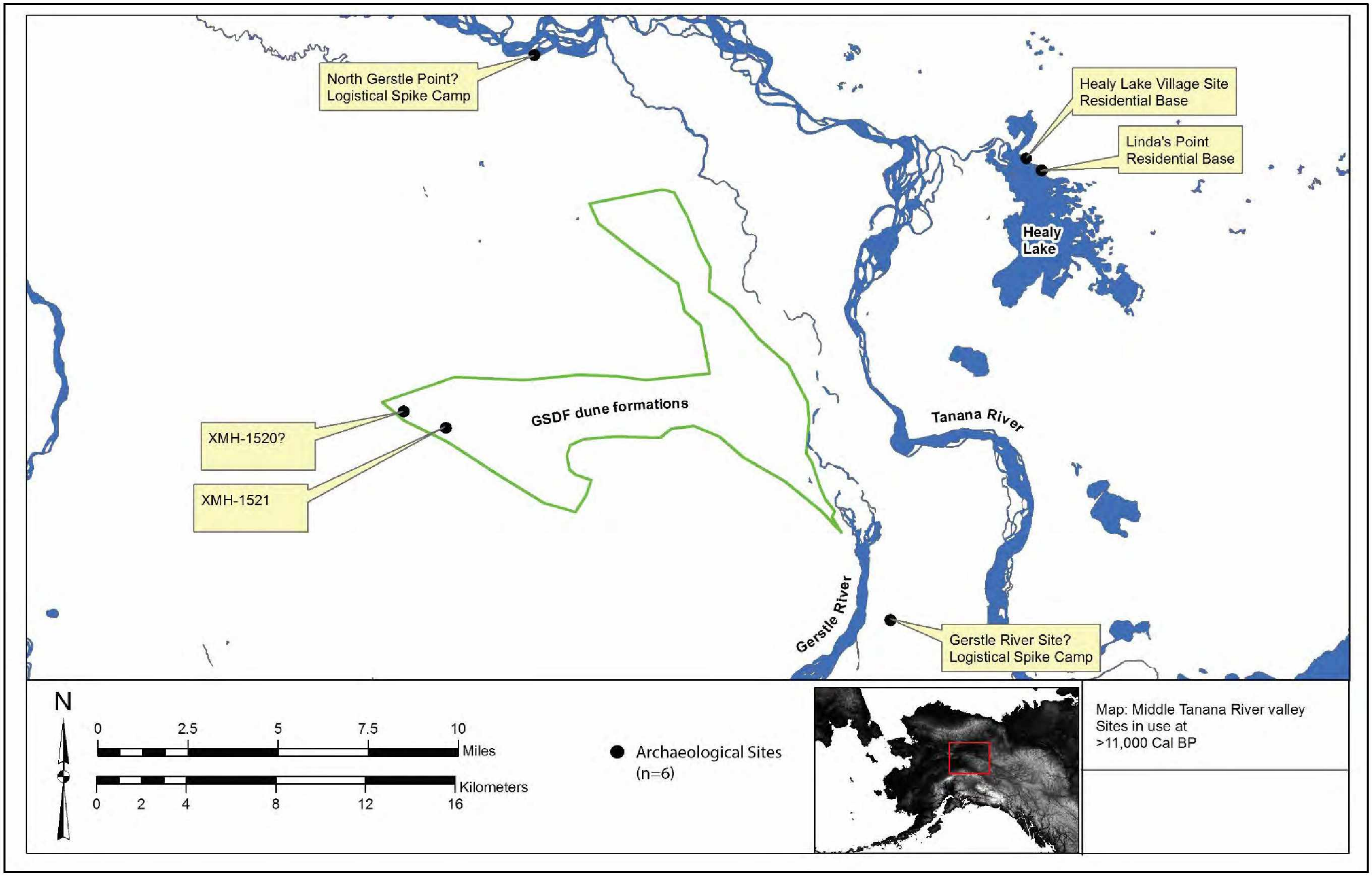


*Figure 5- 33.* Spatial patch distribution of archaeological sites prior to 11,000 Cal BP.

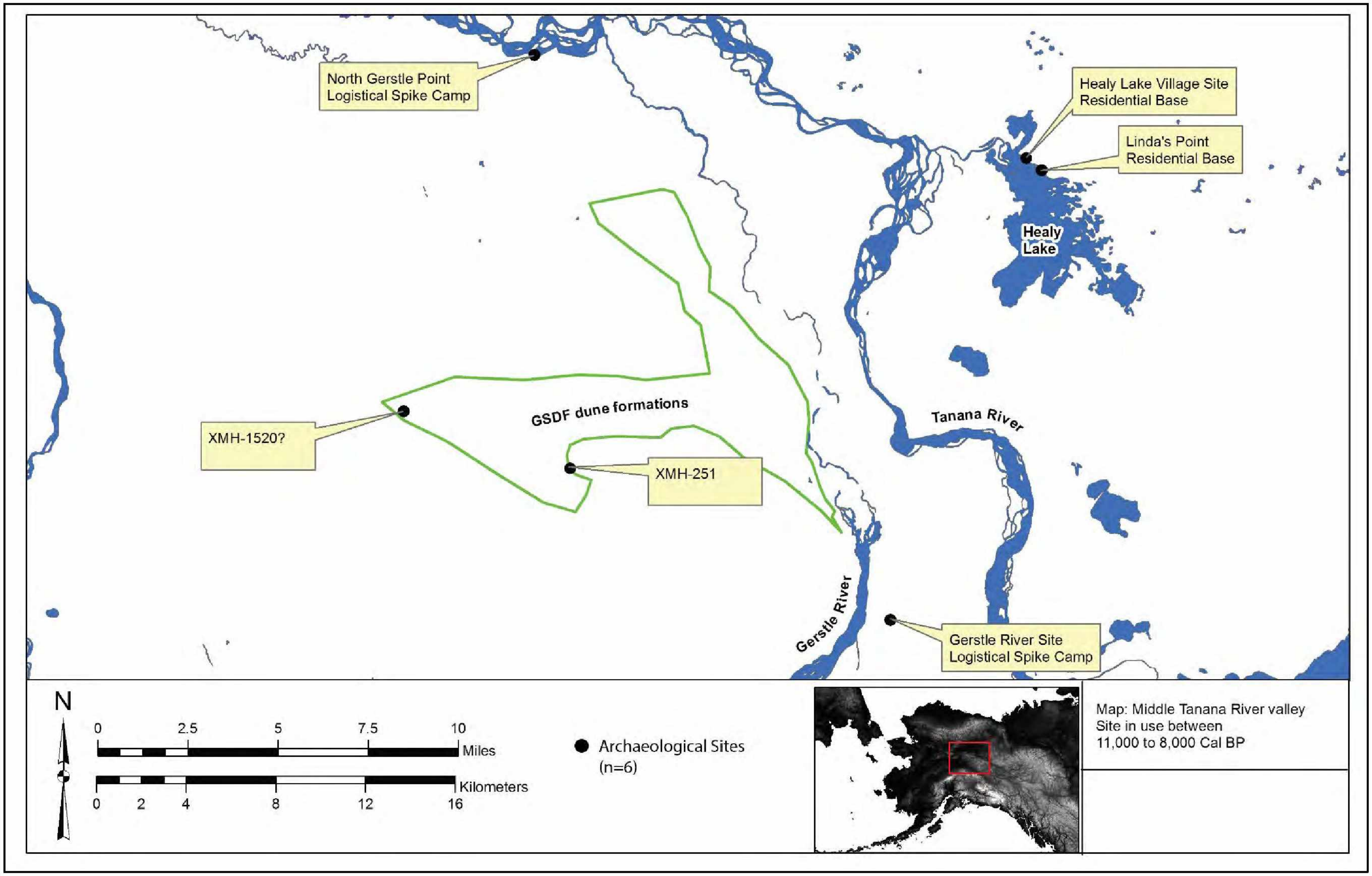


*Figure 5- 34.* Spatial patch distribution of archaeological sites 11,000 to 8,000 Cal BP.

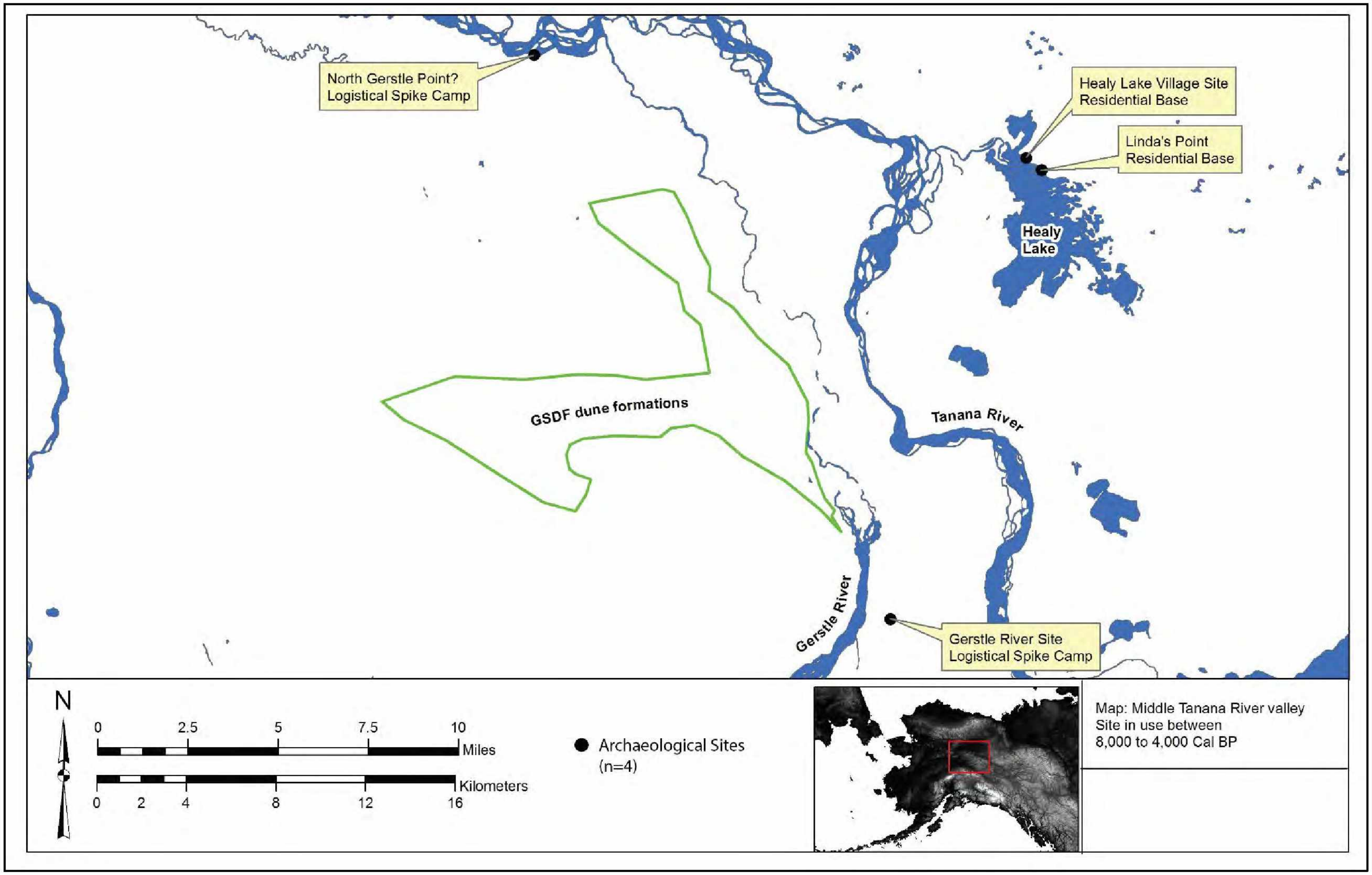


*Figure 5- 35.* Spatial patch distribution of archaeological sites 8,000 to 4,000 Cal BP.

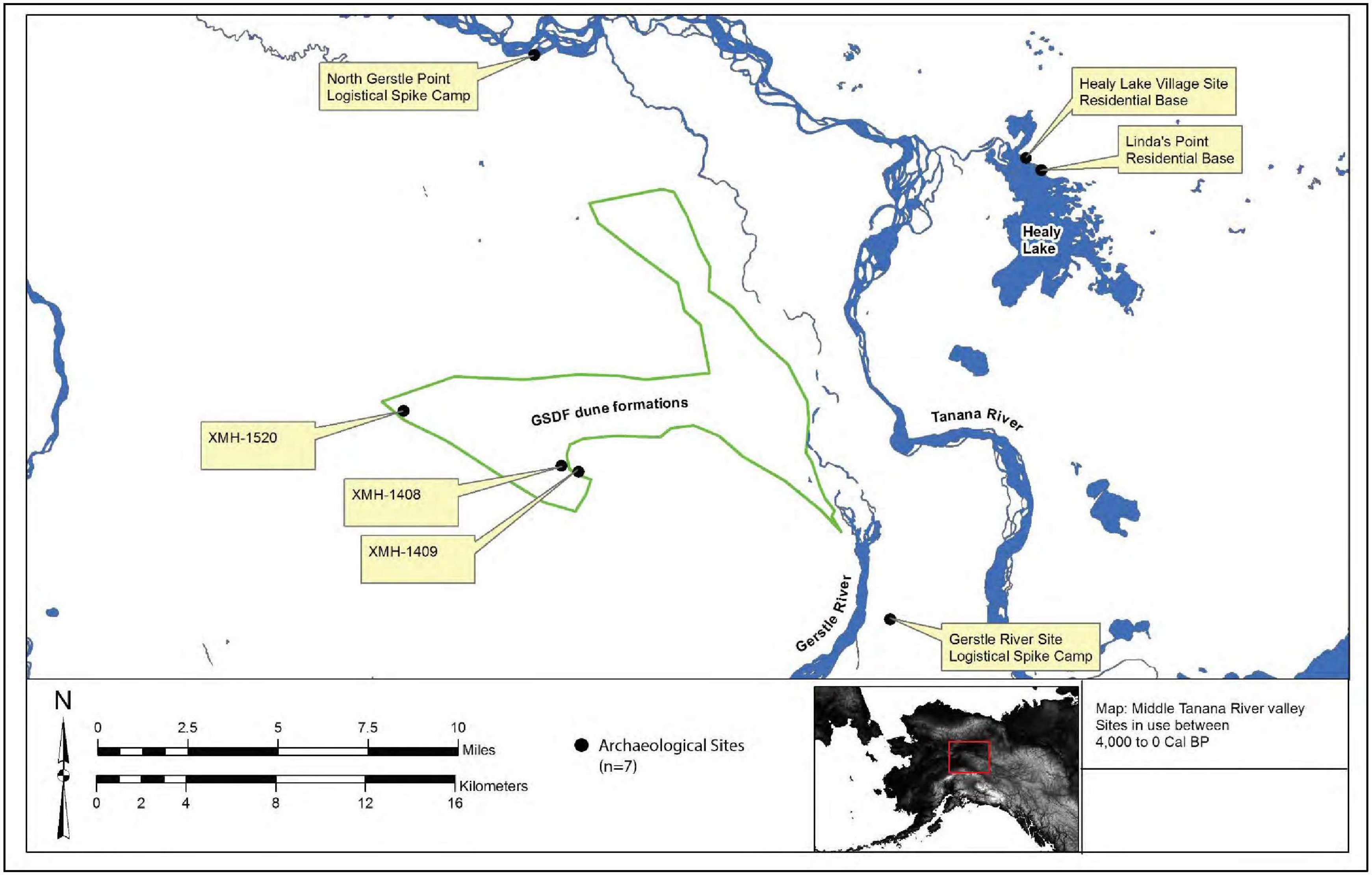


*Figure 5- 36.* Spatial patch distribution of archaeological sites 4,000 to 0 Cal BP.

