ABSENT ICE PATCHES AND THE CONTINUED RELIABILITY OF CARIBOU AS A RESOURCE TO PREHISTORIC HUNTERS THROUHOUT THE HOLOCENE

By

Holly Lynn Koszalinski

Submitted to the Faculty of

The Archaeological Studies Program
Department of Sociology and Archaeology

in partial fulfillment of the requirements for the degree of
Bachelor of Science

University of Wisconsin-La Crosse

2011

ABSENT ICE PATCHES AND THE CONTINUED RELIABILITY OF CARIBOU AS A RESOURCE TO PREHISTORIC HUNTERS THROUGHOUT THE HOLOCENE

Holly Lynn Koszalinski, B.S.

University of Wisconsin-La Crosse, 2011

Ice patches have recently exploded as a new field of research in archaeology and as a vital source to understanding prehistory. The uniqueness of ice patch archaeology lies within the preservation of organic materials offering exceptional information about cultural behavior. Ice patches were traditionally used as hunting locations throughout prehistoric and protohistoric times. With rapidly changing climate conditions, ice patches are melting quickly and in some cases surface ice has completely melted away leaving behind the accumulation of caribou dung. In the 2010 field season, the Basalt Lake ice patches within the Denali Highway region of central Alaska were surveyed and it was observed that caribou still frequented the area even in the absence of surface ice. This paper will examine the significance of continual use of ice patch areas by caribou in the absence of surface ice and what this meant for prehistoric hunters throughout the Holocene during greater climatic shifts.

ACKNOWLEDGEMENTS

I would like to extend the utmost gratitude to Dr. Richard VanderHoek and Randolph M. Tedor for making my volunteer position with the State of Alaska Office of History and Archaeology possible. Without this position and their guidance, this thesis would not have been possible. I would like to especially thank Randolph M. Tedor for all of his support, assistance and guidance throughout my research and writing.

I would like to thank the University of Wisconsin-La Crosse faculty, especially Dr. Joseph Tiffany for his input and commitment as my reader and Dr. David Anderson for all the work he does and for challenging me throughout my academic career at the University of Wisconsin-La Crosse. Also, I would like to thank my peer editors Roberta Vickroy and Jeremiah Clay.

Last but not least, I would like to acknowledge and thank my family for all of their unwavering support throughout my pursuit of archaeology even though it takes me far away for long periods of time; they have been by my side for every step of the way.

INTRODUCTION

As a relatively new area of study in the field of archaeology, ice patches have been a fantastic source of well preserved organic artifacts and an important source of information on the resources available for prehistoric hunters because of the variety of species that sought them out. Canadian researchers coined the well known term "ice patches" as a way to describe perpetual patches of snow and ice which differ from glaciers; but these ice patches are also well known as *aniuvat* to the Inuit communities (VanderHoek et al. 2007a). Ice patches were first noted in 1997 when a Canadian biologist, while sheep hunting in the southern Yukon Territory, noticed caribou dung embedded on a permanent ice patch. This caught his attention because there were no longer caribou herds using the area. Within the month researchers went out to investigate this area and discovered a wooden shaft with sinew twisted around one end. This shaft turned out to be a portion of an atlatl dart and now over 240 artifacts have been recovered from ice patches in northwestern North America (VanderHoek et al. 2007a).

In their most basic form, ice patches are an accumulation of snow that builds up in the winter months in alpine locations. Many times, especially in shaded areas, the snow drifts will develop an ice core that persists through the summer months until snow can accumulate again beginning in the fall (VanderHoek et al. 2007a).

Ice patches have been a valuable resource for animals and humans alike. Many large mammals, like caribou, have sought out the refuge of ice patches for a variety of reasons including relief from heat and insects in the hot summer months. Hunters were able to rely on these areas to carry out ambushes on caribou and evidence collected through archaeological data illustrates hunting was unmistakable along the ice patches. Locations of ice patches are subject to the environment and climate of the area, however ecologically they become part of seasonal movements for caribou and resource rich areas for prehistoric and protohistoric peoples.

Climatology, biology, ecology and archaeology are just some of the important fields that have combined to gain a deeper interdisciplinary understanding of the ice patches. Changing climates have impacted the ice patches and with their melting, new data can be accumulated if recovered in time. It is through the melting of the ice patches that we can create a clearer picture of the past and the important role the ice patches and the ice patch areas had on the relationship between the people and the animals prehistorically. This study will aim at establishing a relationship between prehistoric hunters and caribou in the areas ice patches are located, regardless of the presence of surface ice, and ice patch conditions throughout various climatic changes. Through this establishment, it will be clear that the presence or absence of surface ice is not pertinent to the reliability of the availability of caribou as a resource.

BACKGROUND

Ice Patches

Ice patch archaeology is a relatively new field of study. Ice patches are present all over the world and require certain climatic and geological conditions to form. Ice patches develop in alpine locations usually along north-facing slopes. Winter snowfall and drifting snow that accumulates during the winter months melts and compacts during the warmer summer months creating ice cores (Farnell et al. 2004), and these areas of accumulation are identified to be in hollows and depressions (Dixon et al. 2005). An example of this can be seen in Figure 1. The ice cores maintain existence throughout the summer and accumulate more snow the following winter. This process is what creates the ice patches. According to Dixon et al. (2005), ice patches tend to form along the boundaries of plateaus and are commonly seen along other comparable flat and treeless landforms. Ice patches have similar characteristics to glaciers; however, they differ in that ice patches do not develop enough mass to flow (Farnell et al. 2004).

Figure 1. Basalt Lake ice patch 2 containing surface ice surrounded by caribou dung (personal photograph).

According to Lewis (1939 *as cited in* VanderHoek et al. 2007a:68), there are three different morphological classes of ice patches that reflect the processes of snow deposition and the underlying topography of the area. The first of these classes are transverse ice patches (see Figure 2) which are characteristically recognized by "their major axis running perpendicular to the line of drainage. These slab-like patches generally run parallel to the tops of plateaus or ridges, reflecting the wind deposition of snow on lee slopes." The second class is referred to as longitudinal. These ice patches are commonly found with an orientation downslope within gullies (see Figure 3). The last morphological class of ice patches is circular ice patches. The name is indicative of its main characteristic and these ice patches are thought to be the initial formation of cirque glaciers (VanderHoek et al. 2007a:68).

Figure 2. Basalt Lake ice patch 1 is an example of a transverse ice patch (VanderHoek et al. 2007a:71 fig. 3).

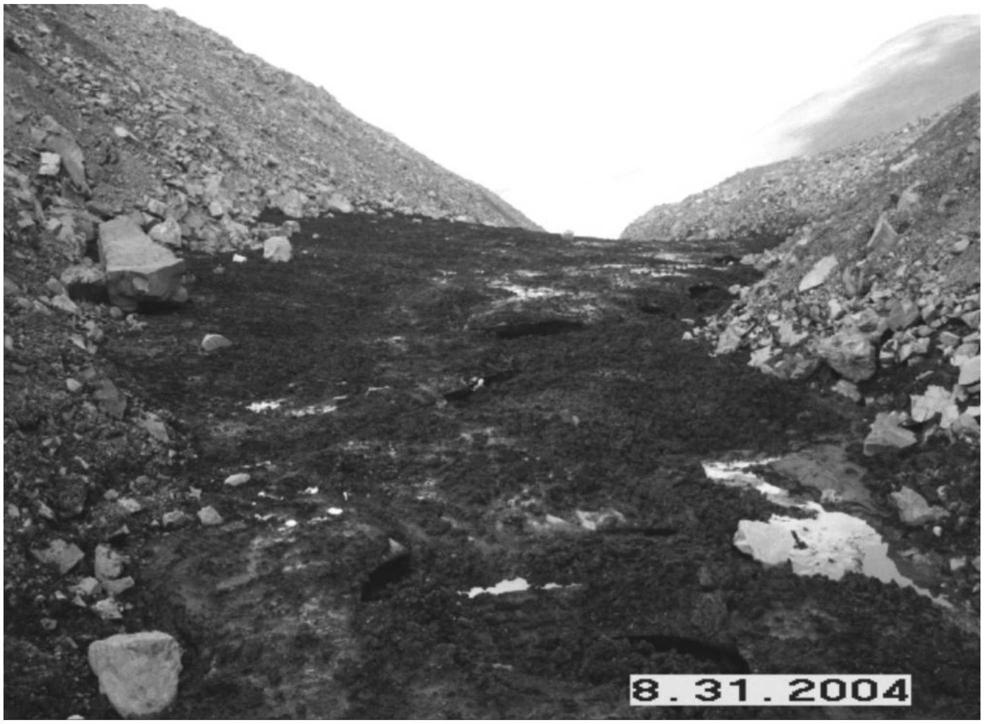

Figure 3. Delta River ice patch 4 is an example of a longitudinal ice patch (VanderHoek et al. 2007a:80 fig. 9).

As ice patches melt, they have a distinct brown color surrounding them (see Figure 4); this is an accumulation of dung from caribou and other mammals that use the ice patches (Dixon et al. 2005). In relation to being surrounded by dung, some ice patches are also surrounded by bare rock (this, on occasion, includes the lack of dung as well). A few different terms have been coined to refer to these zones of bare rock. Farnell et al. (2004:252) refers to this condition as the "lichen-free zone" and this zone "marks the extent of perennial snow and ice cover that prevented lichen growth and is the proxy for the larger size of the ice patches at the end of the Little Ice Age." The bare rock zone has also been called "blonde patches" or "fossil patches." VanderHoek et al. (2007a:68) uses the term fossil ice patch to describe the areas in which the ice patches have completely melted away, whereas lichen-free zones are the bare areas surrounding an ice patch that has had a recent size reduction.

Figure 4. Photograph of an ablation zone showing ice surrounded by caribou dung (personal photograph).

Farnell et al. (2004) states that ice patches have a fairly distinct black and white layering that can be seen from a far distance; this is usually one of the more obvious characteristics and is the layering of clean ice with layers of heavy organic material containing mostly caribou dung, but also windblown detritus and sometimes animal remains.

For ice patches to exist, they need to have a balance between snow accumulation and summer ablation (melting). This basically means the winter accumulation of snow needs to, at the very least, equal the amount of snow that is lost to ablation in the summer. This requires a variety of different factors to be in place including, plenty of winter snowfall, the deposition of windblown snow upon the ice patches and the persistence of ice patches throughout the warm summer months. Ice patches do not require solely areas of high snowfall annually to develop, but can also form in catchment basins within areas of intermediate and even low snowfall (VanderHoek 2007a).

The Earth's land surface has a significant amount of permafrost and ice coverage and these areas were originally thought to be undesirable places for people and animals alike due to their relatively remote locations and presumed low biological productivity (Dixon et al. 2005). It is now clear that ice patches serve different purposes for a variety of species.

Caribou Use of Ice Patches

As stated above, ice patches are often seen with distinct layers of caribou dung. This dung is the result of thousands of years of accumulation by persistent caribou use. Caribou (*Rangifer tarandus)* seek out the ice patches during the summer months to escape the heat and insects. They also use the ice patches as a means of thermal regulation (Farnell et al. 2004). They achieve thermal regulation by standing and lying on the snow or eating the snow on the surface (VanderHoek et al. 2007a).

Mosquitoes and black flies are two of the insects that are a nuisance to caribou herds however, according to Skoog (1968), two different species of bot fly are an exceptionally large pest. Bot flies negatively affect herd vivacity and strength. The large numbers of flies that harass the caribou herds causes a high level of distress and distracts the herds. The caribou become stationary on the hills and the ice patches, reluctant to leave any insect relief and people have been noted to approach these herds while the caribou carry on as if they were not there due to their level of distraction. The summer months of dense insect populations are referred to as "fly-season pause." It was stated that "during the height of fly-numbers the caribou spend most of the daylight hours huddled closely together on windswept areas and/or glaciers and lingering snow-drifts" (Skoog 1968:451).