## 5.8 Lithic Analysis

### 5.8.1 Lithic Quantities by Site

Quantity of lithic materials recovered in situ via excavation is quite low, despite over 50% testing coverage at all sites except XMH-1520, which displays 95% surface area deflation and disturbance (Table 5-12). XMH-1521 displays the highest quantity of buried lithic material with only ten lithic flakes recovered. XMH-1520 displays the highest quantity of surficial lithic material with 158 lithic, however, based on collection parameters for surface sites for this thesis project (reported in Chapter 3) only 31 lithics were collected and analyzed for this site.

Both sites discussed above are located within the Bison Range portion of the GSDF. Within the Sawmill Creek area XMH-1408 displays the largest number of buried recovered lithic material with five flakes followed by XMH-1409 with two buried lithics, and XMH-251 with only 1 buried lithic. XMH-251 displays 93% of its crest area deflated and disturbed with five surface lithics located there (Table 5-11).

*Table 5- 11. Lithic quantities by site.*

| Area | Site | Dune Crest Area (Square meters) | Dune Crest Area Deflated (Square Meters) | % of area deflated | Cumulative Area Excavated (Square Meters) | Number of 50x50 Test Pits | Area of Test Coverage (Square meters) | % of area covered by Tests at Regular Interval | Buried Lithics | Surface Lithics |
|---|---|---|---|---|---|---|---|---|---|---|
| Bison Range | XMH-1520 | 4000 | 3800 | 95 | 2 | 8 | 200 | 5 | 1 | 158 (31 collected) |
| Bison Range | XMH-1521 | 450 | 15 | 3 | 2.5 | 10 | 230 | 51 | 10 | |
| Sawmill Creek | XMH-1408 | 220 | 0 | 0 | 2.5 | 10 | 130 | 59 | 5 | |
| Sawmill Creek | XMH-1409 | 485 | 0 | 0 | 3 | 12 | 250 | 52 | 2 | |
| Sawmill Creek | XMH-251 | 800 | 740 | 93 | 1 | 4 | 60 | 5 | 1 | 5 |

### 5.8.2 Material Types

Cursory lithic analysis of the 37 lithics collected from XMH-1520 shows that chert makes up the majority of the lithic material at the site (n=20) (Figure 5- 37), followed by a reddish purple basalt (n=14). Obsidian (n=1) and rhyolite (n=2) make up three and five percent of the sites assemblage, respectively. At XMH-1521 only 10 lithics were located, chert (n=4) and quartzite (n=4) make up the majority of the lithic assemblage, both at 40% a piece. At this location basalt (n=2) of the same texture and reddish purple hue as seen at XMH-01520 make up 20% of the assemblage. Given the similarity of the basalt between these two locations it is postulated that this material sources from the same location (Figure 5-37).

### 5.8.3Local vs Non-local

An estimation for locally available material versus non-local was made by comparing the quantity of lithic material in total against the weight in grams of lithic material in total at XMH-1520. In order to do so chert was broken down into six distinctive categories based on color and texture and each category was compared against the other along with basalt, obsidian, and rhyolite (Table 5-12). Cherts C1, C2, and C4, along with obsidian returned values expected (with lower clustered values of quantity and weight together) for non-local materials. These lower levels within the total whole indicate further distance from their original source and a higher transport distance (Younie 2016). Cherts C3, C5, and C6, along with basalt and rhyolite return values for material available at closer distances (Figure 5-39). An analysis of percent retouch by weight was also conducted (Figure 5- 40). In general materials determined to be more locally derived from the previous test displayed lower percentages of retouch with the exception of rhyolite and C4 chert.

*Table 5- 12. Chert designations by color and texture.*

| Chert Designations |
|---|
| black (C1) |
| dark gray (C2) |
| very dark gray (C3) |
| very dark grayish brown (C4) |
| dark gray and green (C5) |
| dark greenish gray (C6) |

These calculations were then used to determine the abundance of local to non-local materials present at XMH-1520 and then for XMH-1521, given its closer proximity to the latter (Figure 5- 41and Figure 5- 42). PXRF analysis of the single obsidian bifacial tool located at XMH-1520 returned results of Wiki Peak (Table 5-13). This obsidian source is located within the Wrangell Mountains some 301 km (187 mi) to the southwest of XMH-1520s location. In total at XMH-01520 56% of the recovered assemblage is exotic, where as 44% is local (Figure 5- 41). At XMH-01521 40% of lithic material is exotic, where as 60% is local (Figure 5- 42).

*Table 5- 13.* PXRF analysis of obsidian biface from XMH-01520.

| AOD Number | Catalog Number | Site Number | K | Mn | Fe | Zn | Ga | Th | Rb | Sr | Y | Zr | Nb | Source Provisional |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AOD-50893 | XMH-01520 1st run | XMH-01520 | 36,753.40 | 421.86 | 8,118.76 | 39.5695 | 17.0038 | 13.8389 | 84.8939 | 63.2385 | 14.108 | 103.262 | 8.94521 | Wiki Peak |
| AOD-50893 | XMH-01520 2nd run | XMH-01520 | 36,827.08 | 380.743 | 8,176.64 | 45.3484 | 16.9515 | 15.1369 | 86.3308 | 62.7041 | 15.935 | 102.282 | 8.26948 | Wiki Peak |
| AOD-50893 | XMH-01520 3rd run | XMH-01520 | 36,786.53 | 415.929 | 8,260.51 | 40.7002 | 17.1117 | 14.5213 | 84.2712 | 63.575 | 15.5943 | 103.79 | 8.86474 | Wiki Peak |

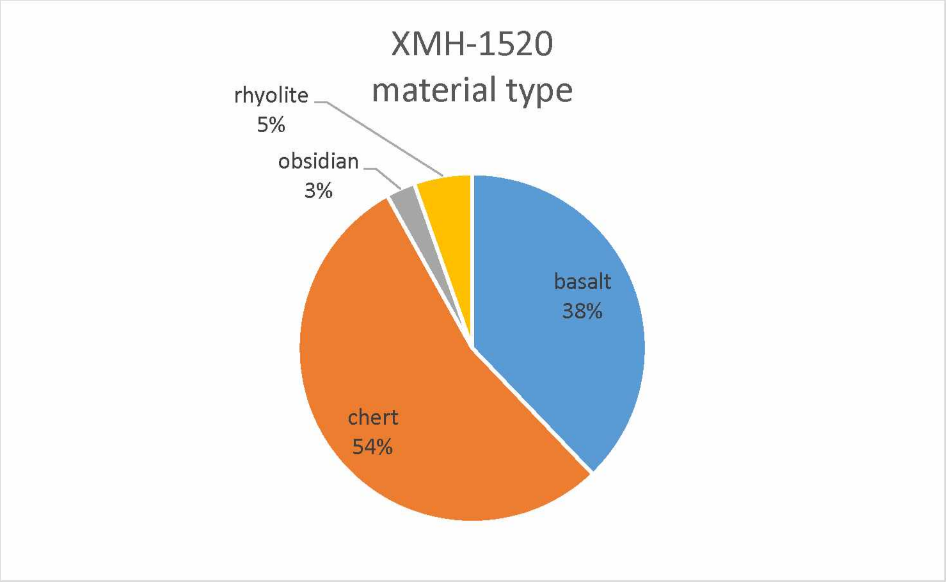


*Figure 5- 37.* XMH-01520 lithic raw material types (n=37).

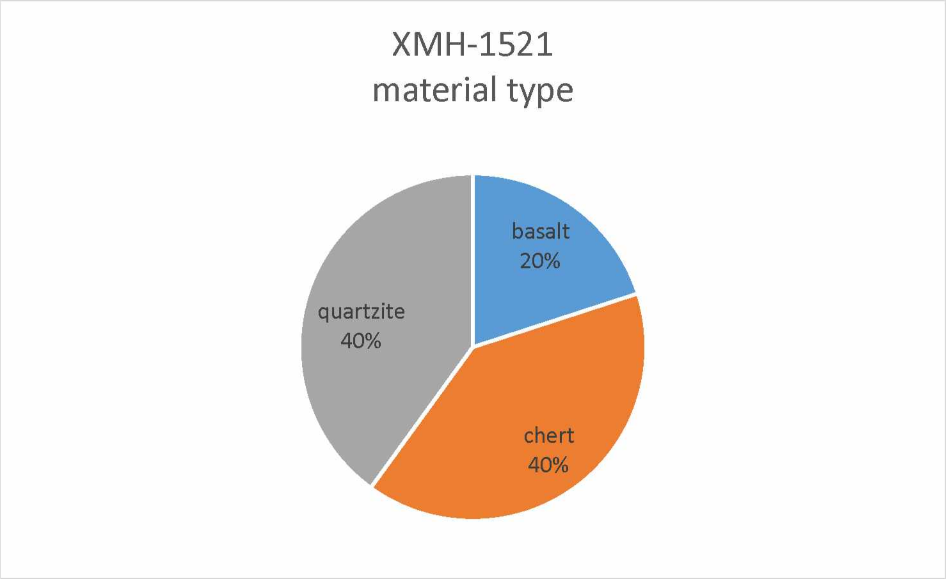


*Figure 5- 38.* XMH-01521 raw lithic material types (n=10).

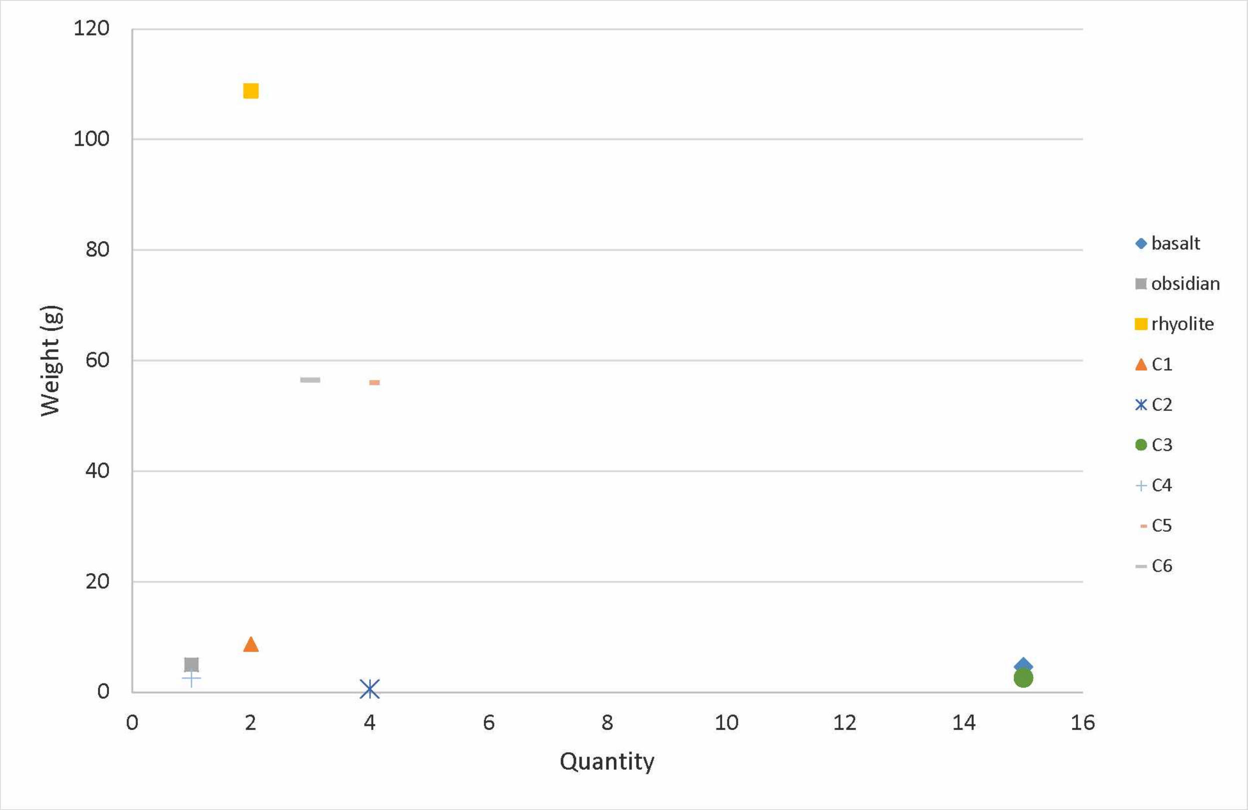


*Figure 5- 39.* XMH-01520 lithics weight (g) v quantity (n=37).

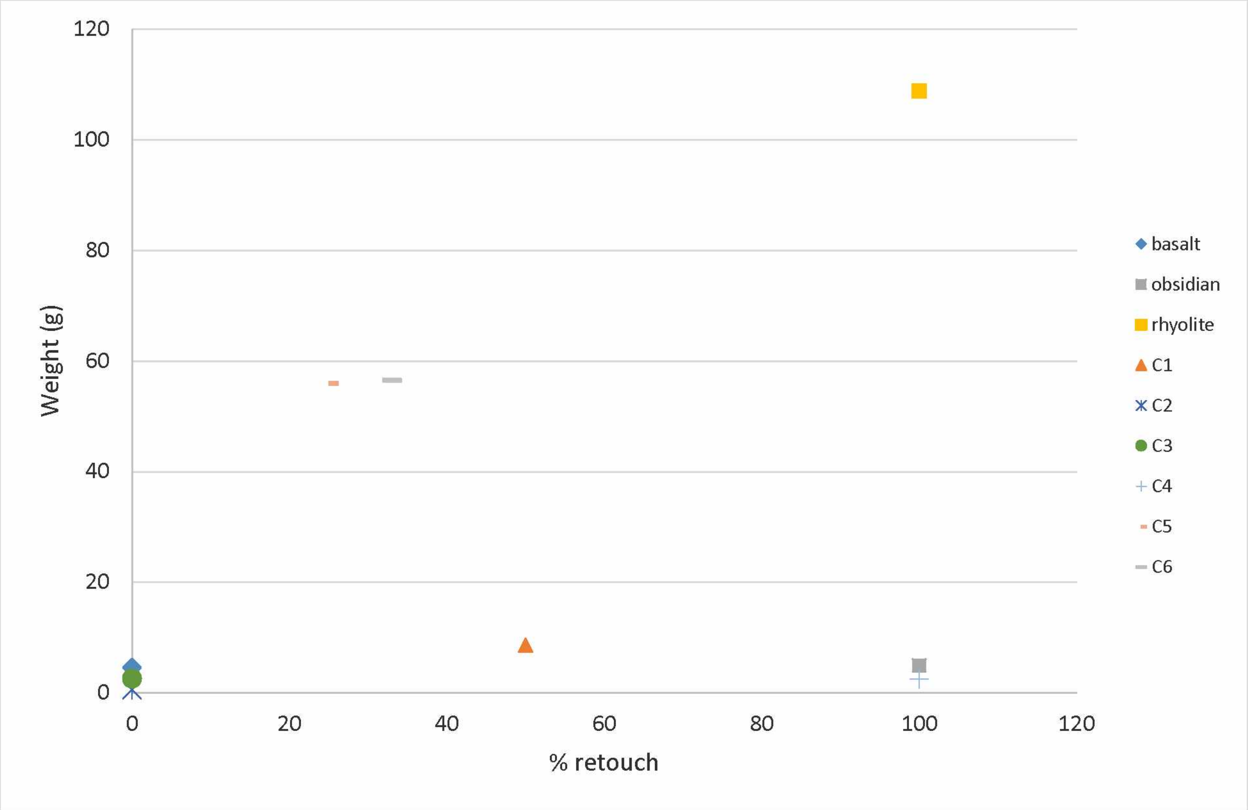


*Figure 5- 40. XMH-1520 weight v % retouch.*

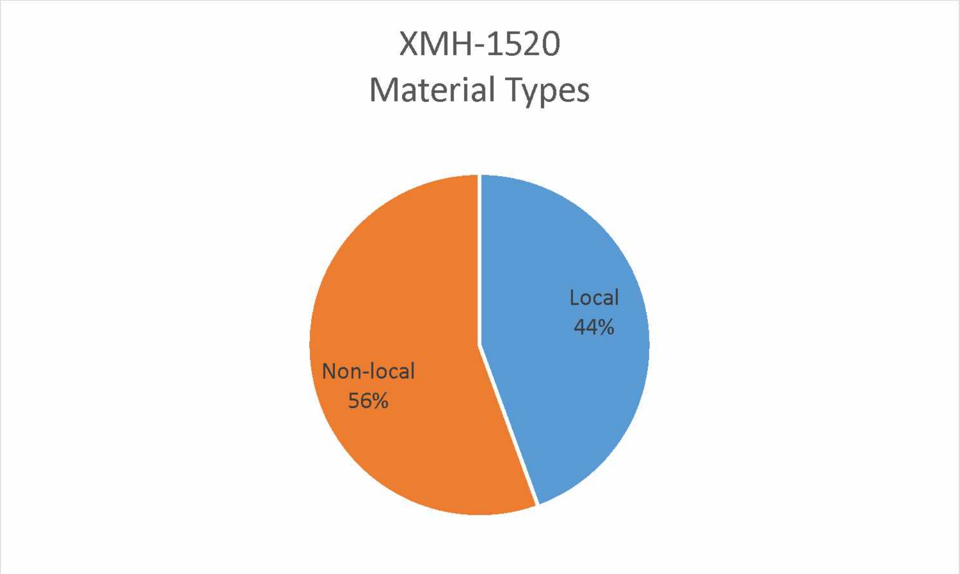


*Figure 5- 41.* XMH-01520 lithic materials, local v exotic (n=37).

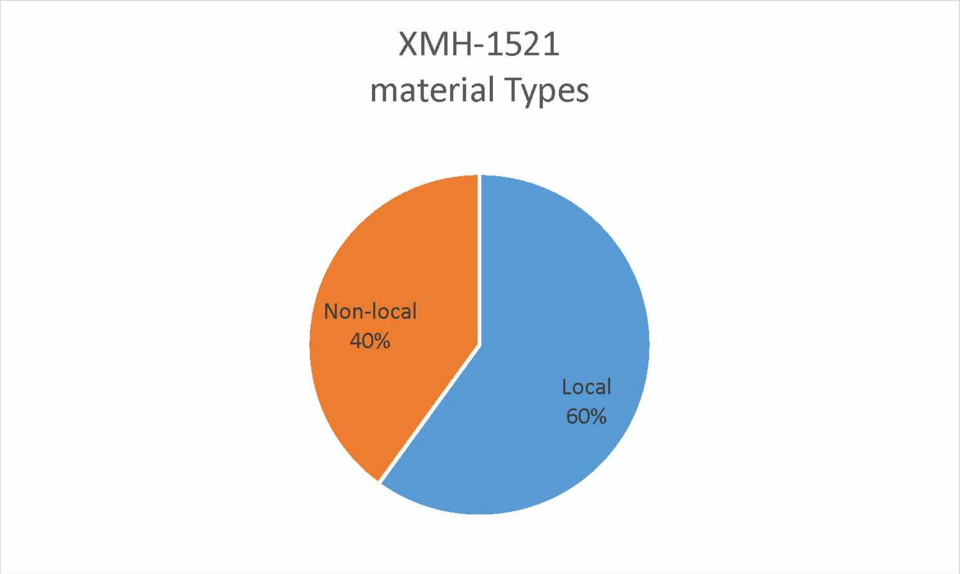


*Figure 5- 42.* XMH-01521 lithic materials, local v exotic (n=10).

*Figure 5- 43.* Lithic tools recovered from XMH-01520. Refer to Appendix C for descriptions.

*Figure 5- 44.* Bifaces recovered from XMH-01520 in 2008 by hunters (No other photos exist).

*Figure 5- 45.* Notched point recovered from XMH-01520 in 2008 by hunters (No other photos exist).

*Figure 5- 46.* Projectile point base recovered from XMH-01520 in 2008 by hunters (no other photos exist).

# Chapter 6 Interpretations and Discussion

## 6.1 Landscape Dynamics and Stability

Combined paleoenvironmental data presented in the Results section suggest that the GSDF displays high degrees of soil formation and landform stability punctuated by dynamic sand dune development, fractionalized geospatially through time up until 4,000 Cal BP, coincident with the ubiquity of the boreal forest enveloping the middle Tanana River valley landscape. This fractionalization corresponds to divisions in local ecological systems, plants and animals colonizing and using the GSDF variably across the area within different timeframes and throughout time. The overall pattern of geomorphological and ecological development and change is described as follows:

### 6.1.1 > 12,000 Cal BP

The older fractions of soil residue extracted from XMH-01408 and XMH-00251 likely provide a radiocarbon date from the abandoned escarpment area comprising the eastern boundary of the Sawmill Creek dune set. This suggests that active drainage was occurring within the area east of the terraced escarpment sometime from 20,000 to 30,000 Cal BP forward. Alluviation likely provided the sand material for local aeolian transport during the initial building stages of the GSDF. Original dune formations began building during this time. These dunes are transverse in morphology with slipfaces pointing northward suggesting that the overall direction and nature of the wind during this time was of a katabatic influence and came from the south, away from the Alaska Range and the glaciers present there. Little to no vegetation or soil organic matter is present from this period of development, suggesting that wind intensity was high, sediment sources were exposed, dunes were continually being built, and early successions of vegetation have not had the time to colonize. Size and concentration of larger sand particles across the GSDF being deposited at this time suggest high wind intensity. Higher levels of sodium present in sediments from this period suggest that the area was drier overall, at least along dune crests. Given the lack of organics, high wind intensity, and overall dryness, presence of larger mammalian animals within the GSDF at this time is highly unlikely (Guthrie 2001).Evidence of large mammal presence does exist just outside of the GSDF for this time period at the Gerstle River site in the form of faunal remains of horse, siaga, and other large mammalian remains occurring prior to 12,000 Cal BP (Potter 2005). It is possible that moisture near active drainages during this time may have provided suitable forage and grazing land for such animals away from the drier and more active portions of the GSDF. This period also corresponds with the deposition of sand at the Gerstle River site.

### 6.1.2 12,000 to 8,000 Cal BP

During this period, ecological division or fractionalization becomes present within the GSDF. Beginning at this time frame, heightened levels of organic carbon, lower levels of Na, and lower Ti/Zr ratios are present in conjunction with smaller sediment sizes, presence of charcoal, and increases in soil development at XMH-01521 within the Bison Range at approximately 12,000 Cal BP. Similar characteristics are present at XMH-01408 and XMH-00251 within the Sawmill Creek area but later around 11,000 to 10,000 Cal BP. Soil patches present throughout this area indicate that these soils developed here early as patches where optimal conditions led to vegetative growth over other less optimal areas, where sediment deposition persisted. Conversely, in the Gerstle Dunes lower amounts of organic carbon, higher particle sizes, higher Na values, and higher Ti/Zr ratios suggest that transverse dune building remained constant in this portion of the GSDF up until around 8,000 Cal BP. Overall this pattern suggests landscape stability, sparse vegetative growth (presumably *Betula* and *Salix* patches with some *Populus* vegetation toward the beginning of the period and but with increasing *Picea* and *Alnus* colonizing towards the periods end based on local lake core pollen records [Barber and Finney 2000; Bigelow and Powers 2001]) within the western portions of the GSDF, and ecologically viable habitat for large mammal resources within the Bison Range. Conversely, conditions favoring landscape dynamics and little to no vegetative growth persisted in the eastern portion of the GSDF, in the Gerstle

Dunes area, much like before 12,000 Cal BP, with this portion of the GSDF likely still not attractive to large mammal resources.

### 6.1.3 8,000 to 4,000 Cal BP

Continued fractionalization and ecological division persists throughout this time frame. Within the Gerstle Dune portion of the GSDF dune development appears to stabilize, first with the development of a forest soil (presumably *Picea* and *Alnus* based on local lake core pollen records [Ager 1975; Bigelow and Powers 2001]) around 8,000 Cal BP, followed by the deposition of aeolian silts in this area into the modern period. This shift in particle size deposition (sand to silt) is also accompanied by lower ratios of Ti/Zr, lower Na values, heightened inorganic carbon, and more alkaline pH. Heightened inorganic carbon and alkalinity are likely tied to the local deposition of more calcareous silts over sands (Reger et al. 2008), comprising the aeolian loess package now present in the area, likely sourcing from the east within the more deeply cross-cutting Gerstle-Clearwater escarpment.

In the forested ecosystems, gross changes in pH have also been observed to be linked to ecological change in forest densities across time and space (Zinko et al. 2006). Given the trends presented between more acidity and alkalinity of sediment and soils between the western and eastern portions of the GSDF during this time frame it can be interpreted that the Gerstle Dunes area was a more open forest during periods of soil development, or deforested until more recent times. The Gerstle River site also appears to have pH values suggesting a more open landscape with a change toward acidity and more forest enclosure occurring at 8,000 Cal BP and a rebound to normal levels (for the site) soon after.

The relative continuous deposition of silt material within this portion of the GSDF is most likely tied directly to its proximity to the Gerstle-Clearwater escarpment. As incision of the alluvial valley to the east increased, more and more energy would have been necessary to move sand on to the plateau created by down-cutting. As the wind shifted to the more westerly dominated direction, as indicated by the morphology of the parabolic dunes in the western half of the GSDF, no sand would have been available for reactivation near the Gerstle Dune area at an appropriate elevation necessary for transport. This low wind energy regime likely waivered in some degree, however, allowing for the development of paleosols around 4,000 Cal BP, as demonstrated from radiometric dating of paleosols observed at GD-RCB-002, which is located closer to the escarpment edge. Multiple paleosols dating to this timeframe with some separation by loess, indicates that these soils were likely short-lived and covered by locally deposited loess from the Gerstle River valley rather quickly. The general thickness of loess across the GSDF area (greater than 100 cm in the Gerstle Dunes area, decreasing to approximately 20 to 50 cm in the Bison Range and Sawmill Creek areas), also indicates that the loess within the area came in large part from the Gerstle River, suggested by the overall wedge shaped depositional pattern (Figure 6-1 and Figure 6-2).