Ice patches can be used casually or on a more long term basis. Long term use of ice patches is more dependent upon its location in relation to summer herd movements of caribou and the ice patch's persistence on the landscape (Farnell et al. 2004). Casual ice patch use can occur in a variety of situations including the separation of individuals for calving, avoidance of predators and forage selection, while Farnell et al. (2004:249) suggests "that 'traditional' ice patch use could be a learned behavior, similar to caribou use of specific mineral licks."

Part of the seasonal movement of caribou involves moving into the high country in the summer months. There is a variety of vegetation available for caribou and in early summer months, willow, dwarf birch, grasses and sedges are all part of the caribou diet and the late summer diet consists mainly of sedges (VanderHoek et al. 2007a). A combination of seasonal movement, heat and insect relief, and available dietary resources attract caribou to the ice patches and this also became a prime location for prehistoric hunters to find valuable resources themselves.

The Archaeology of Ice Patches

Since ice patch archaeology made its debut in 1997, ice patches all over the world have been monitored closely for artifacts. Ice patches are such a vital resource for prehistoric archaeology because organic artifacts are preserved extremely well. According to Dixon et al. (2005:130), "frozen environments have produced some of the most complete examples of prehistoric human remains and artifacts ever discovered." Frozen organic remains have a unique ability to provide a vast amount of data and they can be analyzed in a variety of different ways including radiometric dating and isotopic analysis. Artifacts are discovered on ice patches through survey of ablation zones. Within ablation zones, melting exceeds the amount of snow that accumulated in the winter. This provides areas that were previously covered with ice and snow to be exposed, and this is where artifacts are found. Archaeologists conduct surveys in summer months for the best chance at peak ablation. According to Dixon et al. (2005), ice patches with negative mass balance refers to ice patches having greater ablation than accumulation and ice patches in this condition for one year or more have the greatest potential for surface artifact recovery. If artifacts remain exposed for too long, they risk quick decomposition or damage by animals.

Glacial archaeology has well known finds like the “Ice Man” in the Tyrolean Alps, however ice patches were not considered for archaeological sites until the 1997 discovery of a 4,000-year old portion of an atlatl dart in the southern Yukon Territory (Kuzyk et al. 1999 *as cited in* Farnell et al. 2004:248). As the caribou use the ice patches for relief from heat and insects in the summer, prehistoric hunters used the ice patches as reliable places to hunt and ambush caribou. Hunters were able to predictably use the ice patches and take advantage of the caribou that sought them out as well. Transverse ice patches offered a unique ambush setting and prehistoric hunters could get fairly close to caribou before being detected because of their location right under hilltops and ridges; this provided concealment for hunters. Being aware of diurnal wind shifts allowed hunters to stalk caribou from hilltops and come down right on top of them before being seen or smelled and furthermore, VanderHoek et al. (2007a) states most of the Basalt Lake ice patch artifacts were found near the upper edges of ridges, supporting this hypothesis. According to Hare et al. (2004), the ice itself may have been advantageous as a means to preserve the meat from kills upon the ice patches. Ice patches are currently believed to be specialized hunting areas based upon the existing archaeological data. There is no evidence for domestic artifacts, habitation structures or shelters, or caches “that suggests hunters or their families stayed overnight or for extended periods in the high alpine area” (Hare et al. 2004:262).

Since the portion of atlatl dart was discovered in 1997, over 240 artifacts have been discovered on ice patches all across northwestern North America (VanderHoek et al. 2007a). An investigation in the southern Yukon revealed six different bird species identified from twelve feather fragments including falcon, duck, northern flicker, short-eared owl, white-tailed ptarmigan and gray plumaged gyrfalcon. Feathers were traditionally used as fletching for arrows and darts (Dove et al. 2005).

University of Colorado at Boulder Research Associate Craig Lee discovered a dart made of birch sapling that dates to 10,000 years old. This dart was discovered on an ice patch within the Rocky Mountains close to Yellowstone National Park (Bell 2010).

Alaska and Western Canada have produced remarkable artifacts from ice patches. Some artifacts include portions of darts and arrow shafts, projectile points (Figure 5), barbed antler points (Figure 6), feather fletching (Figure 7), and a gopher stick (Figure 8). The gopher stick was originally thought to be a possible atlatl however it appeared to be much younger than atlatl use in the Yukon (VanderHoek et al. 2007b). After further investigations, the conclusion that the instrument was a gopher stick came from ethnographic data and was similar to implements used by Tutchone women for ground squirrel snares (Beattie et al. 2000 *as cited in* VanderHoek et al. 2007b).

Figure 5. Stone projectile points and wooden shaft from Basalt Lake ice patch 4 (VanderHoek et al. 2007b:191 fig. 6).

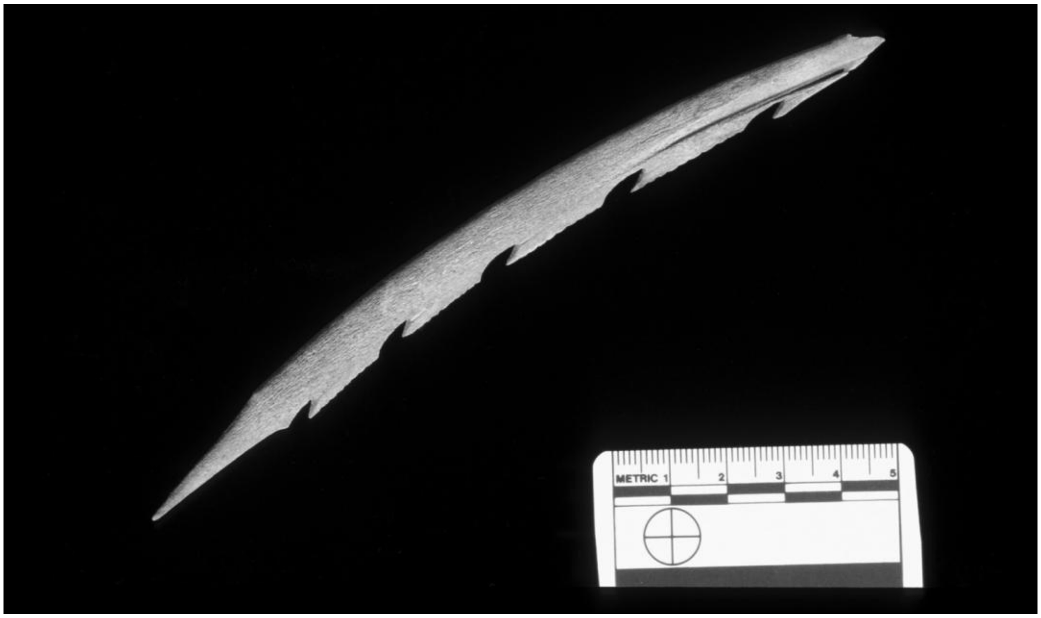

Figure 6. Barbed antler point from Basalt Lake ice patch 1 (VanderHoek et al. 2007b:189 fig. 3).

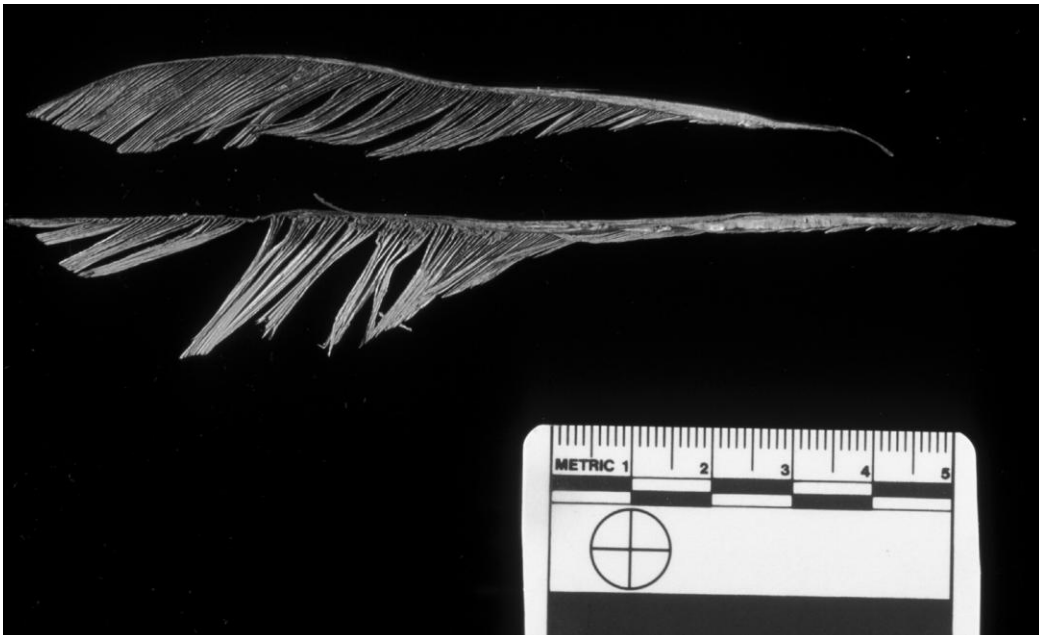

Figure 7. Feather fletching associated with an arrow shaft from Basalt Lake ice patch 1 (VanderHoek et al. 2007b:189 fig. 4).

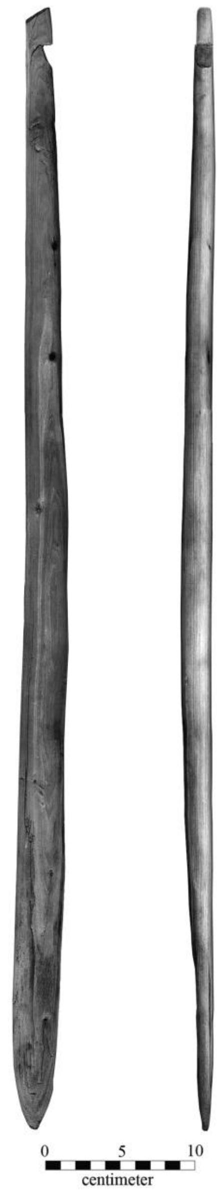

Figure 8. Possible gopher stick (VanderHoek et al. 2007b:193 fig. 7).

In 2005, an artifact was discovered in the University of Alaska Museum of the North rather than in the field, by James W. Whitney. Whitney came across a barbed antler arrow point that had an arrow tip rather than a groove for end blade insertion. According to museum records, this antler point was discovered in 1957 on the edge of a “snowfield” (James W. Whitney 2005, written communication *as cited in* VanderHoek et al. 2007b:195). It is very interesting that it would take another 40 years for the next (documented the first) ice patch discovery to be made.

Southwest Yukon ice patches have had many archaeological investigations as well. Many stone projectile points have been uncovered each with great variability such as "stemmed, unstemmed and side-notched types and ranging from lanceolate to leaf-shaped in outline," Figure 9 below exemplifies the variability (Hare et al. 2004:264).

Figure 9. Sample of stone projectile points collected on Yukon ice patches (Hare et al. 2004:265 fig. 6).