At GD-RCB-002, middle Holocene dates are present at depths near a meter and proximal to the escarpment dividing the lower Gerstle River flats and the dunes on top of the plateau divided by the escarpments. At this location it is interpreted that loess accumulated to a much deeper extent at this location sourcing from the Gerstle River flats (Figure 6-1 and Figure 6-2). Accordingly, sedimentation closer to the contact between the upper silt mantle and the lower dune sands is unknown, as is the presence of early Holocene and terminal Pleistocene soil development or archaeology. Given the approximately 8,000 Cal BP date at GD-RCB-003 around 80 cmBS, if this interpretation holds true than it can be inferred that at least 3,000 years of loess deposition occurred at GD-RCB-002 beyond the reach of hand excavation tools. At all locations within the Gerstle Dunes portion of the GSDF, no reworking of the transverse dunes or parabolic dune development was apparent.

From this point forward dune building at the Gerstle River location likely did not occur due to the continual erosion presented by the further building of this escarpment. This being due to the fact sand particles likely would not have been easily mobilized above the top of the escarpment from the Gerstle River, whereas silt deposition from the river source itself at greater elevations would have occurred more easily.

In the Sawmill Creek area lower Ti/Zr ratios, lower Na values, lower particle sizes, and higher organic carbon values indicate that this portion of the GSDF remained stable with little disruption at the beginning of this time frame. However, sometime just after 8,000 Cal BP local events triggered the redistribution of sand within the western portion of the GSDF, including the Sawmill Creek and Bison Range areas, as indicated by higher Ti/Zr values, higher Na values, and a general increase in particle size from silts to fine to medium sands, and a decrease in organic carbon. This trend also corresponds with the development of the parabolic dune sets present morphologically on top of the already developed transverse sets. Evidence from micromorphology from the Sawmill Creek area and dating of soil residues from the same location suggest that a local reactivation of sediments occurred within what was probably the desiccated basin of the abandoned flood plain east of the escarpment present east of the Sawmill Creek dunes. Micromorphology suggests that by and large the majority of sand transported within the Sawmill Creek area was taken far from its source, likely first fluvially down one of the river or stream drainages from the Alaska range and then by wind into the dune formations. The rather large concentration of schistose lithic fragments in XMH-01409-01 suggests that at this time period something occurred causing more localized sediments to be activated.

The local schistose material present is therefore interpreted to have been eroded from the local glacio-fluvial sediments close by prior to the local abandonment of the older escarpment present on the eastern edge of the Sawmill Creek portion of the dune field. Then, moved westward during reformation of the original transverse dunes into parabolic sets. As sand from the newly destabilized transverse sets became exposed to a higher degree this more highly concentrated schistose sediment was then covered by the sediment with higher feldspar and quartz contents typical within most sedimentary layers of the dune field.

Based on the positioning of XMH-01408 (as well as XMH-00251) and the geomorphology around it, it is therefore inferred that the older carbon fraction, initially discussed in the radiocarbon section of Chapter 5, was deposited during 8,820 to 9,260 Cal BP (Beta-272817; 8120 +/- 50 BP) and in association with the development of the overlying parabolic dune sets in the Sawmill Creek area. As the morphology of these dunes suggests and over all wind direction sourcing from the east and moving west, the source of the more ancient carbon is inferred to have been located in the flood plain based to the east. Based on the timeline of the area provided by Reger et al. (2008) down cutting associated with the formation of the Gerstle-Clearwater escarpment did not likely occur until after the beginning of the Holocene. Therefore, prior to its inception, the escarpment that developed along the edge of the Sawmill Dunes likely functioned as the western most boundary of the Gerstle River drainage during the Pleistocene. After down cutting began occurring in association with the Gerstle-Clearwater scarp, the western portion of the old floodplain area was abandoned by fluvial activity and began to desiccate. At 8,820 to 9,260 Cal BP (Beta-272817; 8120 +/- 50 BP), wind direction shifts associated with the formation of the parabolic dune sets began moving sediments westward. With this sediment, older carbon from the flood plain was moved on top of the closest dune forms along the high points of the escarpment, thereby creating a situation where older carbon contamination occurs within the 8,820 to 9,260 Cal BP (Beta-272817; 8120 +/- 50 BP) time frame only near this area. This interpretation is corroborated by particle size analysis changes within the area and micromorphological data displaying the localized reactivation of highly friable schistose material that could only have been transported over a very short distance before totally weathering apart present at this site as well.

Localized parabolic reactivation appears to have occurred by transporting material through saltation from in between patches or the alluvially reworked areas around, between, and adjacent to dunes. As the parabolic reformation within the GSDF present slipfaces pointing westward, it can be inferred that an overall wind direction from the east to the west was occurring during this time frame.

These dramatic changes within the GSDF during this time frame likely also meant changes to animal habitation as well. With the introduction of localized forestation within the Gerstle Dunes portion of the GSDF it is possible that browsing parkland animals may have entered into the area, potentially away from the reactivated sand dune deposition occurring within the western portions of the GSDF. As the dune morphology within the western portion of the GSDF is parabolic in nature this means that anchors existed in order to lock in the horns of the dune formations, creating their particular shape (Bloom 1998). If grass or sedge vegetation existed in between dune areas, acting as the locking mechanism for the creation of local dune morphology it is possible that larger grazing animals may have been capable of using this portion of the GSDF to their advantage as well. Unfortunately the research design used in this thesis was not set up in such a ways as to capture data regarding this postulation and as such no evidence exist for or to the contrary regarding this theory with the exception of the overall dune morphology during this time.

#### 6.1.4 4,000 to 0 Cal BP

At 4,000 Cal BP the GSDF appears to restabilize into the landscape we are familiar with today. Lower Ti/Zr values, lower Na values, higher amounts of organic carbon, and lower particle sizes suggest that the modern boreal forest soil present now likely cover the totality of the GSDF by then. The lower soil pH toward more acidic in this time frame across the GSDF and at the Gerstle River site is indicative of the further homogenization of the landscape's ecosystem after 4,000 Cal BP and into the current boreal forest system we see today. These conditions remain consistent throughout the GSDF with possible exceptions occurring at the edge of the Gerstle River in the Gerstle Dune sections were soils were buried at the beginning of the time frame, possible related to localized forest fire activity or over active silt deposition causing rapid burial and competing with vegetative growth.

Within the Bison Range during this time frame we see a sequence of higher Na values, higher Ti/Zr values and increases in particle size, interrupted by the development of soils with larger woody charcoal debris and lower Na values from around 5,000 to 3,000 Cal BP and some larger woody debris dating to around only 1,000 Cal BP. These cycles in paleosol development and sand reactivation are likely tied to recurring fire events in this portion of the GSDF, breaking the local stability of the forests in the area, allowing for sands to redistribute through wind mobilization for short periods of time before new soils could develop and trap the sediments.

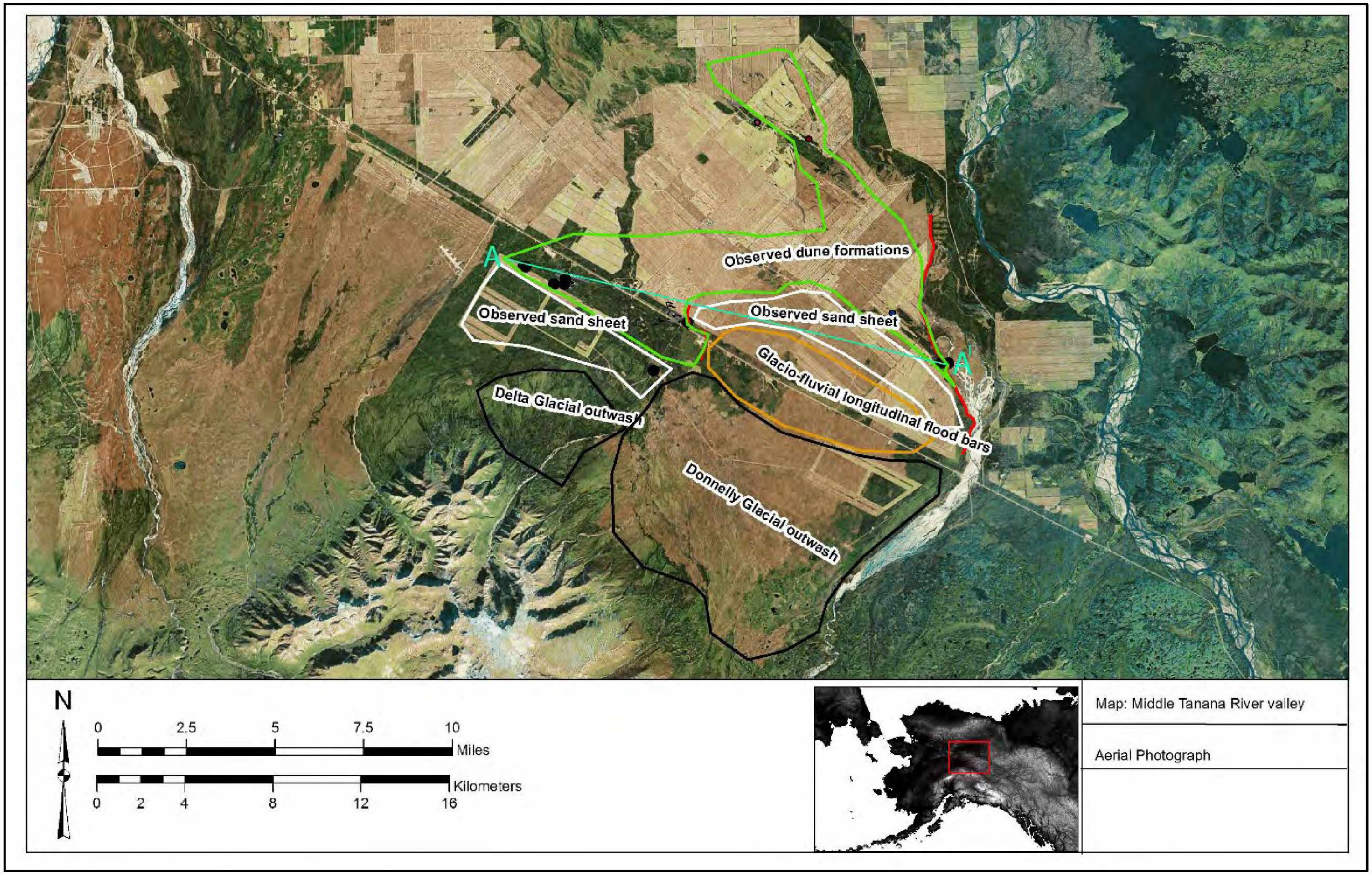


*Figure 6- 1.* Map showing cross-section area within GSDF.

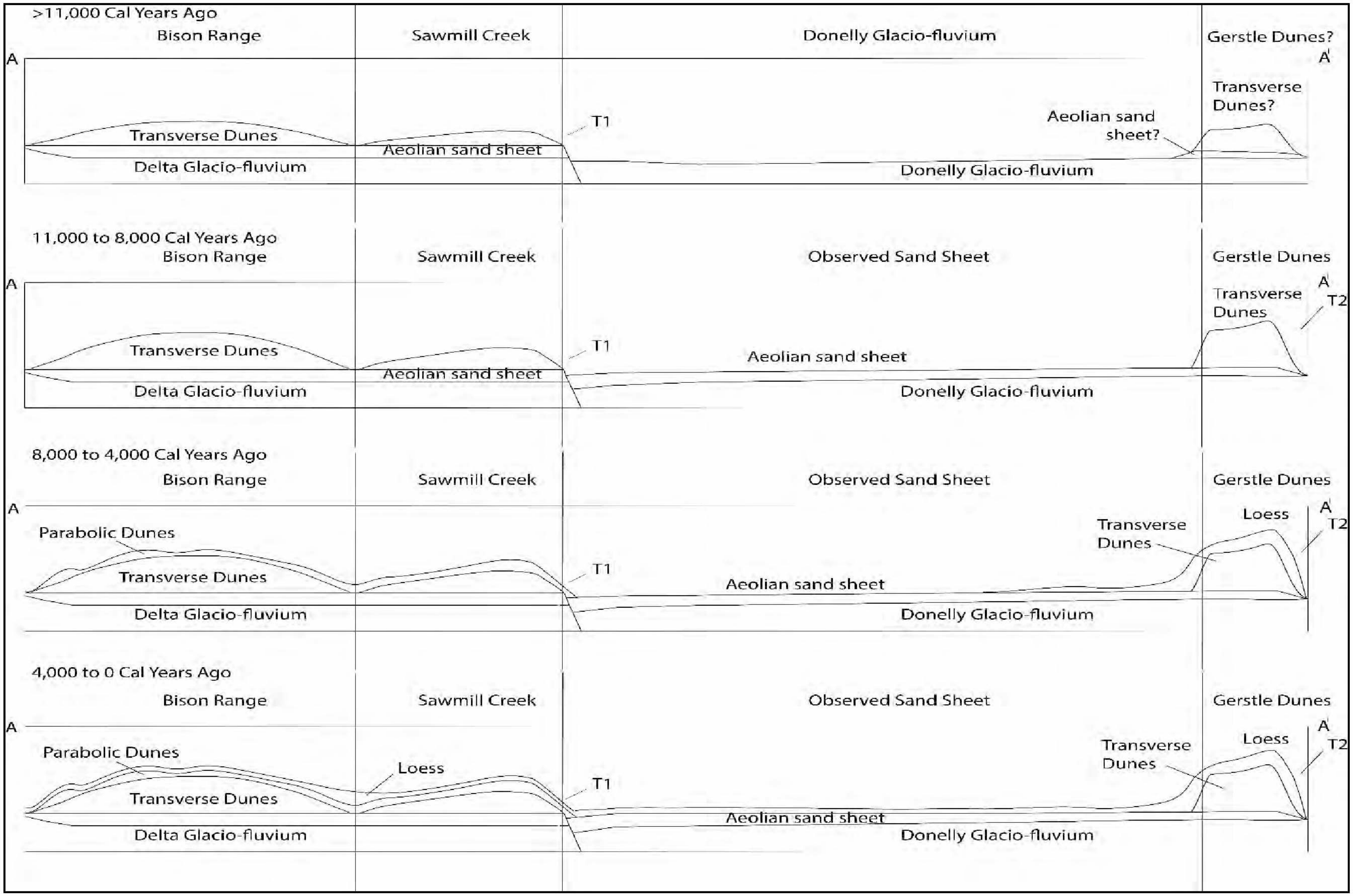


*Figure 6- 2.* Cross-section of sediment deposition through time within the GSDF.

## 6.2 Human Land Use Patterns

In this subsection archaeological results will be presented in the same time frames outlined above in the paleoecological subsection. Sites within the GSDF during each time frame will be compared overall with other sites excavated within the GSDF periphery, including the Gerstle River site, North Gerstle Point, the Healy Lake Village site, and the Linda's Point site. This is done in order to provide a broader degree in patterning of land use within and around the GSDF area, as it likely the GSDF itself, as with all other areas, only constitutes a portion of each time frame's occupational use, subsistence cycle, and mobility system. For, by piecing these portions of landscape usage together, an analysis of prehistoric human behavior as a whole is much more accessible.

The sites within the GSDF itself discovered during this project all likely are hunting stations as suggested by the variety and quantity as well as tool types of lithic material present at each. This interpretation is based on the quantity of lithic material at all sites in the GSDF (as presented in Table 5-11) with the exception of XMH-01520 based on suggestions presented by Binford (1979) and Nelson (1991). Both of these author suggest that low levels of lithic debitage should be present at hunting stations because of reduction likely occurred while waiting for game. XMH-01520 is also interpreted to be a hunting station based on the tool types present at the site. Based on Andrefsky's (1994) designations of formal and informal tool types and raw material use interpretations from Kuhn (1991) this site displays several formal biface fragments of local and non-local material with snap terminations (likely for hunting activities) in conjunction with informal (local raw material) expedient tools (likely for processing) (Appendix C). The concentrations present at XMH-01520 between formal and informal tools are similar in quantity and attribute to hunting stations and hunting station activities presented by Binford (1979), Hofman and Ingbar (1988), and Nelson (1991). These concentrations suggest that hunting activities likely took place in close proximity to the site, with initial processing or at least staging for processing likely occurring at XMH-01520 (Binford 1979; Nelson 1991). Keep in mind that that XMH-1520 also constitutes a likely palimpsest of multiple occupation layers. With this in mind it is entirely possible function at the site may have been different than presented here if separate occupational layers could be parsed out.

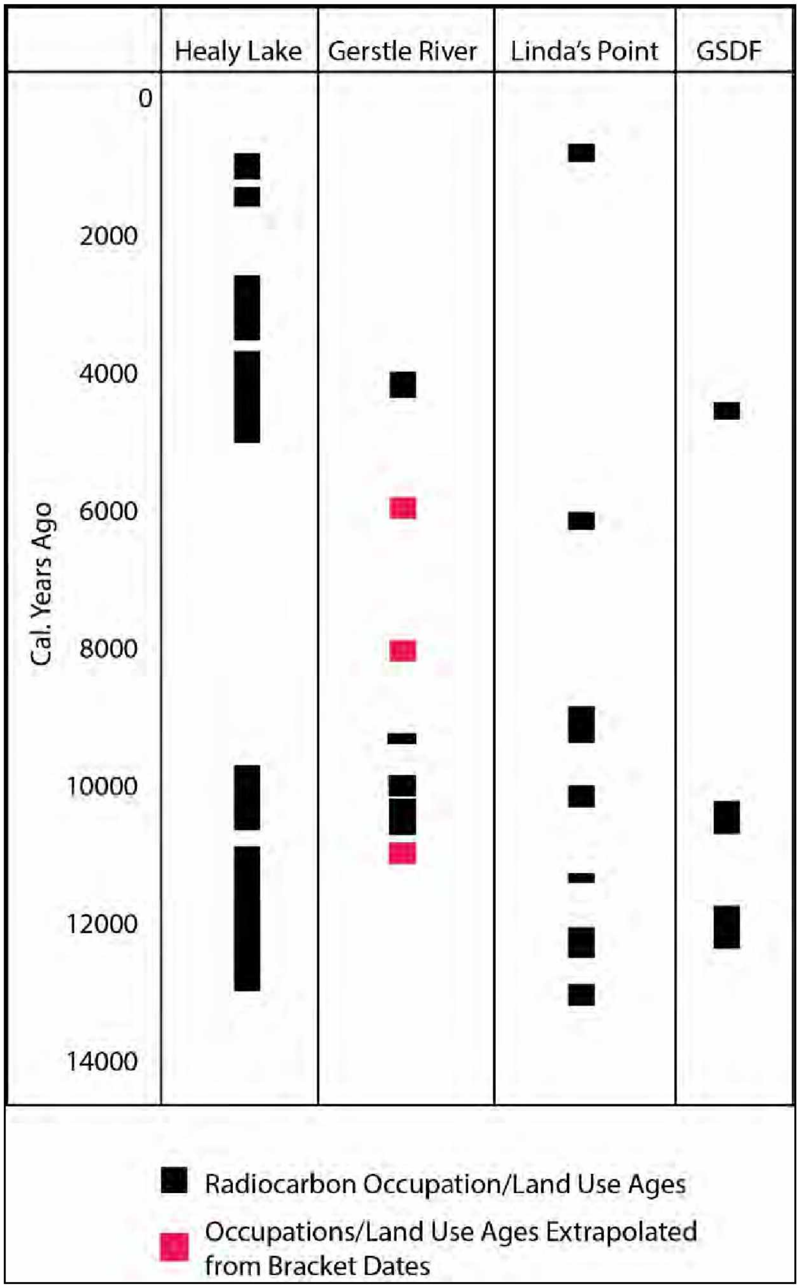


*Figure 6- 3.* Occupation across the GSDF and peripheral sites.

### 6.2.1 >12,000 Cal BP

The earliest levels of occupation occur within the Healy Lake basin at the Healy Lake village site and Linda's Point (Younie 2016). These sites have been interpreted to represent locations where residential activities were taking place or at least areas where more than simply hunting activities were occurring; (Cook 1969; Younie 2016). Radiocarbon dates from these sites are correlate to the 12365-11970 Cal BP (Beta-421547; 10290 +/- 40) date produced at XMH-01521 and Gerstle River site, Component 1 (Potter 2005). Based on the higher portion of non-local lithic material at the site, the low quantity of lithic material, its location with respect to other sites of its time frame, and the geomorphology of the landform on which it rests, XMH-01521 is interpreted to be a logistically operated hunting station (Binford 1980; Grove 2009; Hoffman and Ingbar 1988). Its function with proximity to the Healy Lake basin sites during this time frame potentially suggests that people using Healy Lake as a residential base likely operated within the GSDF, while early patches of vegetation were present and attracting larger mammals, such as wapiti or bison. General dietary breadth analysis provided in the Chapter 5 suggests that in times when resources such as migratory birds and fish were not present on the landscape, large mammal resources, such as bison and wapiti, would have constituted the most likely target for acquisition. The archaeological record at the Gerstle River site also indicates the acquisition of larger mammals inside the GSDF as a hunting area due to its proximity and occupation (Potter 2005).

The lack of a larger and more heavily dispersed number of sites within the GSDF at this time may be tied to many factors, sampling and taphonomy likely playing a significant role. Paleosols within this time frame are only patchily present; however, this likely suggests that large mammals were isolated to said grassy or shrubby patches and travel access areas between them. As this appears to be the case across the GSDF, hunting practices in the area could have consisted of a more direct approach where people may have been able to leave the residential base, examine a patch, acquire game, and return nearly directly to the residential base with less time spent inspecting the landscape engaging in costly searching enterprises.

Keep in mind that these occupations occur directly at the end of the instability of the GSDF area, when the area begins to reach a level of stability. As a result, these incipient movements are likely reflections of the beginning of the local ecological systems formation, general amelioration of wind intensity, and retention of moisture in the area, as stated in the previous subsection.

### 6.2.2 12,000 to 8,000 Cal BP

During this time period, human land use increases from earlier use, with occupation occurring at sites within the Sawmill Creek area and possibly XMH-01520 in the GSDF, North Gerstle Point, the Gerstle River site, and at least at Linda's Point in the Healy Lake Basin (Potter 2005; Vanderhoek et al. 1997; Younie 2016). As stated prior, this time frame constitutes a period of stabilization that had just began to occur at the end of the last time frame (about 12,000 Cal BP). If it can be assumed that Linda's Point still operates as a residential base location than it can be postulated that the Gerstle River site (a logistical spike camp [Potter 2005]) and North Gerstle Point (a postulated spike camp [Vanderhoek et al. 1997]) may have acted as in between locations where scouting and field processing tasks could have taken place closer to the GSDF resource extraction locality. It is also likely that XMH-01520 may have been occupied during the early Holocene, as this portion of the GSDF was likely stable during this time (Bowman 2016) and other sites, such as XMH-01521 and those located within the Sawmill Creek area, were being actively used by humans (Bowman 2015, 2016; Reuther 2010).

The use of this portion of the GSDF may be tied to the increased ubiquity of *Betula*, *Salix,* and *Populus* vegetative cover across the GSDF area. In effect, as the GSDF increased in stability and soil formation processes took hold over a larger spatial area, large mammal resources utilizing the GSDF may have become more abundant, leading to the need to have locations where game could be scouted prior to extraction and a location where secondary processing could take place before moving back to the residential base. Alternatively, as vegetation patches grew, met one another, and began covering the area more ubiquitously, game movements may have become more unpredictable due to the fractionalization of their habitat areas because of the homogenization of less optimal vegetation regimes to human prey (less chance of tracking using ground techniques and less chance of knowing which patch contained the most animals on the landscape), and the use of more highly elevated points on the landscape may have been necessary to locate resource movements. Either situation may lead to increased time and land use within the GSDF, as these results indicate.

At 12,000 Cal BP mammoth, horse, and siaga are gone from the middle Tanana River valley (Guthrie 1968a, 2006), however, continuing through this time frame, at a broader scale, there were no known shifts in overall availability of faunal resources in terms of local extirpation and changes in herd behavior. As such, it is assumed that overall prey choice and selection was not altered within the GSDF lowlands area. However, environmental shifts through time did occur in regard to stability and aridity between the Sawmill Creek area and Bison Range area within the fractionalized environments present. This trend points to a general shift from better conditions for faunal resource attractants, water, vegetation, being more abundant in earlier times in the Bison Range, then shifting, within the middle Holocene to better conditions in the Sawmill Creek area during the middle Holocene. Given this trend, it can be inferred, with all other things being equal, that faunal resource utilization of the landscape changed from one time frame to another. This shift then caused human behavior to alter along with it, changing the spaces used by people to acquire resources, but not the overall breadth of the human diet within the GSDF prehistoric use area pattern.

Due to the ephemerality of cultural material at the sites in the Sawmill Creek Area despite extensive testing the Sawmill Creek sites can be interpreted to represent short-term game observation stations, with differing levels of ephemerality based on the lithic materials recovered from each site and material abundance through time than that observed within the Bison Range area. These dunes may have in part been used for their height over the ancient courses of drainages present to the east prior to down cutting, or to scout game in interdunal areas where natural game confinement may have occurred.

### 6.2.3 8,000 to 4,000 Cal BP

At the beginning of this time frame a gap in habitation exists (between around 8,000 to 6,000 Cal BP) where almost no habitation been discovered within the GSDF or its immediate surrounding area (the Gerstle River site [Component 6] was occupied between 7,000 to 5,800 Cal BP and constitutes the only occupation during this period within the surrounding area [Potter 2005]). That is not to say that a hiatus occurred during this period, radiocarbon dated sites for this time period still exist, but are located within other portions of the middle Tanana River valley (Potter 2008a). This correlates with the reactivation of the GSDF sand dune features and the formation of parabolic dune features above the original transverse dune morphology. Based on the lack of occupation, the increase in wind intensity needed to cause reformation, and associated aridity it is likely that during this time frame the GSDF would have become less hospitable to large mammals and humans seeking to hunt them. Further, no occupation of residential bases exists within the area during this time frame. It is possible that a lack of ability for resource acquisition may have driven people to more productive and optimal resource areas, perhaps even to the point where the use of the Healy lake basin, as a residential base location, was no longer optimal.

Reoccupation of the GSDF peripheral zone appears to begin again around the 6,000 Cal BP mark with occupation occurring again at the Healy Lake Village site and Linda’s Point (Cook 1969; Younie 2016). North Gerstle Point (Vanderhoek et al. 1998) remains inactive until around 4,000 Cal BP, as does the GSDF. This suggests that abundance of other highly ranked resources, such as migratory birds or fish, may have functioned as an attractant for people back into the area, despite a continuing lack of large mammal resources, acquirable within the GSDF. Though large mammal resources may have been acquired in other portions of the landscape system such as within the Shaw Creek flats area.

This time frame also marks the introduction of the more geospatially broad Northern Archaic Tradition into the area along with the continued use of microblade technology (Esdale 2008; Potter 2008a, 2008b), including the use of notched bifaces as a new innovation of technology among other things. Another hypothesis for human land use during this time frame posits that use more upland areas for hunting animals which came into use during this time frame (Potter 2008a), suggested by the fact that Northern Archaic sites are common in upland settings as well as an increase in caribou fauna (Potter 2008a, 2008b). During the point in which the GSDF area became unstable and potentially less hospitable for desired faunal resources, an expansion into a more upland resource based economy may have curbed the need for its use as a primary resource acquisition locality, allowing for the mitigation of a potential disaster. As a result, a return to this portion of the Tanana River valley may not have been necessary until a portion of the area regained a certain level of stability.