A complete dart shaft containing an open socket at the distal end that is designed to fit with a spatulate-stemmed antler projectile point was found among the Yukon ice patches, and this artifact offers valuable information because it radiocarbon dates to 1260 $\pm$ 60 uncalibrated B.P. (see Figure 10). According to Hare et al. (2004:266), "This dart shaft represents the latest appearance of throwing-dart technology and apparently heralds the transition from stone to bone/antler projectiles and the wholesale adoption of bow-and-arrow technology."

Figure 10. Open socket hafting with sinew on the throwing dart (Hare et al. 2004:265 fig. 4).

Because of the variety of hunting technology coming out the ice patches, artifacts from the Yukon have been used to establish a chronology for atlatl technology and bow-and-arrow technology. Hare et al. (2004), states that there is no significant overlap between the two technologies in southern Yukon. The oldest definitive evidence for bow-and-arrow technology is a fragmented maple bow radiocarbon dating 1300 $\pm$ 60 B.P. (uncalibrated) while the most recent evidence for atlatl technology is the dart shaft dating 1260 $\pm$ 60 B.P. (uncalibrated). This puts the shifting period between atlatl and bow-and-arrow technology around 1200 B.P. (Hare et al. 2004:270).

According to Dixon et al. (2005:137), barbed antler projectile points found in Wrangell-St. Elias National Park in Alaska were similar to those found in southern Yukon, but "date about 200-300 radiocarbon years older than the earliest evidence for the introduction of the bow-and-arrow in southern Yukon." Other artifacts include open socket designs with green staining on the shafts suggesting the use of native copper nuggets. Wooden arrow shafts have also been collected along with sinew lashing and atlatl technology noted by two dart shafts collected. Red ochre has been represented in trace amounts on a stone projectile point as well. One of the more unique ice patch discoveries was a 650-year-old half of a shallow birch bark basket. According to Dixon et al. (2005:138) this is a unique artifact because “it suggests that activities other than hunting may be associated with the use of some *aniuvat* [ice patches].” However, the majority of archaeological finds associated with ice patches are related to hunting. Also, because ice patches have the unique ability to preserve organic remains so pristinely, artifacts can look more recent than they appear. It is for this reason that Dixon et al. (2005) suggests the importance of dating everything possible. Ice patches contribute to archaeological data prehistorically and historically; they also contain large amounts of faunal and other organic remains useful for paleo-environmental reconstruction. Ice patches contain an abundance of information across a spectrum of multiple disciplines.

METHODOLOGY

The methodology used in data collection relies greatly on the 2010 pedestrian survey of the Basalt Lake ice patches (BLIPs) located in the Denali Highway region of central Alaska (see Figures 11 and 12).

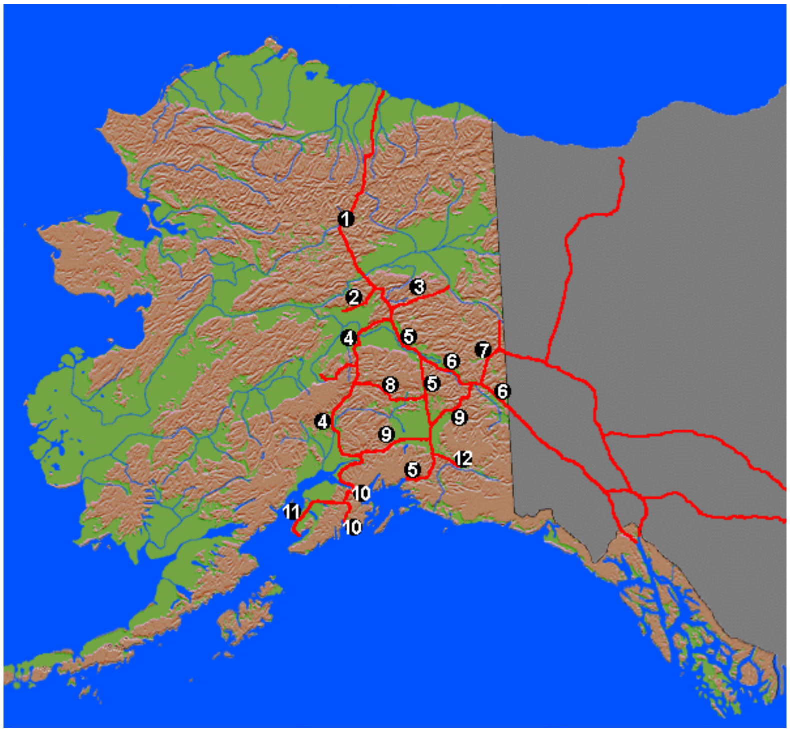

Figure 11. Map of Alaska highways, Highway 8 is the Denali Highway in central Alaska (Gates 2010).

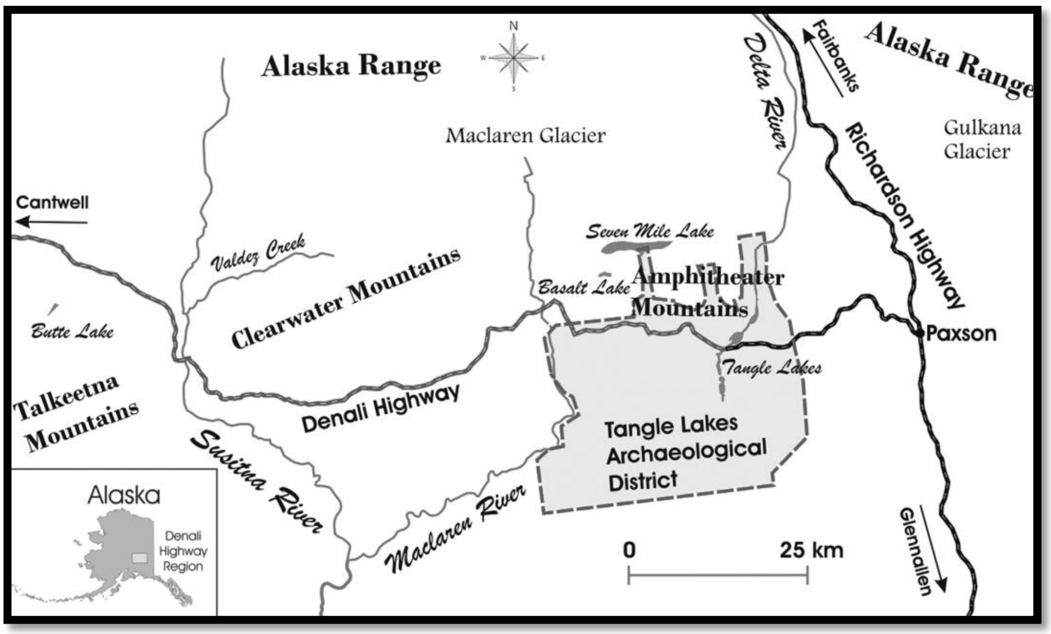

Figure 12. Close up of Denali Highway region, Amphitheater Mountains contain the Basalt Lake ice patches (VanderHoek et al. 2007a:68 fig. 1).

As a volunteer with the State of Alaska's Department of Natural Resources Office of History and Archaeology (OHA), I was able to assist OHA personnel with survey and data collection in this region. The ice patch surveys were done on August 19, 2010. A total of four ice patches were surveyed (BLIP 1 through BLIP 4) by an OHA archaeologist, Randolph Tedor, and myself. Each ice patch area was meticulously examined by surveying up and down each slope across the entirety of the ice patch's known location. Caribou dung was the border for each survey, whether ice was present on the surface or not. Figure 13 shows an aerial photograph of the western Amphitheater Mountains and the locations of each of the BLIPs.

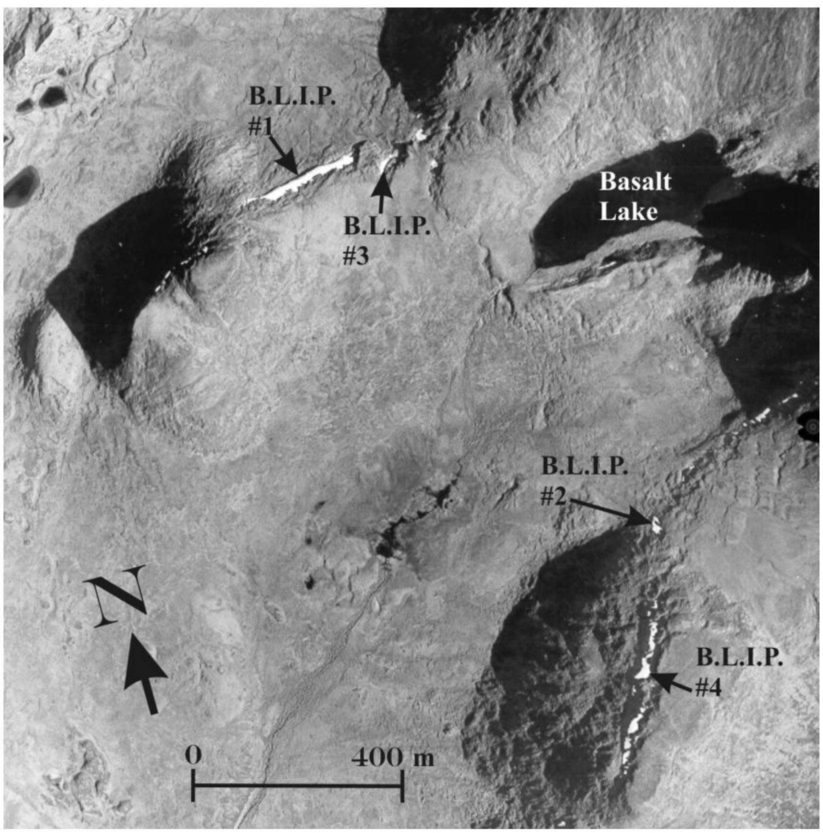

Figure 13. Photograph of western Amphitheater Mountains including Basalt Lake ice patches (VanderHoek et al. 2007a:69 fig. 2).

Beyond pedestrian survey, numerous amounts of multidisciplinary data were collected. A geological and geographical understanding of ice patch formation areas assisted with a basic understanding of ice patches' presence along with acquiring knowledge of other resource potentials in their areas. Furthermore, research in climate data was essential for understanding ice patch conditions. Climate data was examined throughout the Holocene in relation to warming and cooling periods in the Gulf of Alaska region and contemporary climate data was gathered as a comparison for understanding current conditions of ice patches.

In addition to climate research, knowledge of caribou behavioral biology was also important in relation to their use of ice patches. Research pertaining to caribou behavior was examined to gain a deeper understanding of, specifically, their summer habits. Understanding the importance of ice patches to caribou was the key to understanding the significance of ice patches to prehistoric hunters. Background research in ice patch archaeological data gave significant insight into prehistoric usage and reliance on ice patches. Also, a small amount of ethnographic information was accumulated, which guided more information on human usage of ice patches and the significance of caribou to people.

Using all of the information gathered from multiple disciplines and a variety of academic sources along with the pedestrian survey, an interpretation was compiled of ice patch conditions presently and throughout the Holocene. Along with the interpretation of conditions, the data was used to establish relationships between prehistoric hunters and caribou.