### 6.2.4 4,000 to 0 Cal BP

During this time frame occupation continues at the Healy Lake Village site, Linda's Point appears to be abandoned up until approximately 500-600 Cal BP, and the North Gerstle Point site and Gerstle River site are reoccupied, (Cook 1969; Potter 2005; Vanderhoek et al. 1997; Younie 2016). Occupation within the GSDF also occurs at XMH-01520 as well as within the Sawmill Creek area. Pedologically, during this time frame the soils within the GSDF become more ubiquitous until they cover the GSDF becoming the boreal forest soil known today. During this time frame we can postulate that the GSDF and its surrounding area were again used as large mammal resource acquisition areas, at least until both species become extinct on the landscape. Equally, North Gerstle Point and the Gerstle River likely functioned as logistical spike camps and Healy Lake village as a residential base. Within the last 2,000 years of the record the GSDF appears to see no record of human land use until the historic period. This may be due to the loss of bison and wapiti (around approximately 2,000 Cal BP [Potter 2008a]) and the shift toward other resources (such as caribou, moose, and increased salmon use) associated with the Athabaskan tradition (McKennan 1959). Evidence still exists for the Healy Lake basin to have existed as a residential base during this final portion of this time frame (Cook 1969; Younie 2016), as it did into the historic period and does today (Cook 1989).

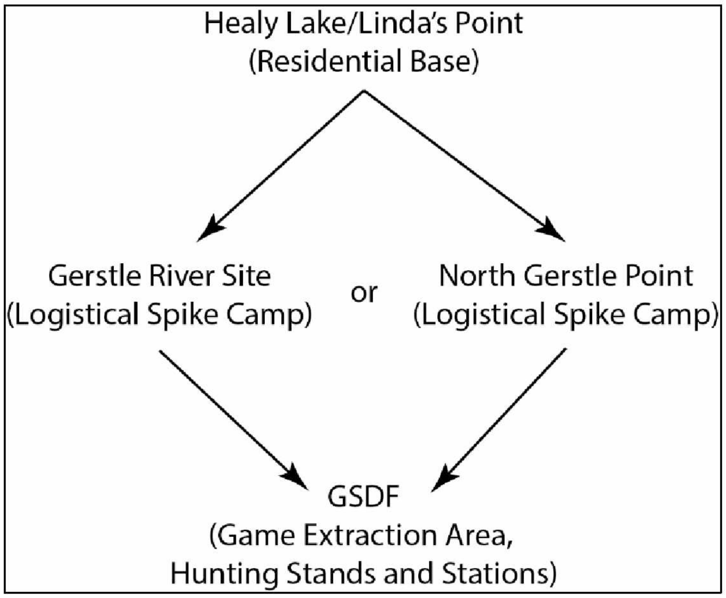


*Figure 6- 4.* Conceptual diagram displaying the GSDF's function during faunal resource acquisition.

## 6.3 Paleoecological Regional Summary

Past behavioral and ecological events and processes as reflected within the GSDF area represent only a small portion of the paleoecological system within the greater middle Tanana River valley region. That being said, the degree of environmental and ecological diversity within just this small portion of the overall region raises some concerns about the validity of the more basic subsistence and settlement regional models used today for ecological and human behavioral interpretations. One key difference in the area focused on in this study is that the GSDF represents a dry terrestrial valley lowland environment, whereas other archaeological and environmental studies in the middle Tanana River valley have been confined to either lakes and bogs or more highly elevated portions of the landscape. On an arid landscape, a lake is a departure from the normal conditions as it provides a source of moisture for the immediate area and a catchment for various particulates (Rapp and Hill 2006: 79). While it is likely that pollen from those surrounding areas and even long distances came to rest in lake sediments through time, it is not unsound to believe that the majority of pollen deposited in a basin cachement over time came from the ecological system directly surrounding it from close to it (Bigelow and Powers 2001; Rapp and Hill: 170-171). More highly elevated upland conditions also are not complete reflections of ecology across a landscape. More elevated areas are exposed to differing degrees of precipitation, solar radiation, sediment deposition, and many other factors that may cause different interpretations if used as a sole source for an ecological reconstruction. Since these two systems make up the majority of sources for paleoenvironmental and paleoecological reconstruction in the middle Tanana River valley area interpretations of the landscape on a regional level likely tend to reflect more elevated and lake basin portions of the landscapes ecology with little regard to the areas in between, such as riverine and dry terrestrial lowland environments. In order to mitigate these biases the data presented in this summary will compare and contrast what we already know from these previous studies of more highly elevated landforms and lake basins against the data presented for the GSDF, a terrestrial lowland valley basin, through time.

*Table 6- 1.* Local reference location for paleoecological regional summary.

| Locations | Depositional Environments | Proxies | Reference |
|---|---|---|---|
| Birch Lake | Lacusterine | Pollen | Ager 1975; Bigelow 1997 |
| George Lake | Lacusterine | Pollen | Ager 1975 |
| Jan Lake | Lacusterine | Pollen | Carlson and Finney 2004 |
| Dune lake | Lacusterine | Pollen | Bigelow 1997 |
| Windmill Lake | Lacusterine | Pollen | Bigelow 1997 |

*Table 6- 1. Continued*

| | | | |
|---|---|---|---|
| Gerstle River Site | Upland Terrestrial | Stratigraphic Record, Organic/Inorganic Carbon content, Particle Size | Potter 2005 |
| Rosa-Keystone Dunes, Shaw Creek Flats | Upland Terrestrial | Stratigraphic Record, Organic/Inorganic Carbon content, Particle Size | Reuther 2013 |

To begin, prior to the Holocene, it is generally agreed that conditions were more arid and ecosystems present at the time mirrored those of the tundra steppe with vegetation communities consisting of lower scrub brush (Ager 1975; Anderson 1975; Brubaker et al. 1983; Carlson and Finney 2004). Data from the more highly elevated portions of the landscape during this time frame suggests that deposition of sediments occurred at a quick enough rate to only allow for earlier successions of *Betula* and *Salix* vegetation (Reuther 2013), which would have been attractive to grazing animals capable of feeding on them. In more highly elevated portions of the landscape vegetation either existed to such an ephemeral degree that they were not preserved or may not have existed at all, potentially presenting denuded portions of the landscape (Potter 2005). In such a situation it can be said that vegetation and the animals that fed on them throughout the lake basin areas and more highly elevated areas existed in isolated areas or patches of concentration on the landscape, surrounded by areas where little to no vegetation occurred. Data from the GSDF is consistent with this argument, from roughly 25,000 to 13,000 Cal BP, no evidence exists to suggest that anything other than sand dune development was occurring in the GSDF area. However, from 13,000 to 10,000 Cal BP, patches of vegetation, as demonstrated by the presence of localized paleosols begin to occur in both the Bison Range and Sawmill Creek areas, at least one with data suggesting longer term stability, through the Younger Dryas period.

At the beginning of the Holocene paleoenvironmental data suggests an overall change in regional ecosystems. Ager's (1975) data from local lake basins near the GSDF area suggest that this was the point in time when coniferous forests become present on the landscape. This ecosystem intrusion is believed to have initially proceeded along river systems, becoming well established in the area at approximately 10,000-9,000 Cal BP (Ager 1975; Bigelow 1997; Bigelow and Powers 2001; Carlson and Finney 2004). In more upland areas spruce forests appear to have colonized in patches, competing with herbaceous tundra, shrubs, and deciduous forest (Reuther et al. 2015). Again, in the higher portions of the landscape like the Gerstle River site, denudation is present, but with periods of some soil development (Potter 2005). In the GSDF ecosystems are fractionalized. Soil development was wider spread within the Bison Range area with the development of a thick Bb horizon, while only patchy Ab horizon soil development was present in the Sawmill Creek area, and the Gerstle Dunes displayed active sand mobilization at this time.

Based on the lake record by approximately 8,500 to 7,000 Cal BP spruce appears to decline in favor of alder (Ager 1975; Carlson and Finney 2004). In more elevated areas to the west after 8,000 Cal BP the expansion of black spruce and peatlands appear to stabilize portions of the landscape (Reuther et al. 2015). At the more highly elevated Gerstle River site soil development appears to occur at 8,050-8,705 Cal BP, and then is denuded again until approximately 7,000 Cal BP (Potter 2005). In the GSDF ecosystems continued to be fractionalized, however the pattern changed somewhat. In the Gerstle Dunes, dune development stabilizes and soil development begins to occur. In the Sawmill Creek and Bison Range, dune reactivation occurs leading to the development of overlying parabolic dunes sets. This is followed by continued activation in the Bison Range, and stabilization through vegetative recolonization in the Sawmill Creek area, occurring from the 8,000 to 4,000 Cal BP time frame.

By 4,000 Cal BP lake records indicate that the vegetation present is representative of the modern vegetation present today, with many lakes throughout the middle Tanana River valley showing that this trend towards our modern vegetation beginning around 7,000 Cal BP (Ager 1975; Bigelow 1997; Carlson and Finney 2004). In the more highly elevated dune systems present in the Shaw Creek area, little change occurred after 8,000 Cal BP (Reuther et al. 2015), indicating that near modern conditions were in effect at the 4,000 Cal BP time point. At the Gerstle River site denudation occurs again around the 4,000 Cal BP time point, followed by the development of the modern forest soil present today (Potter 2005). In the GSDF, ubiquitous forest soil coverage was present with the exception of some denudation and loess coverage, followed by soil rebound at the edge of the Gerstle Dunes/Gerstle-Clearwater escarpment. The Bison Range also displays periodicity of sand reactivation and soil development at highly localized areas (TRA-01), likely tied with local forest fire activity (hypothesized based on the presence of larger, more intact fragments of charcoal for this time period and an overall lack of dateable pieces of charcoal and woody material from earlier soils within the area).

Given this data set it can be concluded that a wide variety of smaller, more localized ecological conditions were occurring throughout the middle Tanana River valley, especially at differing elevations. At the lowest points in the landscape, such as local lake basins, periods of stability are more commonly broken by ecosystem/vegetative community changes (Ager 1975; Bigelow 1997; Carlson and Finney 2004). In areas such as the GSDF, increases in aridity and moisture act as drivers to allow for ecosystem stabilization and rapid destabilization despite their lower elevations. The same can be said about the more highly elevated dune systems present in the Shaw Creek area, however the timing and history of dune development and change differs from that observed in the GSDF. In even more highly elevated locations such as the Gerstle River site, periodic soil development and denudation also fail to co-occur with development with the GSDF until after 4,000 Cal BP. Generally, it can be said then that sampling and analysis at one or even two of these locations, with respect to building a generalized ecological model for the middle Tanana River valley would not present a holistic picture of the area through time.

# Chapter 7 Conclusions

## 7.1 Site Locations within Period Ecosystems in the GSDF

The earliest sites dating between 12,000 and 10,000 Cal BP located within the GSDF are associated with periodic soil patches on the landscape. Due to a lack of cover and the existence on highly productive patches with fertile herbaceous and shrub vegetation soil areas on the landscape, where larger grazing mammals such as bison were likely more concentrated within the GSDF, knowledge of game movement and presence on the landscape would have been easier to obtain, even from outside the GSDF. Based on the limited sample of lithic material we have for sites in the Bison Range and the Sawmill Creek area, only limited amounts of cultural materials were left behind during forays into the GSDF. This indicates that hunters using the GSDF had a great deal of knowledge about the area before needing to enter it, allowing for surgical and precise acquisition of faunal resources within the area.

In the middle Holocene, around 4,000 Cal BP, when human presence occurs again on the GSDF landscape, a more ubiquitous gallery forest is present on the landscape. With this shift in ecosystems we also see a shift in landscape use to a heavier focus on the Sawmill Creek area (still with only limited amounts of lithic material present) and the only use of the Bison Range area during this time period at XMH-01520 (with higher degrees of lithic material abandoned at the site). Data presented in this thesis indicates that a shift in the local moisture regime occurred at this time, similar to those presented by Carlson and Finney (2004) around this time range and Bigelow (1997) approximately 1,000 to 2,000 years later, within the middle Tanana River valley, likely making the Sawmill Creek area moister and more ecologically productive. Thereby, creating a more productive or more attractive ecological patch for faunal resource extraction, as opposed to the surrounding uniform boreal forest ecosystem. Given the surrounding forest coverage during this time frame, it is likely that less knowledge of the landscape could have been acquired prior to entrance into the GSDF area, leading to less precise forays into the area, more intense use of stations with good viewsheds that increased the potential for capturing and processing prey within the GSDF (like XMH-01520), and more time spent depleting known productive patches, possibly containing a narrow variety of resources, such as those within the Sawmill Creek area (Jones 2009). These differences in patch use and resource extraction could also be a reflection of a group of new people (associated with Northern Archaic technology) using this area as well with differing levels of mobility and game acquisition technology (Janetski et al. 2012), or a loss of local area knowledge due to the lack of area use between this time period and the period of previous use. Northern Archaic tradition technology is present at XMH-01520 during this time period (notched bifaces and microblade technology). Whether the influx of Northern Archaic tradition constitutes a population replacement or the addition of new technology to the older technological suite, the lack of use of the GSDF from this period to prior likely would have been enough time to remove operational knowledge of the area from any group that may have used it before.

## 7.2 Ecological Patterns and Human Utilization

People using the GSDF were highly influenced by the dynamics of sand dune generation and soil stability in the area. As ecological systems changed, stability altered, and moisture regimes shifted, human landscape use patterns shifted with them. While at the Gerstle River site just to the east occupation of many components correlated with periods of little to no soil development (C2, C3, C4, and C5) (Potter 2005), in the GSDF, human land use always appears to correlate with landscape stabilization and soil development, whether in isolated soil patches or within more productive ecosystem patches within a more uniform forested area. This is in sharp contrast to human land use of dune systems within the Shaw Creek area, where more dynamic conditions appear to attract larger grazing and browsing animals that people extracted from that area (Reuther 2013).