RESULTS

HOLOCENE CLIMATE THROUGHOUT THE GULF OF ALASKA

It is well known that climatic shifts have been a natural part of Earth's history. However, through the conducted research there appears to be some difference in opinion as to the relative condition of ice patches throughout the Holocene. Looking at ice patch data from southern Yukon, Farnell et al. (2004) suggests that radiocarbon dates from dung below the Granger ice patch and the vegetation beneath it, put its formation around 8300 to 8000 years B.P. (uncalibrated). It is suggested that these ice patches had continuous formation except for an interval of time between 6730 and 4780 years B.P. leaving a period of 1950 years during the Holocene where there was no net accumulation of ice. Farnell et al. (2004) suggests that this does not support ice reduction, only a lack of accumulation or condensed ice from rapid melting. However, it should be clearly noted that different regions contain different geological settings and therefore different ice patch characteristics. For example, the southern Yukon ice patches studied were mostly located between 1,550 and 2,075 meters above sea level, about 60^{o} to 61^{o} North latitude and were usually found in cirques or nivation hollows; they also range from 10 to 80 meters in height, which makes them relatively thick ice patches. The Wrangell Mountain ice patches are found at about 1,675 meters in elevation and about 61^{o} to 62^{o} North latitude (VanderHoek et al. 2007a). It was noted that in the northern Alaska peninsula, ice patches were observed as low as 400 meters in elevation and about 59^{o} North in latitude (Dale Vinson 2005, personal communication *as cited in* VanderHoek et al. 2007a:77). Higher latitude ice patches can exist under the circumstances of large enough catchment basins and relatively short melt seasons. Ice patches along Alaska's North Slope have been found to exist at 150 to 200 meters in elevation. The Basalt Lake ice patches are found at about 1,340 and 1,400 meters in elevation and approximately 63^{o} North latitude (VanderHoek et al. 2007a:77).

The differences in the areas discussed above are to portray fluctuations in elevation and latitude suggesting the variability in the ability for ice patches to exist. The different characteristics of ice patches and their geological settings are subjected to climatic conditions differently. As stated above, the southern Yukon ice patches were fairly thick and mostly found in cirques and as suggested by Farnell et al. (2004) it is possible that they have remained on the landscape throughout the duration of their existence however; the Basalt Lake ice patches tend to be much thinner and in the Tangle Lakes region of central Alaska (refer back to Figure 12). At elevations around 1,500 meters ice patches that have enough volume begin to form cirque glaciers (VanderHoek et al. 2007a). Due to the characteristics of the Basalt Lake ice patches it is possible that they did not exist continuously throughout the Holocene as it is suggested some ice patches potentially did.

There are four climatic intervals that comprise the Holocene which are: the Hypsithermal, Neoglaciation, Medieval Warm Period and the Little Ice Age. There is great climatic difference between these intervals that are responsible for the expansion and retreat of glaciers and surface ice around the world. The peak of each interval is different from region to region, so data collected on the Holocene climatic shifts was used from the Gulf of Alaska region (see Figure 14).

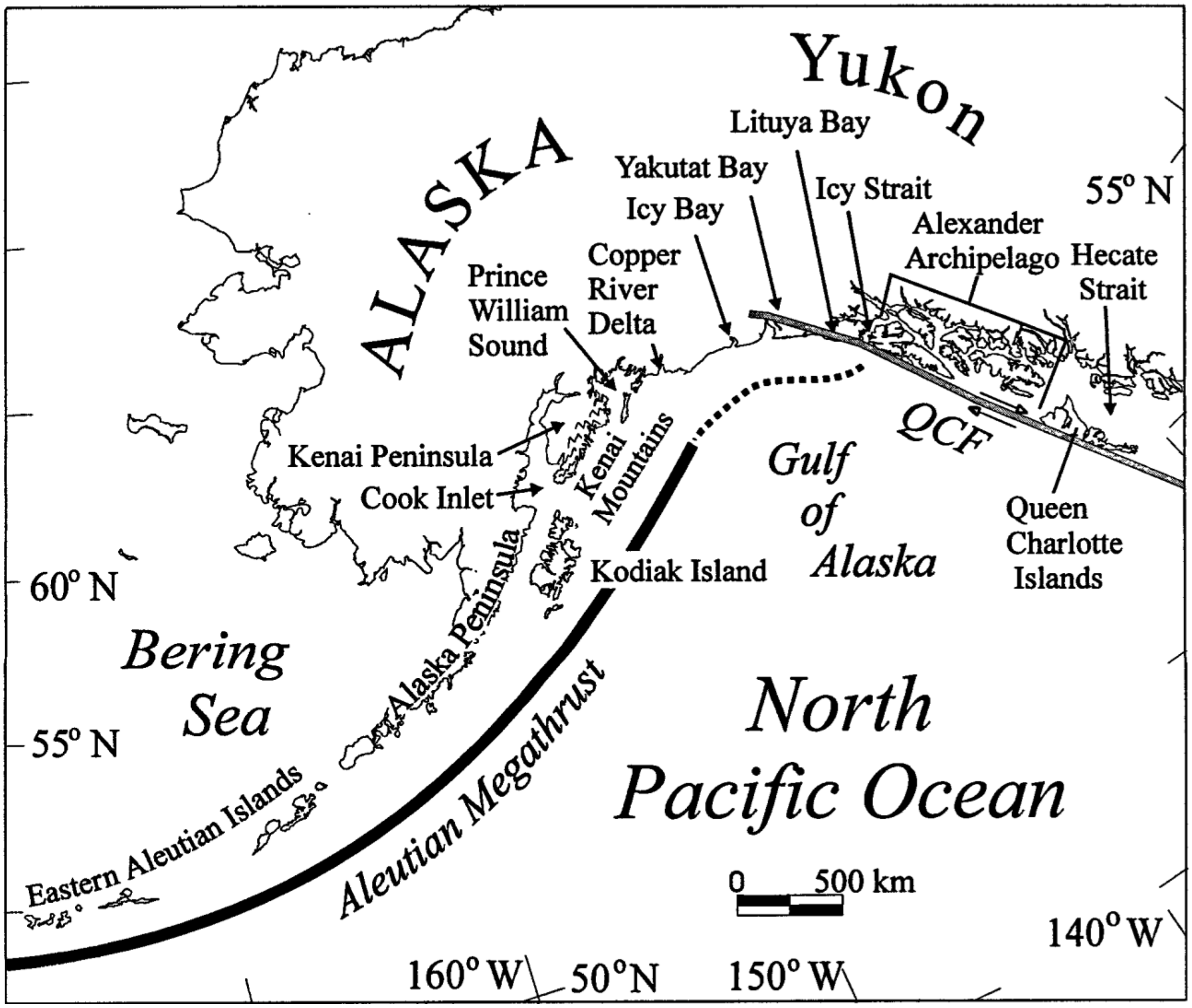

Figure 14. Map of the Gulf of Alaska region (Mann et al. 1998:114 fig. 1).

<u>Hypsithermal Period</u>

The Hypsithermal interval is the warmest climatic interval of the Holocene. It occurred in the Gulf of Alaska around 9,000 to 6,000 years ago. The summers were warmer and drier than they are today. Using palynology, it was suggested by Mann et al. (1998), that from the peak of the Hypsithermal around 8,000 years ago to the coldest period of the Neoglacial, there was approximately a 3^{o} Celsius drop in temperature. Figure 15 shows the climatic intervals of the Holocene with the average temperature for July. The temperatures for the Hypsithermal are significantly greater than that of the following climatic intervals. It should be noted that the Holocene is comprised of multiple temperature increases as well as decreases.

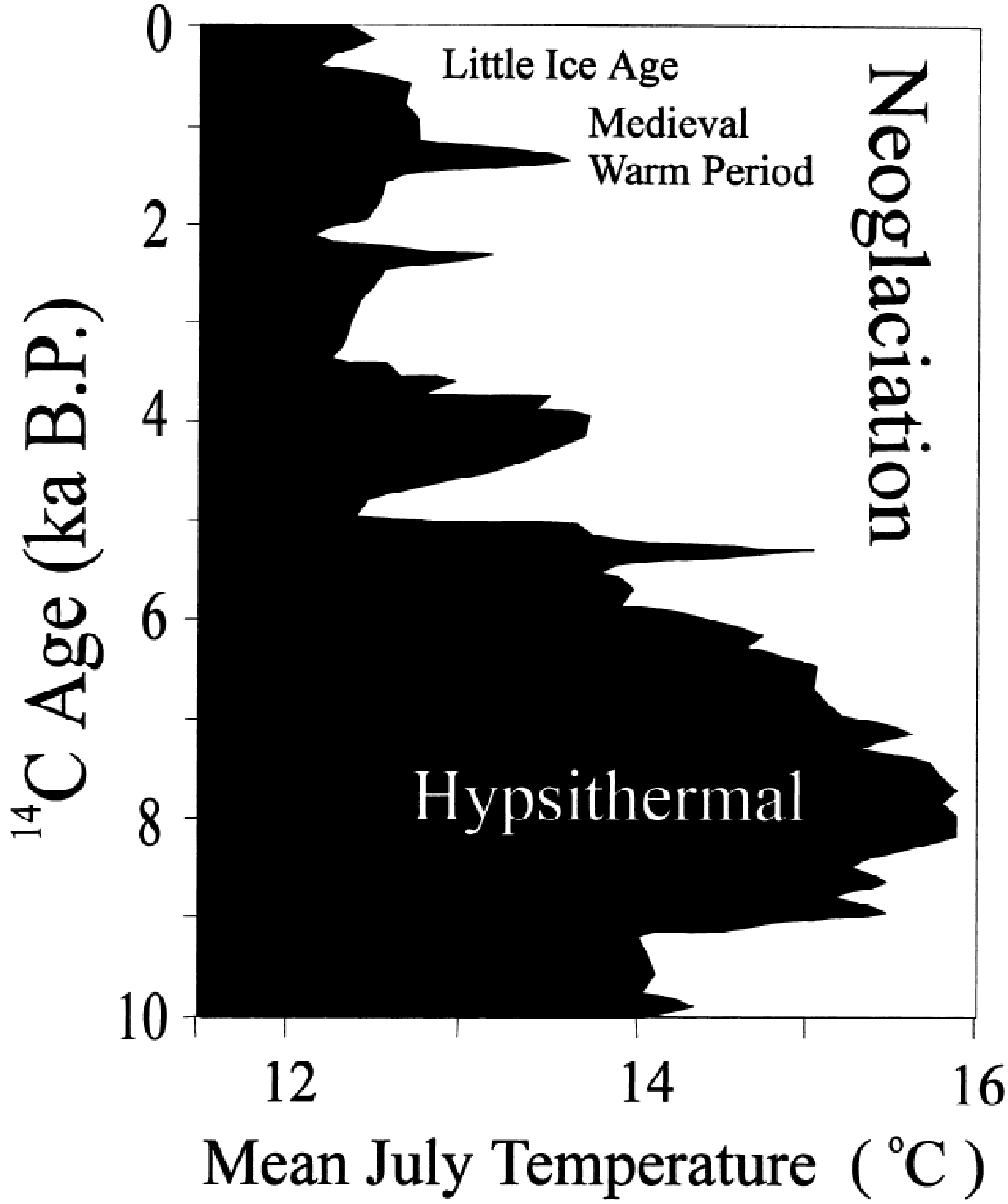

Figure 15. Graph of average July temperatures throughout the Holocene (Mann et al. 1998:115 fig. 2).

Neoglacial Period

The Neoglacial interval followed the Hysithermal around 6,000 years ago and is characterized by multiple climatic fluctuations. This period resulted in the rebirth of alpine glaciers or the renewed growth of existing glaciers. This transitional period following the Hypsithermal caused immense cooling and increased precipitation and the height of the Neoglacial interval occurred around 4,000 or 3,500 years ago. The climatic fluctuations recognized within the Neoglacial consist of the Medieval Warm Period and the Little Ice Age (Mann et al. 1998).

Medieval Warm Period

The Medieval Warm Period occurred in the Gulf of Alaska around A.D. 900-1350. Using glacial geology as a measure of climatic shifts shows southern Alaska glacial retreat behind the modern terminus around A.D. 1000, approximately at the beginning of the Medieval Warm Period. This means that the glaciers retreated past the current glacial foot or location of the end of the glacier (Mann et al. 1998). Significant glacial retreat creates the distinct possibility that shallow ice patches also underwent severe melting if not complete melting episodes.

Little Ice Age Period

The Little Ice Age immediately followed the Medieval Warm Period and occurred around A.D. 1350 to 1900. This climatic interval was not just a cooling event but was characterized with cooling intervals and warming periods. Using dendrochronology as a source of climate data, it revealed useful information on climate fluctuations within the past few centuries. Tree rings with relatively narrow growth exhibit cooling intervals and studies revealed by Wiles et al. (1996 *as cited in* Mann et al. 1998:116) show notable cold intervals at A.D. 1730-1740, 1750-1760, 1805-1815, 1845-1865, 1895-1905 and 1970-1975. Also noted were especially warm intervals occurring in decades at A.D. 1745, 1825, 1870, and 1920. Little Ice Age glacier retreating events have been recorded in southern Alaska occurring in the early A.D. 1700s and 1800s.

CONTEMPORARY CLIMATE DATA

Contemporary climate data used for Central Alaska was taken from meteorological data from monitoring Gulkana Glacier recorded by the U.S. Geological Survey (USGS). These measurements are most applicable to the Denali Highway region were the Basalt Lake ice patches are found (refer back to Figure 13 for general region). However, Figure 16 shows a detailed map of the location of Gulkana Glacier in relation to the Denali Highway.

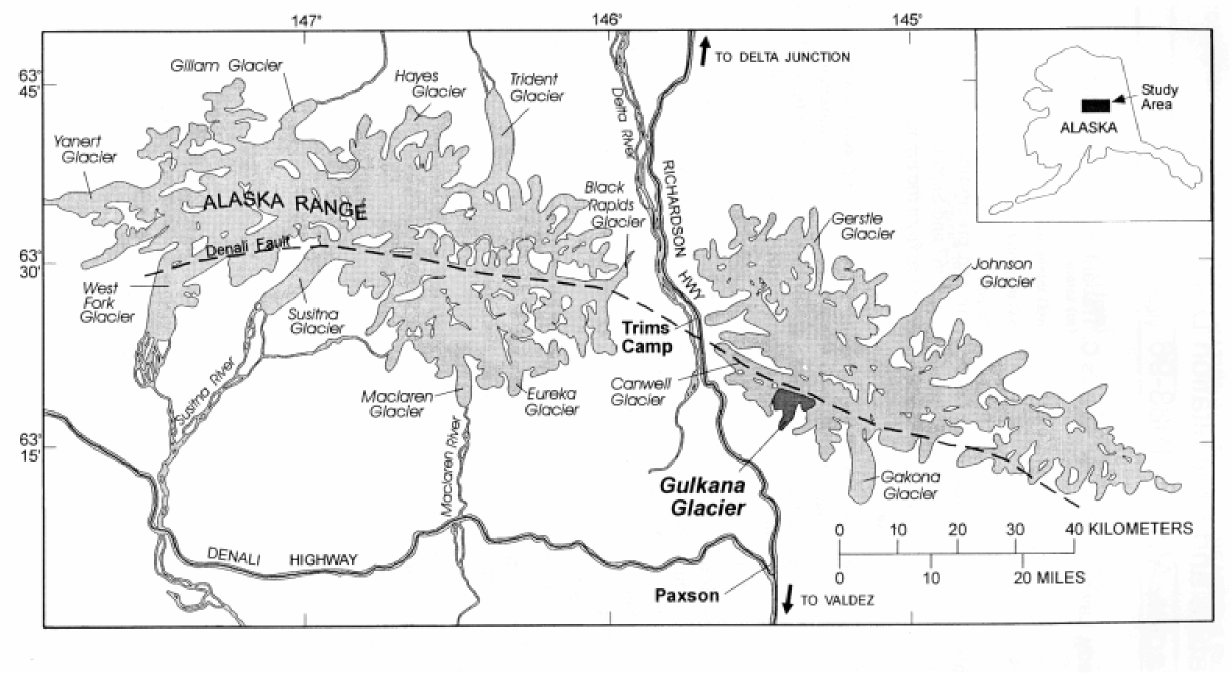

Figure 16. Map of Gulkana Glacier relative to Denali Highway, central Alaska (USGS 2011).

The meteorological station that records the climate data for Gulkana Glacier is located at an altitude of approximately 1,480 meters. Temperatures are taken in degrees Celsius and the monitored precipitation consists mainly of snowfall. The measurements are taken in hydrolic years (October 1 through September 30) and have been recorded from 1968 through 2007. There are a few years with missing data, but the air temperature data set is 96 percent complete while the precipitation-catch is 83 percent complete (USGS 2011). This provides an excellent data set for roughly the past 40 years on annual temperature and precipitation-catch in central Alaska. Table 1 shows the annual average and monthly air temperature recorded from the Gulkana Glacier meteorological station. It is important to note again that this data is collected at an elevation of 1,480 meters which is only slightly higher than the Basalt Lake ice patches at 1,340 to 1,400 meters and Basalt Lake ice patch 1 is located approximately 48 kilometers from Gulkana Glacier. Table 2 contains the data for the annual average and monthly precipitation-catch (dominantly snowfall) also recorded from the Gulkana Glacier meteorological station.

The precipitation-catch totals for each year consist of N/A if the yearly cumulative record is unavailable (USGS 2011). It is also noted that these data sets do not go all the way to 2010, however looking at the recent past few years in combination with past Basalt Lake ice patch surveys and conditions (years 2003-2005), allows for contemporary climate and ice patch condition interpretations in relation to the Basalt Lake ice patches.

The USGS also monitored three glaciers for a Benchmark Glacier Program including Gulkana Glacier in central Alaska, Wolverine glacier in south-central Alaska and Southern Cascade glacier in Washington (VanderHoek et al. 2007a). The data collected shows the mass balance of each glacier and Figure 17 shows the graph of the data.

Table 1. Monthly and annual air temperatures recorded at 1,480 meters elevation (USGS 2011).

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Average
1968	- 6.4	-11.0	-13.3	-17.6	-10.8	-11.2	- 7.6	3.4	6.3	8.1	6.2	- 1.1	- 4.6
1969	- 5.4	- 8.3	-14.0	-16.6	-11.3	- 8.3	- 1.9	1.9	8.4	5.2	1.6	2.2	- 3.9
1970	- 0.8	-10.9	- 6.1	-15.6	- 5.9	- 6.2	- 5.9	2.1	3.1	5.2	3.3	- 1.9	- 3.3
1971	- 8.6	-10.3	-15.4	-20.8	-12.1	-14.4	- 6.1	- 1.0	6.7	7.3	5.4	0.4	- 5.7
1972	- 6.8	-11.8	-14.8	-18.6	-15.2	-15.2	-10.2	- 0.6	3.3	6.7	5.3	- 2.7	- 6.7
1973	- 7.1	- 9.5	-12.6	-17.1	-12.0	- 9.4	- 5.8	- 0.8	3.4	4.7	1.5	- 0.9	- 5.5
1974	- 7.3	-14.5	-11.1	-15.9	-14.3	-12.4	- 4.1	2.6	5.2	6.9	5.9	3.2	- 4.6
1975	- 4.8	-10.1	-12.1	-15.7	-13.3	-14.2	- 8.7	0.8	4.0	6.9	4.7	1.2	- 5.1
1976	- 7.5	-13.3	-15.3	-13.0	-15.1	-11.4	- 5.2	0.2	N/A	N/A	5.1	0.0	N/A
1977	- 5.9	- 5.6	-10.8	- 6.9	- 7.7	-12.6	- 6.1	0.9	5.2	6.5	7.7	0.4	- 2.9
1978	- 4.1	-12.8	-14.7	- 7.9	- 8.5	- 9.1	- 4.5	1.3	2.8	6.0	6.1	1.4	- 3.6
1979	- 4.9	- 9.6	-12.2	-10.1	-18.2	- 8.3	- 3.9	2.4	3.2	5.7	6.3	2.2	- 3.9
1980	- 2.4	- 5.7	-15.4	-13.9	- 5.9	- 8.8	- 2.5	2.1	5.0	6.6	4.9	0.3	- 3.0
1981	- 3.2	- 7.3	-14.8	- 4.3	- 9.8	- 5.5	- 6.3	3.9	5.0	5.3	5.2	0.1	- 2.6
1982	- 4.8	- 9.5	-11.3	-16.1	-14.5	-11.2	- 6.9	0.9	5.3	7.2	5.4	1.4	- 4.4
1983	-10.0	- 9.6	- 9.3	-12.9	-10.1	- 9.1	- 4.8	1.1	4.2	5.9	2.6	- 2.7	- 4.5
1984	- 6.4	- 7.2	-10.9	-11.6	N/A	N/A	- 4.8	0.4	5.1	4.4	3.2	1.9	N/A
1985	- 5.4	-11.0	-12.1	- 6.5	-16.5	-11.3	- 7.9	- 0.2	3.2	6.3	3.5	- 0.5	- 4.8
1986	- 9.3	-12.8	- 6.2	- 8.8	-10.5	-12.0	- 9.9	- 0.6	4.9	7.0	2.7	1.5	- 4.5
1987	- 2.6	-11.1	N/A	N/A	N/A	N/A	- 4.2	1.8	4.1	7.1	5.7	0.3	N/A
1988	- 4.2	- 7.8	-11.0	-10.0	-10.3	- 8.0	- 3.7	2.5	5.3	7.3	4.5	- 0.4	- 3.0
1989	- 5.9	-11.0	-10.8	-18.9	- 7.8	-10.4	- 1.1	2.3	5.8	8.7	7.7	1.5	- 3.3
1990	- 6.4	-14.1	- 8.8	-15.3	-19.1	- 7.6	- 1.8	3.7	5.2	7.4	6.4	1.0	- 4.0
1991	- 7.7	-18.4	N/A	-13.6	-10.8	-11.1	- 4.1	1.3	5.7	4.6	2.7	1.5	N/A
1992	- 7.0	- 8.5	N/A	N/A	-13.9	-11.1	- 6.6	- 1.4	N/A	N/A	N/A	- 6.4	N/A
1993	- 7.6	- 8.5	-14.0	-14.1	- 8.1	- 8.5	- 2.0	2.7	5.8	8.2	4.5	- 0.5	- 3.5
1994	- 3.5	-10.2	- 8.6	-10.6	-15.4	- 9.7	- 1.5	1.9	5.1	7.8	8.5	0.0	- 2.9
1995	- 5.9	-17.0	-12.6	-11.0	-12.4	-13.8	- 1.5	3.4	5.8	6.6	4.5	3.6	- 4.1
1996	- 4.6	-11.4	-13.0	-16.7	-13.1	- 9.8	- 4.6	- 0.1	4.7	6.1	2.8	- 0.2	- 4.9
1997	- 9.9	- 9.3	-12.7	-13.0	- 7.4	-13.0	- 4.2	0.0	5.9	7.4	5.5	1.7	- 4.1
1998	- 9.9	- 8.0	-11.3	-11.7	- 7.6	- 7.4	- 4.7	0.2	4.2	6.1	2.7	- 0.6	- 4.0
1999	- 4.8	- 7.7	-10.6	-15.0	-15.7	- 9.9	- 5.5	- 0.7	7.1	7.7	7.1	1.1	- 3.8
2000	- 5.6	-10.1	-12.3	-13.5	- 7.4	- 7.1	- 4.7	- 0.7	6.5	7.0	3.8	- 0.7	- 3.7
2001	- 5.6	- 6.6	- 7.4	- 6.9	- 8.9	- 9.7	- 4.1	- 0.2	7.4	6.8	7.5	2.3	- 2.1
2002	- 6.3	- 8.8	-13.2	- 9.7	-10.7	-11.6	- 8.4	2.4	5.5	7.7	5.5	2.1	- 3.8
2003	- 1.3	- 3.2	- 8.7	- 6.7	- 8.1	-13.4	- 4.5	1.0	6.5	8.3	5.8	- 0.1	- 2.0
2004	- 0.8	-12.2	-10.3	-16.1	- 7.6	-10.5	- 2.0	4.2	10.5	9.3	10.2	- 1.5	- 2.2
2005	- 4.4	- 8.1	-10.0	-11.2	-10.6	- 6.9	- 1.8	4.0	7.3	7.5	7.3	1.9	- 2.0
2006	- 4.7	-12.1	- 6.1	-12.6	-11.3	-11.5	- 5.9	2.2	5.2	7.9	4.5	2.9	- 3.5
2007	- 3.9	-16.0	- 9.1	-11.0	-14.2	-15.1	- 2.4	2.1	7.9	8.5	8.0	1.8	- 3.7
1968-2007 Average	**- 5.6**	**-10.3**	**-11.4**	**-12.8**	**-11.4**	**-10.4**	**- 4.8**	**1.3**	**5.4**	**6.8**	**5.2**	**0.4**	**- 3.8**

Table 2. Monthly and annual precipitation-catch in millimeters recorded at 1,480 meters elevation (USGS 2011).