Many reasons may exist for these differences including potential view sheds and extraction ability within the area, seasonality of each area's use, or even elevation of the area and ecosystem development associated with elevational changes. The Shaw Creek area and the GSDF are only 40 km apart, so it is likely that the same cultural groups occupied the area (technological continuity is prevalent between both areas for Denali and Chindadn tools [Potter 2005; Potter et al. 2013; Yesner 1996], as well as for the Northern Archaic tradition [Potter 2008a, 2008b], and for the late prehistoric Athabaskan tradition Upper Tanana as described by McKennan [1959] in recent prehistory). As stated in the introduction of this thesis there is no overarching prescribed cultural function given to dune fields through prehistoric time and it appears that only at a 40 km distance from one another dune landscapes were used quite differently, albeit in both systems, game acquisition practices appear to be taking place. Therefore, the function of each individual dune system must be a function of its specific ecological situation based on its local environmental characteristics and the subsystems present, ever changing within them.

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# APPENDIX A

## Micromorphological Analysis Results

*Table A- 1.* Micromorphological analysis for GSDF sample locations.

| Sample Number | Stratigraphic Position | Mineral Composition | Microstructure | Granularity | Voids | Pedological Features | Organic Structures |
|---|---|---|---|---|---|---|---|
| XMH1408-05 | 103-112cmbs; series of Ab Hoz, clay laminations, or lag deposits | Medium sand; Majority quartz approx 60%, Plag approx 40%; Fine sand; Majority quartz 60%, Plag approx 10%, schistose lithic frags approx 20%, Olivine approx 10%, very minor amounts of muscovite | subangular blocky | Fine to medium sand, approx equal in presence, fine sand sub-angular to angular, medium sand sub-rounded to sub-angular | Degraded root fragment penetration voids, regular minor vughs | none | root castings, minor charcoal fragments, soil fungus |
| XMH1408-01 | 83-92cmbs; Bwb Hoz | Medium sand; Majority quartz approx 60%, Plag approx 40%; Fine sand; Majority quartz 60%, Plag approx 10%, schistose lithic frags approx 20%, Olivine approx 10%, very minor amounts of muscovite | subangular blocky | Fine to medium sand, approx equal in presence, fine sand sub-angular to angular, medium sand sub-angular to angular | Degraded root fragment penetration voids | iron oxide quasicoating | minor amounts of iron oxide coating, root castings |
| XMH1408-02 | 68-77cmbs; Ab Hoz | Fine sand majority quartz and plag, approx 40/40/, Schistose lithic frags approx 20%, minor amounts of olivine | angular blocky | Fine sand, angular, minor subangular fragments | Degraded root fragment penetration voids | iron oxide hypocoating | root castings, minor charcoal fragments |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| XMH1408-03 | 51-60cmbs; Ab Hoz | Medium sand: Majority quartz approx 75%, Plag approx 20%; Fine Sand: Minor olivine approx 80%, Majority muscovite, Unknown red lithic frags | subangular blocky | Majority fine sand, some medium sand grains, Medium sand angular to subangular, Fine sand angular, No apparent organization | Degraded root fragment penetration voids | none | Minor amounts of iron oxide coating |
| XMH1408-04 | 54-63cmbs; Ab Hoz | Medium sand: Majority quartz approx 75%, Plag approx 20%; Fine Sand: Minor olivine, Majority muscovite approx 80%, Unknown red lithic frags | subangular blocky | Majority fine sand, some medium sand grains, Medium sand angular to subangular, Fine sand angular to subangular, No apparent organization | regular minor vughs | iron oxide hypocoating | minor amounts of iron oxide coating |
| XMH1408-08 | 15-24cmbs; Clay Lamellae | approx 50/50 quartz and plag | subangular blocky | fine sand, subangular to round, no apparent organization | regular minor vughs | iron oxide hypocoating | charcoal frags, soil fungus |
| XMH1408-06 | 14-23cmbs; Modern A/B Hoz | approx 50/50 quartz and plag, very minor amounts of olivine | subangular blocky | Majority fine sand, some medium sand grains, Medium sand angular to subangular, Fine sand angular to subangular, No apparent organization | regular minor vughs, degraded root fragments | iron oxide quasicoating below, hypocoating above | charcoal frags, soil fungus |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| XMH1408-07 | 9-13cmbs; Modern A/B Hoz | approx 50/50 quartz and plag, very minor amounts of olivine and red lithic fragments | subangular blocky | Majority fine sand, some medium sand grains, Medium sand angular to subangular, Fine sand angular to subangular, No apparent organization | regular minor vughs, degraded root fragments | iron oxide quasicoating below, hypocoating above | root castings, charcoal frags, soil fungus, minor amounts of iron oxide coating on individual grains |
| XMH-1409-01 | 81-90cmbs; Ab Hoz | medium sand; majority quartz approx 60%, plag approx 40%, fine sand majority schistose lithic fragments approx 85%, 15% approx equal amounts quartz and plag, minor red lithic frags and olivine | angular/subangular blocky | majority fine sand, some medium grains, medium sand subangular to subround, fine sand angular and elongate by majority | irregular vughs common | iron oxide hypocoating irregular and discontinuous | iron oxide coatings predominately around schistose lithic frags, soil fungus, |
| XMH-1409-02 | 69-78cmbs; Ab Hoz | fine sand majority schistose lithic fragments approx 85%, 15% approx equal amounts quartz and plag, minor red lithic frags and olivine | angular blocky | fine sand, subangular to angular | regular minor vughs | iron oxide hypocoating irregular and discontinuous | root castings, charcoal frags, soil fungus, minor amounts of iron oxide coating on individual grains |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| XMH-1409-03 | 60-69cmbs; Ab Hoz lamination | Fine sand majority approx 80% muscovite and 20% plag, minority olivine; Medium sand grains majority quartz, minor plag | subangular blocky | Fine to medium sand, approx equal in presence, Fine sand angular, Medium sand angular to subangular | minor vughs present but uncommon | iron oxide hypocoating irregular and discontinuous | Minor charcoal fragments, minor degrees of iron oxide coating, lighter dendritic coating pattern present in one location |
| XMH-1409-04 | 35-49cmbs; Bwb Hoz | medium sand majority plag approx 75%, approx 25% quartz, minor amounts muscovite and olivine | subangular blocky | fine to medium sand, majority fine sand, medium sand angular to subangular, fine sand angulare to subangular | minor vughs present but uncommon | iron oxide hypocoating regular and continuous | root castings, charcoal frags, iron oxide coatings, soil fungus |
| XMH-1409-05 | 19-28cmbs; B and Bt Hoz, cultural layer | medium sand majority plag approx 75%, approx 25% quartz, minor amounts muscovite, very minor but large lithic fragments of schistose bedrock material | subangular blocky | medium and fine sand present, medium sand angular to subangular, fine sand majority angular, some subangular frags | irregular vughs common | root pentration, iron oxide quasicoating and minor hypocoating | root castings, soil fungus, iron oxide coating on individual grains, minor charcoal fragments |

## APPENDIX B

### WDXRF Analysis Results

*Table B- 2.* GSDF Elemental concentrations and ratios in percent weight.