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	record	total
1968	59	167	87	37	134	21	31	65	33	40	49	73	0	796
1969	47	45	27	12	25	52	20	40	31	181	62	13	0	555
1970	88	28	35	92	85	107	47	35	74	163	240	159	0	1,153
1971	109	49	85	44	121	27	59	78	59	212	346	156	0	1,345
1972	168	10	84	81	48	75	44	32	117	48	196	277	0	1,180
1973	207	37	36	51	31	103	52	48	102	67	264	46	0	1,044
1974	98	0	3	0	81	40	49	3	142	124	113	85	0	738
1975	115	62	105	74	7	0	92	43	81	114	91	212	0	996
1976	93	10	24	64	55	84	22	40	6	37	88	89	0	612
1977	184	141	38	99	64	80	89	28	35	22	13	255	0	1,048
1978	116	36	73	64	37	44	33	61	190	109	61	90	0	914
1979	218	89	119	47	16	195	59	37	93	117	70	122	0	1,182
1980	127	155	78	51	31	57	33	68	95	243	191	121	0	1,250
1981	102	56	45	52	84	57	17	36	159	448	418	98	0	1,572
1982	166	1	16	15	27	25	30	52	96	160	102	143	0	833
1983	128	77	57	40	30	10	72	75	53	78	327	201	0	1,148
1984	212	14	29	48	N/A	N/A	45	36	55	125	134	27	116	841
1985	0	33	93	115	55	67	9	20	132	60	157	218	0	959
1986	67	38	138	87	28	51	45	36	88	152	155	39	0	924
1987	85	81	N/A	N/A	N/A	N/A	80	39	78	97	89	182	370	1,100
1988	178	54	84	48	116	87	56	82	102	69	184	140	0	1,200
1989	159	53	130	87	37	75	66	104	105	86	64	282	0	1,248
1990	155	108	183	113	86	71	35	33	82	58	164	349	0	1,437
1991	36	30	N/A	75	69	91	16	3	10	80	79	84	142	715
1992	52	23	N/A	N/A	32	50	8	53	N/A	N/A	N/A	N/A	491	709
1993	6	51	33	91	45	26	0	31	11	9	217	228	25	748
1994	73	137	59	37	20	93	35	35	157	22	39	107	0	814
1995	101	77	79	14	13	26	0	33	86	59	58	97	0	643
1996	23	12	62	16	66	21	29	58	65	148	230	49	0	779
1997	114	45	24	28	65	14	25	100	66	110	166	31	0	788
1998	130	54	41	34	27	22	37	77	95	143	226	153	0	1,039
1999	64	5	27	51	31	45	64	52	71	171	149	125	0	858
2000	209	30	83	84	73	48	51	40	62	126	111	169	0	1,086
2001	90	68	59	52	89	113	66	70	25	207	44	98	0	982
2002	59	19	37	77	34	6	79	60	127	114	470	195	0	1,279
2003	224							82	54	212	204	160	0	N/A
2004	27	117	58	17	57	79	45	81	62	72			0	N/A
2005	164	137	106	104	63	46	62	56	48	61	155	279	0	1,285
2006	37	120	106					69	111	129	488	133	185	1,385
2007	180	2	38	121	5	26	17	94	43	94	58	152	0	829
1968-98 Average	**110**	**57**	**67**	**56**	**53**	**58**	**40**	**48**	**83**	**113**	**153**	**138**		**978**

Cumulative Net Mass Balance

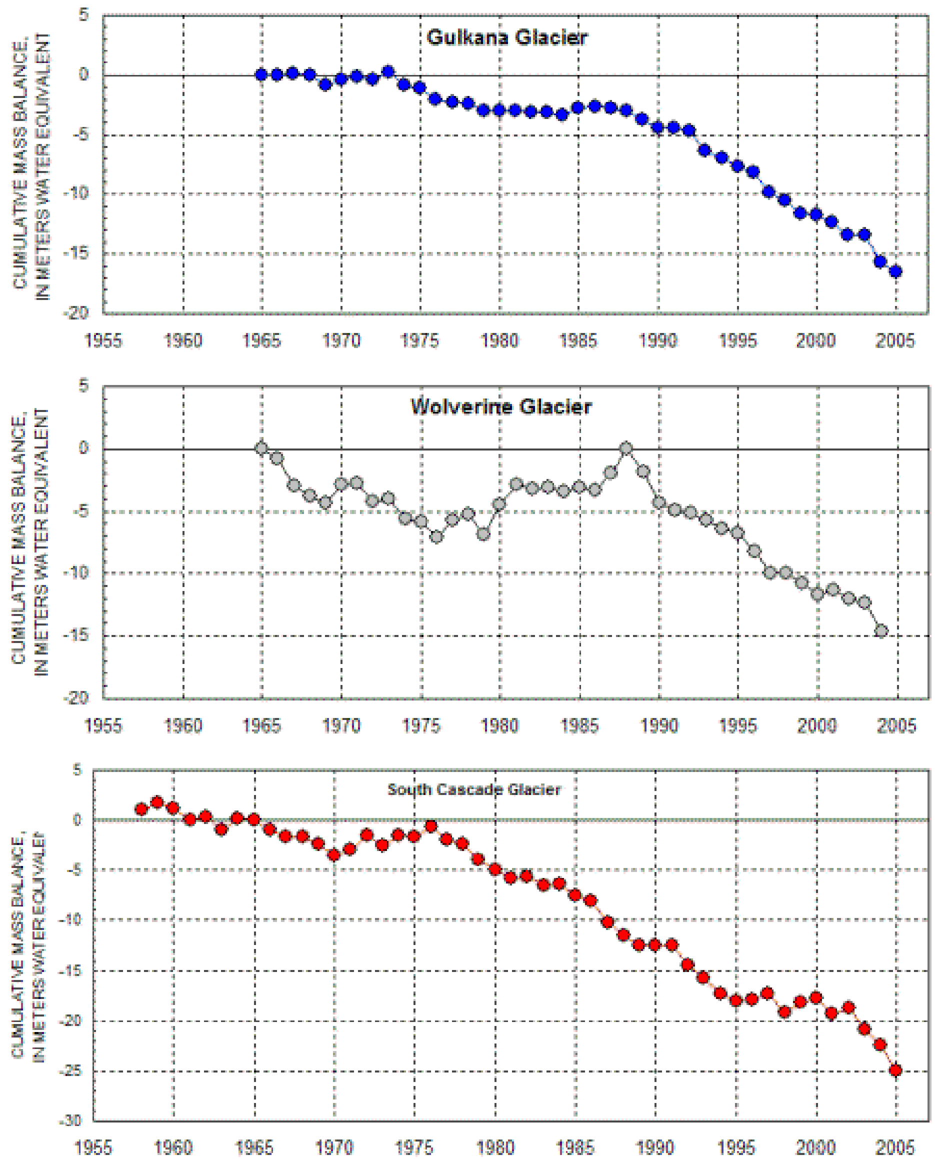

Figure 17. 3-Glacier mass balance (USGS 2011).

Looking at Figure 17, and focusing on the Gulkana Glacier mass balance, there is an obvious steady retreat or negative mass balance occurring over time. Combining the air temperature and precipitation-catch data with the recorded negative mass balance of the Gulkana Glacier shows some general warming trends for central Alaska. Warming does not necessarily mean record highs for temperatures, but slightly increased temperatures from previous years can have significant impact on surface ice in the area. The 2007 precipitation-catch data also shows decreased precipitation throughout the year in relation to the previous few years where cumulative precipitation was able to be recorded. The contemporary climate data shows slight changes in temperature and precipitation from year-to-year, but they are not extraordinary changes. Comparing this with the conditions of the Basalt Lake ice patches throughout the last decade shows how sensitive the ice patches can be to annual fluctuations in climate.

2010 PEDESTRIAN SURVEY

Basalt Lake Ice Patch 1

Basalt Lake ice patch 1 or (BLIP 1) is a transverse ice patch and the largest low elevation ice patch in the Amphitheater Mountains (refer back to Figure 12 and 13 for maps). It is located within a kilometer of Basalt Lake and lies on the north facing side of a saddle (VanderHoek et al. 2007a). BLIP 1 has produced cultural materials and for a reference of the cultural materials found associated with each BLIP, see Appendix A. Figure 18 is BLIP 1 in 2003 and Figure 19 shows BLIP 1 in 2004 almost completely absent of surface ice. The USGS data from glacial mass balance (refer back to Figure 17) shows 2004 to be one of the most significant glacial melt years from Gulkana Glacier up through 2005 (that is when the mass balance is no longer recorded). Figures 20 and 21 are also used for the sequence in the comparison of surface ice for years 2005 and 2010. In 2004, BLIP 1 had melted from approximately 275 meters across in 2003 down to two small fragments, one 13 meters across and one less that a meter.

Figure 18. BLIP 1 in 2003 (VanderHoek et al. 2007a:71 fig. 3).

Figure 19. BLIP 1 in 2004 (VanderHoek et al. 2007a:72 fig. 4).

Figure 20. BLIP 1 in 2005, note the return and persistence of surface ice (VanderHoek et al. 2007a:74 fig. 6).

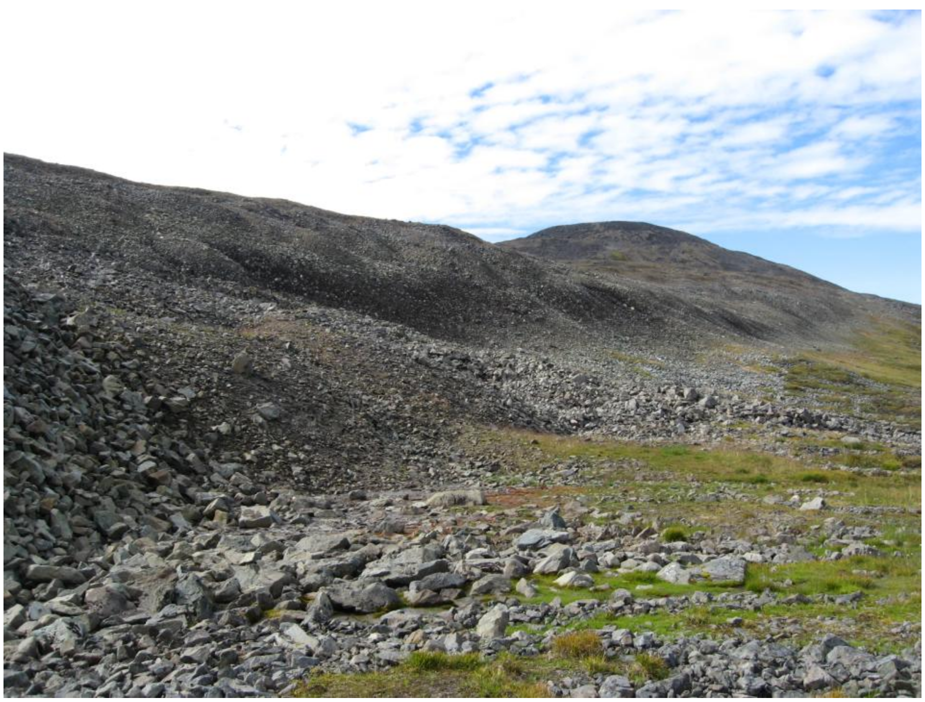

Figure 21. BLIP 1 in 2010, note the absence of surface ice (personal photograph).

In the 2010 pedestrian survey of the BLIPs, no new cultural materials were found on any of the four ice patches. However, Figure 21 shows the complete absence of surface ice on BLIP 1, and caribou beds were noted in the dung (Figure 22). This is a feature that has not been noted or discussed thoroughly in ice patch archaeology.

Figure 22. BLIP 1 Caribou bed in dung, note the flattened area (personal photograph).

<u>Basalt Lake Ice Patch 2</u>

Basalt Lake ice patch 2 is considered a longitudinal ice patch and in 2004 had no visible surface ice (VanderHoek et al. 2007a). This ice patch was the only one surveyed in 2010 that had remnants of ice and snow from the previous winter still present on the surface (Figure 23). Because BLIP 2 is longitudinal it occupies a notable gully. This gully accumulates a distinguishable amount of moisture during seasonal melts and the dung created a more mud-like, sloppy surface and no caribou beds were noted on this ice patch. Also, no new cultural materials were found in the 2010 survey.

Figure 22. BLIP 2 with minimal surface snow and ice (personal photograph).

Basalt Lake Ice Patch 3

Basalt Lake ice patch 3 is also considered a longitudinal ice patch. It appears transverse in early summer, but as it begins to melt it reveals underlying longitudinal characteristics (VanderHoek et al. 2007a). The 2010 survey revealed no new cultural materials and this ice patch was also completely lacking surface ice. However, no caribou beds were noted on BLIP 3. This ice patch is located rather close to BLIP 1 and was originally considered a part of BLIP 1, however because it was recorded as being more than 50 meters away from BLIP 1, it was assigned its own

AHRS number (note Appendix A) and classified as a separate ice patch (VanderHoek et al. 2007a).

Basalt Lake Ice Patch 4

Basalt Lake ice patch 4 has the highest elevation of all four BLIPs and is also considered a transverse ice patch (VanderHoek et al. 2007a). The 2010 survey revealed BLIP 4 was also absent of surface ice and contained obvious caribou beds as well with the presence of caribou hair (Figure 23 through 25). No new cultural materials were found in BLIP 4.

Figure 23. BLIP 4 in 2010, note darker spots of caribou dung and no surface ice (personal photograph).

Figure 24. BLIP 4 in 2010, note the caribou bed characterized by flattened dung (personal photograph).

Figure 25. Close up of caribou bed on BLIP 4 containing caribou hair (personal photograph).

The two BLIPs that are transverse ice patches were the only two experiencing noticeable caribou beds in the dung. All radiocarbon dates received for the BLIPs are listed in Appendix B, however it should be noted that no dates exceeded 2000 years cal B.P. (2 sigma). Although no dates were older than this, the stone projectile points recovered from the BLIPs are similar in typology to points associated with the Middle Taiga Period and Late Taiga Period (see Figure 26) according to Holmes (2008). There is a variety of tool typologies that define these periods that are considered Northern Archaic and include notched points and lanceolate points. Similar notched points and lanceolate points hafted with sinew to atlatl dart shafts were found in the Wrangell/St. Elias Moutains (Dixon 2005) as well as in central Alaska in the BLIPs (VanderHoek et al. 2007b). The time periods associated with these typologies start at 6000 years cal B.P. (2 sigma) (Holmes 2008).

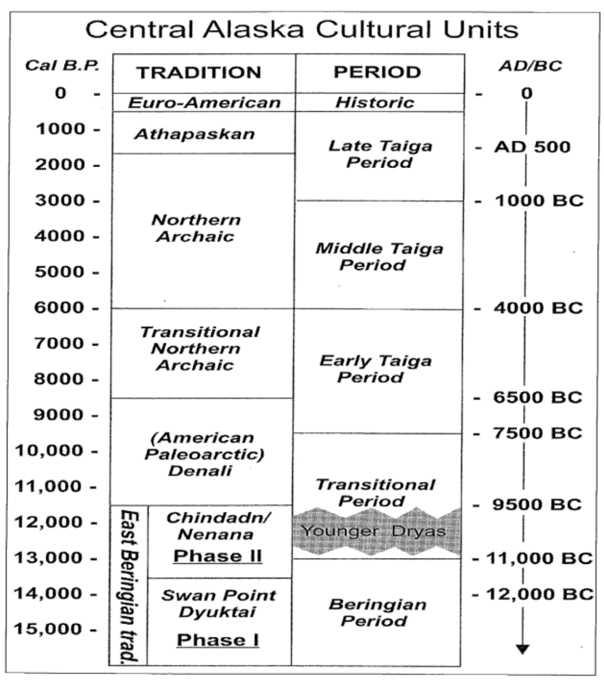

Figure 26. Cultural tradition and associated time period (Holmes 2008:70 fig. 1).

ETHNOGRAPHIC DATA

The Basalt Lake ice patches are situated along human traveling corridors and caribou corridors as part of seasonal movements. An Ahtna summer trail has been recorded west of Basalt Lake and because the ice patches exist on two obvious saddles in the Amphitheater Moutains, the general geography of the area channels caribou movements through. According to VanderHoek et al. (2007a), BLIP 2 and BLIP 3 were located in close proximity to deep caribou trails. It is suggested that ice patches existing closely to other known resources such as lakes or streams, caribou migration corridors, berry patches and lithic sources have high probability of containing cultural material. The BLIPs are all located within a kilometer of Basalt Lake (refer back to Figure 13) and although Basalt Lake does not have a significantly noted fish population, Seven Mile Lake is located just 2.5 kilometers north and is a popular present day fishing spot (VanderHoek et al. 2007a).

Radiocarbon dates on the artifacts from the Amphitheater Mountain ice patches (this includes the BLIPs) suggest these locations were used by ancestors of modern Athapaskan people. Ethnographic accounts of Ahtna groups show that they would set up a base camp around a river or other body of water during mid to late summer and fall. A large group of men, women and children would move into the high country and generally the women and children would gather berries, fish and snare ground squirrels while men would move high into the mountains to hunt caribou. Similar behaviors were noted ethnographically in southern Yukon by Southern Tutchone groups. Many ice patch sites in southern Yukon are located within 10 to 15 kilometers of known archaeological base camps in nearby valleys (VanderHoek et al. 2007a).

Ethnographic and oral histories from First Nations' groups in southern Yukon also discuss a heavy importance of caribou on their existence. Caribou were needed for food and clothing and many elders referred to the abundance of caribou in mountains and the stories of caribou hunting trips. The elders also mentioned the decline of caribou populations today in reference to a much larger herd existence in the recent past (Carcross-Tagish First Nation et al. 2005).

DISCUSSION

Ice patch archaeology, because of its relatively recent appearance to the field, has not been explored on this subject of continued use by caribou through changing surface ice conditions. The climatic data for the Holocene shows very extreme changes and shifts in climate over thousands of years. This would have definitely affected the Basalt Lake ice patches and ice patches that had a similar geological setting. As mentioned above, ices patches form in a variety of settings and contain different characteristics; the Basalt Lake ice patches are fairly shallow in depth in comparison to other noted ice patches and exist at a slightly lower elevation than, for example the recorded Yukon ice patches. However, the Basalt Lake ice patches are not among the lowest elevation ice patches as seen with ice patches on the North Slope, but they experience significant changes in surface ice area with slight climate fluctuations. Because of this sensitivity to slight changes in precipitation and temperature, it is highly probable that they were fluctuating as well throughout the greater Holocene climate shifts. To further support this idea, the radiocarbon dates on artifacts recovered from the BLIPs fall within the past 2000 years cal B.P. (see Appendix B), but stone projectile point typologies are similar to those falling within the Northern Archaic tradition that extends back to 6000 years cal B.P. (Holmes 2008); this could represent earlier melting episodes in which older organic artifacts did not survive.

The contemporary climate data does not show extreme differences in air temperature or precipitation-catch. This illustrates how easily the Basalt Lake ice patches are impacted by a slight decrease in precipitation or increase in air temperature annually. Figures 18 through 21 portray precisely the variability in ice patch conditions on a smaller scale consisting of the last decade. The caribou beds noted on BLIPs 1 and 4 depict the use of the ice patches regardless of the fluctuations in surface ice. BLIP 1 and 4 are each transverse ice patches and, as stated earlier, VanderHoek et al. (2007a) suggests that transverse ice patches were heavily used for ambushes as their location to ridges was perfect for approaching caribou undetected. Also, the BLIPs' location among human corridors and caribou corridors, make them extraordinary hunting locations and their location as part of seasonal movements suggest more than the ice patches draw caribou to the area. The ice patches were definitely beneficial to caribou due to their extensive use as noted by caribou dung, faunal remains (see Appendix C), and caribou behavior.

With the data collected and the variety of factors that draw caribou to specific locations of ice patches, it is concluded that the BLIPs, and ice patches experiencing similar features to the BLIPs, would have been reliable to prehistoric hunters throughout the Holocene regardless of fluctuations in the presence of surface ice because caribou have exhibited continued use among the BLIPs seen through the presence of caribou beds.

Ice patch archaeology is drawing the interest of many people and there is great involvement in ice patch research due to the rapid rate at which they are presently melting. It is important to collect and recover artifacts before they are subjected to environmental elements causing them to decompose or be trampled by animals. By monitoring caribou herds or tracking previously known seasonal movements it is possible to find locations similar to those presented by the Basalt Lake ice patches that lack surface ice, but may contain the potential for artifact recovery and introduction to new archaeology sites. Ice patches offer a unique view into the past with the preservation of organic materials; however inorganic materials can also be recovered so whether absent or present, ice patches should continue to be monitored and newly discovered patches or ice patch areas hold the potential for being archaeological resources.