| Depth | Ti | Al | P | Na | K | Ca | Ba | Mn | Mg | Zr | Ti/Zr | Sr/Na | Description | Sample # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -10 | 0.5062 | 9.7608 | 0.101 | 0.7238 | 2.3248 | 0.7098 | 0.0564 | 0.0404 | 0.8345 | 0.0202 | 25.05941 | 0.015888 | A | 50 |
| -27 | 0.5511 | 10.0527 | 0.0541 | 0.8646 | 2.2196 | 0.6857 | 0.0657 | 0.0512 | 0.8469 | 0.0323 | 17.06192 | 0.016077 | B | 49 |
| -35 | 0.3329 | 6.2648 | 0.0487 | 0.9724 | 1.8085 | 0.6155 | 0.0406 | 0.022 | 0.6931 | 0.0118 | 28.21186 | 0.010181 | B/C | 48 |
| -40 | 0.3613 | 7.0906 | 0.0514 | 0.9808 | 1.5701 | 0.6891 | 0.0408 | 0.042 | 0.8013 | 0.0149 | 24.24832 | 0.013051 | C | 45 |
| -50 | 0.4853 | 9.3031 | 0.0497 | 0.9629 | 2.1706 | 0.8038 | 0.0612 | 0.0524 | 1.0628 | 0.0239 | 20.30544 | 0.01537 | Bb | 44 |
| -55 | 0.3528 | 6.0944 | 0.0405 | 1.0389 | 1.6561 | 0.7572 | 0.0405 | 0.0355 | 0.7361 | 0.0128 | 27.5625 | 0.010973 | C2 | 43 |
| -70 | 0.25 | 4.2356 | 0.0578 | 1.0802 | 1.286 | 0.7484 | 0.028 | 0.0288 | 0.4715 | 0.0086 | 29.06977 | 0.010924 | C3 | 30 |
| -100 | 0.1954 | 3.9897 | 0.0498 | 1.0611 | 1.3639 | 0.7671 | 0.0394 | 0.0297 | 0.414 | 0.0083 | 23.54217 | 0.011026 | C4 | 41 |
| 0 | 0.4558 | 7.4583 | 0.1277 | 0.9429 | 1.9728 | 1.18 | 0.0482 | 0.0373 | 0.8617 | 0.0159 | 28.66667 | 0.012515 | O/AB | 7 |
| -48 | 0.2423 | 4.8709 | 0.0555 | 0.9393 | 1.3896 | 0.6601 | 0.0343 | 0.0368 | 0.4706 | 0.0075 | 32.30667 | 0.01022 | Ab/Bb | 4 |
| -50 | 0.314 | 6.3271 | 0.0637 | 0.9514 | 1.7556 | 0.7472 | 0.0409 | 0.041 | 0.5975 | 0.0124 | 25.32258 | 0.010616 | Ab/Bb | 11 |
| -60 | 0.4294 | 8.4298 | 0.1028 | 0.7471 | 1.7503 | 0.6907 | 0.0479 | 0.0567 | 0.7602 | 0.0147 | 29.21088 | 0.014322 | Bwb | 12 |
| -80 | 0.2712 | 5.3895 | 0.0503 | 0.9803 | 1.4348 | 0.6014 | 0.0384 | 0.024 | 0.5957 | 0.0095 | 28.54737 | 0.008467 | C2 | 13 |
| -10 | 0.5118 | 9.7633 | 0.0505 | 0.8759 | 2.3545 | 0.9991 | 0.0573 | 0.0398 | 0.986 | 0.0235 | 21.77872 | 0.015527 | A | 63 |
| -25 | 0.5038 | 10.0595 | 0.0478 | 0.8791 | 2.514 | 0.7238 | 0.0768 | 0.0439 | 1.0666 | 0.0216 | 23.32407 | 0.013423 | B | 62 |
| -38 | 0.2452 | 5.368 | 0.0326 | 0.8737 | 1.4783 | 0.5163 | 0.035 | 0.0305 | 0.5983 | 0.009 | 27.24444 | 0.0095 | B/C | 61 |
| -45 | 0.2785 | 5.0523 | 0.0444 | 0.9872 | 1.5177 | 0.5913 | 0.0337 | 0.028 | 0.603 | 0.0097 | 28.71134 | 0.00861 | Bwb | 60 |
| -100 | 0.1901 | 4.2388 | 0.0395 | 0.9456 | 1.3794 | 0.4731 | 0.0292 | 0.0303 | 0.5216 | 0.0075 | 25.34667 | 0.009518 | C2 | 58 |
| -3 | 0.555 | 10.0307 | 0.0613 | 0.8115 | 2.51 | 0.7941 | 0.0651 | 0.0399 | 0.9956 | 0.0276 | 20.1087 | 0.015157 | A/B | 6 |
| -10 | 0.4733 | 8.1602 | 0.1139 | 0.7574 | 2.0214 | 0.8238 | 0.0423 | 0.0485 | 0 | 0.0169 | 28.00592 | 0.01624 | B | 5 |
| -28 | 0.4926 | 8.7869 | 0.0812 | 0.9367 | 2.2119 | 0.9176 | 0.048 | 0.0412 | 1.0753 | 0.0196 | 25.13265 | 0.025622 | B/C | 2 |
| -35 | 0.4847 | 9.2141 | 0.0715 | 0.8488 | 2.371 | 0.8132 | 0.0616 | 0.0543 | 1.0484 | 0.0226 | 21.4469 | 0.015198 | C/Bwb | 15 |
| -40 | 0.5239 | 8.3684 | 0.0825 | 0.8665 | 2.0698 | 0.9115 | 0.0455 | 0.053 | 1.0022 | 0.0182 | 28.78571 | 0.015695 | Bwb | 3 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -65 | 0.4447 | 7.145 | 0.0586 | 0.9567 | 1.87 | 1.0201 | 0.0395 | 0.0466 | 0.8876 | 0.0163 | 27.28221 | 0.012125 | C2 | 1 |
| -100 | 0.2968 | 4.4119 | 0.056 | 1.0006 | 1.2453 | 0.7188 | 0.0324 | 0.0357 | 0.5554 | 0.0087 | 34.11494 | 0.009494 | C3 | 14 |
| -2 | 0.4835 | 7.7106 | 0.1003 | 1.0842 | 2.294 | 2.6783 | 0.0691 | 0.0851 | 1.1832 | 0.0264 | 18.31439 | 0.021583 | A | 25 |
| -37 | 0.526 | 8.3701 | 0.0703 | 1.2957 | 2.0017 | 2.5204 | 0.0576 | 0.0689 | 1.2211 | 0.0219 | 24.01826 | 0.019217 | A/B | 24 |
| -48 | 0.5066 | 8.9332 | 0.0775 | 1.0741 | 2.6655 | 1.7274 | 0.0708 | 0.0534 | 1.1643 | 0.0249 | 20.34538 | 0.019179 | B | 23 |
| -63 | 0.497 | 8.1811 | 0.0955 | 1.3106 | 2.1269 | 2.4308 | 0.0556 | 0.0633 | 1.3006 | 0.0214 | 23.2243 | 0.017626 | C | 21 |
| -70 | 0.5071 | 8.2457 | 0.1036 | 1.2494 | 2.1931 | 2.7514 | 0.0623 | 0.0907 | 1.2509 | 0.0217 | 23.36866 | 0.018249 | Ab | 20 |
| -78 | 0.5023 | 8.6202 | 0.0864 | 1.1552 | 2.214 | 2.2081 | 0.065 | 0.0681 | 1.2363 | 0.024 | 20.92917 | 0.019823 | C2 | 19 |
| -88 | 0.5035 | 8.723 | 0.0873 | 1.135 | 2.2217 | 2.141 | 0.062 | 0.0671 | 1.228 | 0.0237 | 21.24473 | 0.020705 | Bwb | 18 |
| -100 | 0.5146 | 9.2501 | 0.0741 | 0.9743 | 2.5343 | 1.6561 | 0.0742 | 0.0588 | 1.2391 | 0.0258 | 19.94574 | 0.020117 | C3 | 36 |
| -4 | 0.5246 | 8.4709 | 0.0837 | 1.1839 | 2.0834 | 2.4761 | 0.0472 | 0.0551 | 1.1839 | 0.024 | 21.85833 | 0.021708 | A | 38 |
| -40 | 0.5389 | 8.6141 | 0.0869 | 1.201 | 2.1268 | 2.5651 | 0.0591 | 0.0687 | 1.2654 | 0.025 | 21.556 | 0.019817 | B | 37 |
| -76 | 0.5157 | 9.3725 | 0.0592 | 0.8549 | 2.6469 | 1.4413 | 0.0844 | 0.0667 | 1.2288 | 0.0247 | 20.87854 | 0.019651 | C | 32 |
| -85 | 0.5007 | 9.0873 | 0.0711 | 0.8345 | 2.8698 | 1.6165 | 0.0736 | 0.0604 | 1.1716 | 0.0244 | 20.52049 | 0.018933 | Bwb | 29 |
| -90 | 0.4825 | 8.701 | 0.0667 | 0.8837 | 2.6775 | 1.3657 | 0.0536 | 0.0535 | 1.1631 | 0.0172 | 28.05233 | 0.015956 | C2 | 10 |
| -100 | 0.3918 | 5.9764 | 0.0626 | 1.137 | 1.5425 | 1.3396 | 0.0422 | 0.0532 | 0.9792 | 0.0124 | 31.59677 | 0.013017 | C3 | 27 |
| -20 | 0.5025 | 8.8574 | 0.0901 | 0.8313 | 3.1781 | 0.8911 | 0.0608 | 0.0629 | 0.9669 | 0.0361 | 13.91967 | 0.014556 | Y1 | A2 |
| -40 | 0.5061 | 8.8469 | 0.0989 | 0.8387 | 3.1017 | 1.9102 | 0.0795 | 0.0844 | 1.0806 | 0.0316 | 16.01582 | 0.021581 | R2 (Bwb) | A3 |
| -65 | 0.4891 | 9.1684 | 0.1138 | 0.7253 | 2.5686 | 1.68 | 0.0693 | 0.0591 | 0.9954 | 0.0386 | 12.67098 | 0.018889 | Y2 | A4 |
| -66 | 0.5084 | 9.6586 | 0.0768 | 0.7588 | 3.7958 | 1.2376 | 0.0765 | 0.058 | 1.0201 | 0.0361 | 14.0831 | 0.015287 | R3a | A5 |
| -68 | 0.5033 | 9.475 | 0.0822 | 0.6866 | 3.7239 | 1.5537 | 0.0844 | 0.0669 | 1.0829 | 0.0362 | 13.90331 | 0.019516 | R3b | A7 |
| -75 | 0.4602 | 9.5124 | 0.076 | 0.6758 | 3.8874 | 1.7496 | 0.0818 | 0.0706 | 1.0012 | 0.0363 | 12.67769 | 0.021456 | Y3a | A8 |
| -80 | 0.4921 | 9.5899 | 0.0972 | 0.7638 | 3.8061 | 1.4246 | 0.0859 | 0.0716 | 1.0539 | 0.0371 | 13.26415 | 0.018068 | Y3b | A9 |
| -95 | 0.4856 | 10.439 | 0.0807 | 0.6263 | 4.166 | 0.8992 | 0.0992 | 0.0603 | 1.0912 | 0.0348 | 13.95402 | 0.019 | R4 | A10 |
| -125 | 0.5001 | 10.811 | 0.0848 | 0.6599 | 4.3589 | 0.5424 | 0.0959 | 0.0727 | 1.073 | 0.0367 | 13.6267 | 0.017124 | Y4a (C4?) | A11 |
| -130 | 0.5015 | 11.106 | 0.0693 | 0.6885 | 4.4928 | 0.6391 | 0.1 | 0.0669 | 1.1171 | 0.0333 | 15.06006 | 0.013943 | R5 | A12 |
| -140 | 0.5413 | 9.9824 | 0.0797 | 0.7019 | 3.9443 | 0.4952 | 0.0916 | 0.0627 | 0 | 0.324 | 1.670679 | 0.013392 | Y4b (C5?) | A13 |
| -142 | 0.3843 | 9.2301 | 0.063 | 0.7855 | 3.7338 | 0.3383 | 0.084 | 0.0527 | 0.9107 | 0.0199 | 19.31156 | 0.009421 | S5c | A14 |
| -144 | 0.357 | 7.2011 | 0.0707 | 0.7988 | 2.74 | 0.3101 | 0.0374 | 0.0473 | 0.7137 | 0.0179 | 19.94413 | 0.008262 | S5b | A15 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -148 | 0.3879 | 5.9465 | 0.055 | 0.7803 | 1.87 | 0.256 | 0.0296 | 0.0466 | 0.5819 | 0.0166 | 23.36747 | 0.007946 | S5a (sandy loess) | A16 |
| -150 | 0.438 | 8.1527 | 0.079 | 0.7806 | 3.0135 | 0.3545 | 0.0441 | 0.0617 | 0.7709 | 0.0234 | 18.71795 | 0.009608 | S5a | A17 |
| -155 | 0.5126 | 10.5314 | 0.0768 | 0.7464 | 4.0961 | 0.4641 | 0.0754 | 0.0546 | 1.0123 | 0.0379 | 13.52507 | 0.013532 | Y5a | A18 |
| -160 | 0.518 | 9.756 | 0.0921 | 0.8199 | 3.5788 | 1.1871 | 0.0796 | 0.0882 | 1.1001 | 0.0319 | 16.23824 | 0.018783 | P1 | P1 |
| -163 | 0.4399 | 7.2361 | 0.0891 | 0.7993 | 2.479 | 1.6392 | 0.0455 | 0.0622 | ,8585 | 0.0234 | 18.79915 | 0.014513 | yellowish brown sand (top) | A19 |
| -280 | 0.4399 | 7.2361 | 0.0891 | 0.7993 | 2.479 | 1.6392 | 0.0455 | 0.0622 | 0.8585 | 0.0234 | 18.79915 | 0.014513 | yellowish brown sand (bottom) | A19 |
| -290 | 0.3711 | 6.0902 | 0.0751 | 0.9283 | 2.0615 | 1.1922 | 0.0258 | 0.0538 | 0.6637 | 0.0175 | 21.20571 | 0.008618 | lighter coarser yellowish brown sand | A20 |
| -300 | 0.3332 | 5.9439 | 0.0619 | 1.1479 | 1.8713 | 1.449 | 0.0384 | 0.0546 | 0.9196 | 0.0139 | 23.97122 | 0.011935 | | A21 |
| -320 | 0.269 | 5.2121 | 0.0626 | 1.1018 | 1.6293 | 1.3525 | 0.0335 | 0.04 | 0.8103 | 0.013 | 20.69231 | 0.011799 | lighter coarser dark brown sand | A22 |
| -340 | 0.3818 | 5.6995 | 0.0791 | 1.4708 | 1.1425 | 2.7575 | 0.0439 | 0.0543 | 1.0944 | 0.0148 | 25.7973 | 0.021213 | gray sand | A23 |
| -370 | 0.3371 | 6.6117 | 0.0796 | 1.9011 | 1.3533 | 2.7132 | 0.0525 | 0.0536 | 1.0858 | 0.0134 | 25.15672 | 0.013255 | gray sand with ventafacts | A24 |
| | | | | | | | | | | | | | | |
| | Na | | | | | Ti/Zr | | | | | | | | |
| Trend Line Average | 0.9231 | | | | Trend Line Average | 21.7877 | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Range for Wetter | 0-0.9231 |  |  |  | Range for more Stable | 0-21.7877 |  |  |  |  |  |  |  |  |
| Range for Drier | 0.9231-2 |  |  |  | Range For more Dynamic | 21.7877-35 |  |  |  |  |  |  |  |  |

# APPENDIX C

## Descriptive Analysis of Tools, Technology, and Equipment Types from XMH-01520

### *Flake Tools*

GSDF-15-07 is made from a very dark grayish brown (10YR 3/2) chert and measures 30.97 mm in maximum size, 7.43 mm in maximum thickness, and 2.51 g in weight. Based on this tools morphology it is potentially a bifacial thinning flake struck off of a biface near a retouched notch. Flake scars are present on right edge ventral side. Retouch is present inside the notched edge (left edge), snap terminations are present on proximal and right edge. This tool was likely polished by sand abrasion as indicated by abrasion scars and polish on both sides.

GSDF-15-08 is a short axis beveled flake uniface that typologically matches end scraper forms found throughout Alaska (Powers 1983). This tool is made from black (Gley1 2/N) chert and measures 25.56 mm in maximum size, 7.57 mm in maximum thickness, and weighs 5.78 g. This tool was made from a single flake and displays steep retouch along its distal margin.

GSDF-15-09 is an end scraper made from dark gray chert with greenish gray speckles (Gley1 4/N with Gley1 6/10Y specks). It measures 28.22 mm in maximum size, 4.1 mm in maximum thickness, and 1.94 g in weight. This tool was made from a single flake and displays steep retouch along its distal margin.

GSDF-15-15 is a uniface made from dark greenish gray chert (Gley 1 4/10Y). It measures 76.72 mm in maximum size, 16.37 mm in maximum thickness, and 55.79 g in weight. This tool is unifacially worked with regular and continuous retouch along the distal edge. Flake scars on the dorsal side display feather terminations regularly.

*Bifaces*

GSDF-15-10 is a yellow (10YR 7/6) rhyolite biface measuring 33.75 mm in maximum size, 19.52 mm in maximum width, 8 mm in maximum thickness, and weighs 4.16 g. This tool is triangular in outline and is snapped on its far end. The base is beveled to a point and convex in form with no other modification.

GSDF-15-11 is a very pale brown (10YR 8/3) rhyolite biface. It measures 101.59 mm in maximum length, 52.54 mm in maximum width, 20.33 mm in maximum thickness, and weighs 104.64 g. It is complete in condition and lunate in outline. This biface is crudely constructed and likely represents an expedient tool, most retouch scars end in snap terminations and flaking is irregular and semi-continuous.

GSDF-15-13 is a very dark gray (Gley 1 3/N) chert biface. It measures 26.36 mm in maximum dimension, 16.02 mm in maximum width, 3.67 mm in maximum thickness, and 1.55 g in weight. It is rectangular in outline and displays semi-regular and continuous retouch on one edge. On the opposite edge steeper retouch is semi-regular and continuous and snapped on either side of those. Possible burination is present at one point, facial modification displays irregularly flaking.

GSDF-15-16 is an obsidian biface and measures 37.21 mm in maximum dimension, 18.91 mm in maximum width, 6.7 mm in maximum thickness, and weighs 4.99 g. It is tear-drop shaped in outline and displays regular continuous flaking on all sides. Morphologically it is similar in size shape and form to chindadn points found in the area (Cook 1969) and likely functioned as a knife or projectile point based (Holmes 2001). It is thickest at base before tapering to a point, facial modification is irregular, arrises are abraded, likely by aeolian sand, and is lenticular in cross section. A small portion of the tip of the tool is missing.

GSDF-15-17 is a very dark gray (5R 3/1) basalt biface with a purplish hue. It measures 40.15 mm in maximum dimension, 18.31 mm in maximum width, 8.63 mm in maximum thickness, and 5.89 g in weight. It is stretched hexagonal shape in outline, trapezoidal in cross-section. Flaking is semi-regular continuous on all edges, possible remnants of platform are present on one side. This tool likely originated as a bifacial thinning flake based on its morphology.

GSDF-15-18 is a biface made from greenish gray (Gley 1 5/10Y) basalt. It measures 129.59 mm in maximum dimension, 74.2 mm in maximum width, 46.58 mm in maximum thickness, and 121.23 g in weight. It is triangular in outline and appears to be made from a fractured cobble, worked with large flake scars into a rough chopper.

### *Mircoblades*

GSDF-15-05 is a microblade or possible facet rejuvenation flake made from black (Gley 1 2.5/N) chert. It measures 26.99 mm in maximum size dimension, 2.86 mm in maximum thickness, and .27 g in weight. This microblade is complete with a clear overshot termination and what appears to be dorsal trimming on distal edge. It is likely that this microblade was never used and potentially may have been struck off of a core in order to create a fresh surface for making new microblades.

GSDF-15-12 is a medial microblade fragment made from dark greenish gray Gley 1 4/10GY) chert. It measures 16.44 mm in maximum size dimension, 1.33 mm in maximum thickness, and .09 g in weight. This tool is trapezoidal in axis and was likely snapped for use. However, no retouch or usewear is present on any edge.

### *Previously Recovered Tools for XMH-01520*

Previously recovered tools from XMH-01520 include basal fragments from three bifaces (Figure 5-38, Figure 5-39, and Figure 5-40). Two of these bifaces are bipointed in form and made from black chert (Figure 5-38), while one is basally ground and only slightly convex along its basal edge (made from very dark gray chert) (Figure 5-40). The other tool recovered from XMH-01520 is a notched biface with a missing tip (Figure 5-39). This tool is made from black chert and is asymmetrical.