APPENDIX A

Table 3. Cultural materials of the Basalt Lake ice patches through 2007 (VanderHoek et al. 2007b:192 table 3)

AHRS #	UA CATALOG #	LOCATION	MATERIAL	ARTIFACT	WEIGHT (grams)	LENGTH (mm)
XMH-01081	UA2004-148-1	BLIP 1	Wood	Shaft	2	148
XMH-01081	UA2004-148-2	BLIP 1	Wood	Shaft	8.8	330
XMH-01081	UA2004-148-3	BLIP 1	Wood	Shaft	1.5	54.8
XMH-01081	UA2004-148-4A	BLIP 1	Wood	Shaft	0.2	53.8
XMH-01081	UA2004-148-4B	BLIP 1	Wood	Shaft	0.2	42.3
XMH-01081	UA2004-148-4C	BLIP 1	Wood	Shaft	0.2	37.7
XMH-01081	UA2004-148-4D	BLIP 1	Wood	Shaft	0.2	36.7
XMH-01081	UA2004-148-4E	BLIP 1	Wood	Shaft	0.2	41.7
XMH-01081	UA2004-148-4F	BLIP 1	Wood	Shaft	0.9	119
XMH-01081	UA2004-148-4G	BLIP 1	Wood	Shaft	0.1	26
XMH-01081	UA2004-148-5	BLIP 1	Antler	Arrow Point	7.09	151.1
XMH-01081	UA2004-148-6	BLIP 1	Wood	Birch Bark	3.1	141
XMH-01081	UA2004-148-7	BLIP 1	Feather	Fletching	<0.1	124.6
XMH-01081	UA2004-148-8	BLIP 1	Feather	Fletching	<0.1	106
XMH-01082	UA2004-149-1	BLIP 2	Antler	Arrow Point	14	270
XMH-01166	UA2004-150-1	BLIP 3	Antler	Worked	421	590
XMH-01166	UA2004-150-2	BLIP 3	Wood	Birch Bark	45	281.4
XMH-01191	UA2004-153-4	BLIP 4	Wood	Shaft	2.6	217
XMH-01191	UA2004-153-1	BLIP 4	Lithic	Projectile Point	11.1	56.4
XMH-01191	UA2004-153-2	BLIP 4	Lithic	Projectile Point	11.4	65.1
XMH-01191	UA2004-153-3	BLIP 4	Lithic	Projectile Point	16.6	63.1
XMH-01192	UA2004-154-1	DRIP 5	Wood	"Gopher Stick"	241	755

***DRIP 5 refers to the Delta River ice patch also located in the Amphitheater Mountains**

APPENDIX B

Table 4. Radiocarbon dates for artifacts recovered from Basalt Lake ice patches (radiocarbon dates from CALIB 5.0, IntCal 04 [Reimer et al. 2004 as cited in VanderHoek et al. 2007b:186 table 1])

SITE #/NAME	LAB #	SAMPLE # (OHA)	ITEM	MATERIAL TYPE	TAXON	TECHNIQUE	CONVENTIONAL C-14 AGE	CALIBRATED AGE RANGE A.D. (2 SIG.)
XMH-081 (BLIP 1)	Beta-185014	XMH-1081A	Arrow Shaft	Wood	*Picea*	AMS	60 +/- 30	1952-1956, 1812-1919, 1694-1727
XMH-1082 (BLIP 2)	Beta-201470	XMH-1081A2004	Antler Point	Antler	*Rangifer*	AMS (ext. count)	1010 +/- 40	901-917, 966-1059, 1066-1072, 1075-1155
XMH-1166 (BLIP 3)	Beta-185015	XMH-1166A	Chopped Antler	Antler	*Rangifer*	AMS	950 +/- 40	1016-1179
XMH-1191 (BLIP 4)	Beta-201471	XMH-1191A2004	Arrow (?) Shaft Frag.	Wood	*Picea*	AMS	1000 +/- 40	975-1155
XMH-1192 (DRIP 5)	Beta-201472	XMH-1192A2004	"Gopher Stick"	Wood	*Picea*	AMS	390 +/- 40	1437-1528, 1545-1545, 1551-1634

APPENDIX C

Table 5. Faunal remains from Basalt Lake ice patches (VanderHoek et al. 2007b.:187 table 2)

LOCATION	AHRS #	MATERIAL	DESCRIPTION	ANIMAL
BLIP 1	XMH-1081	Bone	Skull fragment (maxilla)	caribou
BLIP 1	XMH-1081	Bone	Rear left maxilla with 3 molars	caribou
BLIP 1	XMH-1081	Bone	Skull fragment	caribou
BLIP 1	XMH-1081	Bone	Distal-medial right tibia frag.	caribou
BLIP 1	XMH-1081	Bone	Rib	caribou?
BLIP 1	XMH-1081	Bone	Longbone fragment	caribou?
BLIP 1	XMH-1081	Bones	Proximal left ulna and radius	small caribou
BLIP 1	XMH-1081	Bones	Two lower mandibles (right and left)	marmot
BLIP 1	XMH-1081	Bones	Eight rib fragments	caribou
BLIP 1	XMH-1081	Bone	Cervical vertebra	caribou
BLIP 1	XMH-1081	Bone	Thoracic vertabra	caribou
BLIP 1	XMH-1081	Velvet	Long thin strips	caribou
BLIP 1	XMH-1081	Antler	Three pieces	caribou
BLIP 1	XMH-1081	Bone	Distal left metacarpal	caribou
BLIP 1	XMH-1081	Hoof	Weathered hoof fragment	caribou
BLIP 1	XMH-1081	Bone/Ant.	Skull fragment with left antler intact	caribou
BLIP 1	XMH-1081	Bone	Right maxilla fragment with molars	caribou
BLIP 1	XMH-1081	Bone	Left metacarpal	caribou
BLIP 1	XMH-1081	Bone/Ant.	Righ maxilla with teeth and small broken tine	caribou
BLIP 1	XMH-1081	Bones	Right metacarpal, two carpals, four ankle bones including one right lunate	caribou

Table 5. (continued) Faunal remains from Basalt Lake ice patches (VanderHoek et al. 2007b.:187 table 2)

LOCATION	AHRS #	MATERIAL	DESCRIPTOIN	ANIMAL
BLIP 2	XMH-1082	Bone	Rib	medium mammal
BLIP 2	XMH-1082	Bone/Ant.	Skull fragment with left antler intact	caribou
BLIP 2	XMH-1082	Bone	Small mammal rib	unknown
BLIP 2	XMH-1082	Bone	Astragilus	caribou
BLIP 2	XMH-1082	Bones	Three metapodial and joint bones	caribou
BLIP 3	XMH-1166	Bone	Right scapula	caribou
BLIP 3	XMH-1166	Bone	Left mandible with teeth	caribou
BLIP 3	XMH-1166	Bone	Rib	caribou?
BLIP 3	XMH-1166	Bone	Gnawed	caribou?
BLIP 3	XMH-1166	Bone/Ant.	Skull fragment with right antler intact	caribou
BLIP 4	XMH-1191	Bone	Proximal left tibia	small caribou

BIBLIOGRAPHY

Beattie, O., B. Apland, E. W. Blake, J. A. Cosgrove, S. Gaunt, S. Greer, A. P. Mackie, K. E. Mackie, Dan Straathof, Valerie Thorp, and P. M. Troffe

2000 Kwaday Dan Ts'inchi Discovery From a Glacier in British Columbia. *Canadian Journal of Archaeology* 24(1):129–147.

Bell, Bob

2010 10,000 Year Old Weapon Found in Melting Rocky Mountains Ice Patch. Electronic Document, D:\North American Ice Patch Archaeology\10,000 year old weapons found in melting Rocky Mountain.mht, accessed December 12th 2010.

Carcross-Tagish First Nation, Champagne and Aishihik First Nations, Kluane First Nation, Kwanlin Dün First Nation, Ta'an Kwäch'än Council, Teslin Tlingit Council

2005 *Ice Patch*, Issue 2. Newsletter published by Carcross-Tagish First Nation, Champagne and Aishihik First Nations, Kluane First Nation, Kwanlin Dün First Nation, Ta'an Kwäch'än Council and Teslin Tlingit Council, Yukon, Canada. On file, Champagne and Aishihik First Nations,Whitehorse.

Dixon, James E., Craig M. Lee and William F. Manley

2005 The Emerging Archaeology of Glaciers and Ice Patches: Examples from Wrangell-St. Elias National Park and Preserve. *American Antiquity* 70(1):129-143.

Dove, Carla J., P. Gregory Hare and Marcy Heacker

2005 Identification of Ancient Feather Fragments Found in Melting Alpine Ice Patches in Southern Yukon. *Arctic* 58(1):38-43.

Farnell, Richard, P. Gregory Hare, Erik Blake, Vandy Bowyer, Charles Sweger, Sheila Greer and Ruth Gotthardt

2004 Multidisciplinary Investigations of Alpine Ice Patches in Southwest Yukon, Canada: Paleoenvironmental and Paleobiological Investigations. *Arctic* 57(3):247-259.

Gates, Douglas

2010 Great Land of Alaska. Electronic Document, http://www.greatlandofalaska.com /index.html, accessed March 25th, 201.1

Hare, Gregory P., Sheila Greer, Ruth Gotthardt, Richard Farnell, Vandy Bowyer, Charles Sweger and Diane Strand

2004 Ethnographic and Archaeological Investigations of Alpine Ice Patches in Southwest Yukon. *Arctic* 57(3):260-272.

Holmes, Charles E.
2008 The Taiga Period: Holocene Archaeology of the Northern Boreal Forest, Alaska. *Alaska Journal of Anthropology* 6(1&2):69-81.

Kuzyk, G., D.E. Russell, R.S. Farnell, R.M. Gotthardt, P.G. Hare and E. Blake
1999 In Pursuit of Prehistoric Caribou on Thandlät, Southern Yukon. *Arctic* 52(2):214-219.

Lewis, W. V.
1939 Snow-Patch Erosion in Iceland. *The Geographical Journal* 94(2):153-161.

Mann, Daniel H., Aron L. Crowell, Thomas D. Hamilton and Bruce P. Finney
1998 Holocene Geologic and Climatic History Around the Gulf of Alaska. *Arctic Anthropology* 35(1):112-131.

Reimer, P. G., M. G. L. Baillie, E. Bard, A. Bayliss, J. W. Beck, C. Bertrand, P. G. Blackwell, C. E. Buck, G. Burr, K. B. Cutler, P. E. Damon, R. L. Edwards, R. G. Fairbanks, M. Friedrich, T. P. Guilderson, K. A. Hughen, B. Kromer, F. G. McCormac, S. Manning, C. Bronk Ramsey, R. W. Reimer, S. Remmele, J. R. Southon, M. Stuiver, S. Talamo, F. W. Taylor, J. van der Plicht, and C. E. Weyhenmeyer
2004 IntCal04 Terrestrial Radiocarbon Age Calibration, 0–26 Cal Kyr bp. *Radiocarbon* 46:1029–1058.

Skoog, R. O.
1968 Ecology of the Caribou (*Rangifer tarandus* granti) in Alaska. Unpublished Ph.D. dissertation., Department of Biology, University of California, Berkley.

U. S. Geological Survey
2011 Glacier and Snow Program of Alaska and Washington Science Centers. Electronic Document, http://ak.water.usgs.gov/glaciology/gulkana/met/precip _monthly.htm, accessed March 22, 2011.

VanderHoek, Richard, Brian Wygal, Randolph M. Tedor and Charles E. Holmes
2007a Survey and Monitoring Ice Patches in the Denali Highway Region, Central Alaska, 2003-2005. *Alaska Journal of Anthropology* 5(2):67-86.

VanderHoek, Richard, Randolph M. Tedor and J. David McMahan
2007b Cultural Materials Recovered from Ice Patches in the Denali Highway Region, Central Alaska, 2003-2005. *Alaska Journal of Anthropology* 5(2):185-200.

Wiles, G. C., P.E. Calkin and A. Post
1996 Temperature Changes Along the Gulf of Alaska and the Pacific Northwest Coast Modeled from Coastal Tree Rings. *Canadian Journal of Forest Research* 26:474-481.