FINAL REPORT TO GLACIER NATIONAL PARK: ICE PATCHES AS SOURCES OF ARCHEOLOGICAL AND PALEOECOLOGICAL DATA IN CLIMATE CHANGE RESEARCH

Complied by

Robert L. Kelly, co-PI
Craig M. Lee, co-PI

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Executive Summary

Climate change is melting ice in America's national parks and forests. Newly exposed artifacts and natural items with unique scientific and cultural value are threatened by destruction through accelerated taphonomic processes and inadvertent loss, e.g., unauthorized collection. Glacier National Park's (GNP) alpine regions have long been important to the Salish, Kootenai, and Blackfeet. The Confederated Salish and Kootenai Tribes (CSKT), Blackfeet Nation (BN), and researchers from the University of Wyoming and University of Colorado at Boulder partnered in an unprecedented collaboration to develop and implement protocols for culturally appropriate scientific methods to recover and protect endangered objects. The protocol is an important resources and was shared with numerous parks as well as the park service's Intermountain Region and Washington, DC office. Traditional Native uses of alpine areas were researched and a plan for Native American burials (in the event of a discovery) was developed; however, no burials or human remains were encountered. Student and tribal crews conducted three seasons of fieldwork in alpine and subalpine areas of the park in the late summers of 2010, 2012, and 2013, surveying 25 ice patches. No artifacts were located, but paleobiological specimens (e.g., wood, non-human bone) were collected and analyzed. In addition, the project cored an ice patch (Siyeh Pass), which produced evidence that the park's ice patches had significantly retreated or even disappeared between 6000 and 7000 years ago. Skeletal remains of a bison (*Bison bison*) recovered at one of the ice patches were radiocarbon dated to 1000-years-old and the mtDNA signature of the specimen was added to a growing database of bison aDNA. Extant aerial images of ice patches in GNP obtained by the US Geological Survey in 1998 were orthorectified for comparison with modern extents, and now provide a data point for the park, CSKT and BN to monitor climate change at GNP ice patch locations in the future. Additionally, oblique aerial images of several ice patch targets were acquired in 2015. Results of the project, have been shared through papers and presentations in professional meetings and public outreach venues. A video conveying tribal perspectives on the impacts of alpine climate change to Native peoples, was shared at "Frozen Pasts: The 3rd International Glacial Archaeology Symposium" and is available with additional content through an interactive website developed by the project (www.glaciericepatch.org).

ACKNOWLEDGEMENTS

We thank the Culture Committees of the Salish, Pend d'Oreille, and Kootenai Tribes, as well as the Blackfeet Nation, for their support of and participation in our work in Glacier National Park. We thank the Park Service and Glacier National Park in particular for their unflagging efforts to support our collective endeavor. Our work in Glacier National Park was financially supported by the National Park Service's Climate Change Response Program, as well as by Glacier National Park. An incomplete list of individuals who helped with aspects of the project includes, Blackfeet Nation: John Murray, Carol Murray, Joe Riviera and Greg Hall; Confederated Salish Kootenai Tribe (CSKT): Kevin Askan, Francis Auld, Clarinda Burke, Rosemary Caye, Mike Durglo, Sr., Pete Gillard, Marcia Pablo, Ira Matt, David Rockwell, Don Sam, Dave Schwab, Frank Tyro, and Martin Zobel; National Park Service: Lon Johnson, Sierra Mandelko, John Kinsner, Deirdre Shaw, Leigh Welling, Melanie Wood, and Alexander J.S. New; Rocky Mountain Cooperative Ecosystem Studies Unit: Tom Fish, Kathy Tonnessen, and Pei-Lin Yu; University of Colorado Institute of Arctic and Alpine Research: Joan Eaton, Sedrick Frazier, Julie Hughes, Catherine Larkins, Leanne Lestak, Lindsay McCandless, and William Manley; USGS: Dan Fagre and Lisa Mckeon; University of Wyoming: Rick Weatherman, Rachel Reckin, and Claren Copp-Larocque; University of Wisconsin-Madison Ice Drilling Design and Operations: Kristina Dahnert and Jay Kyne. Wood collected was identified by Kathryn Puseman with preliminary identifications by Rick Weathermon and Claire Alix.

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INTRODUCTION

The issue of global warming has been a topic of intense public debate and scientific discussion over the last decade. Perhaps nowhere else in the United States is the evidence for global warming more apparent than in Glacier National Park (GNP). The park, which contained over 150 glaciers in 1910 at the time of establishment, contained only 25 glaciers in 2015—a reduction of about 67 percent. As a group, this is the most pronounced glacial recession of any glaciated region in the lower 48 states, with some computer-simulation climate models suggesting that all of the park's glaciers could be lost sometime between 2030 and 2080 (Carrara 1989; Key et al. 2002; Roe et al. 2016). In addition, ancient ice in non-glacial snow and ice patches is being lost at unprecedented rate, although there are fewer data on this phenomenon.

With warming temperatures at high latitudes and elevations, and as a result of focused surveys, an increasing number of archeological sites and paleontological specimens are being discovered in association with melting snow and ice resources (e.g., Andrews et al. 2012; Lee and Benedict 2011; VanderHoek et al. 2012; Farnell et al. 2004; Hare et al. 2012). Although artifacts are occasionally found on glaciers, they are primarily recovered at smaller, perennial snow and ice features, or "ice patches," that persist in many mountainous regions as a result of seasonal accumulations of windblown snow (Dixon et al. 2005). Ice patches are not massive enough to become glaciers, although snow in these locations can eventually turn into névé or firn ice through freeze-thaw cycles and compaction. As described here, the term "ice patch" does not refer to the highest elevation snow and ice that occurs along jagged arêtes hundreds of feet above timberline; rather, it refers to permanent snow and ice at the lowest elevations.

These features were used in ancient times for a variety of purposes, but predominantly hunting. Most archeological discoveries have been made at high latitudes, e.g., in Yukon Territory and Alaska (or in Norway in Europe). In Canada, for example, the remains of an individual, complete with clothing and tools, and dating to nearly 500 years old, were recovered on the melting margin of a small glacier (Beattie et al. 2000). Other discoveries include complete arrows with fletching, sinew lashing and projectile points, as well as bark quivers, basket fragments and clothing, e.g., moccasins. Efforts aimed at identifying similar environments at lower latitudes, e.g., in Rocky Mountain and Yellowstone National Parks have produced similar spectacular and unique archeological materials such as atlatl darts and foreshafts, as well as paleobiological specimens, e.g., bison remains, large game feces, and other specimens dating > 7,500 years BP (Lee 2009, 2008a, 2008b). Such remains have been preserved, sometimes for millennia, in snow and ice. Their exposure in recent years is a direct result of changing (warming) climate.

Given that archaeological and paleobiological materials have been found in British Columbia and Alberta and in southern Montana, the possibility that similar items are preserved in the ice and snow of Glacier National Park's alpine and sub-alpine zones was worth investigating. In summer and fall, certain high benches provided good forage and were likely habitat for mountain bison, elk, mountain sheep, and other ungulates (Reeves and Peacock 2001). Further, the trails accessing high altitude areas are linear expressions of human movement through and to key areas, and likely to be associated with material remains of travel, resource procurement, and spiritual activity.

These archeological and paleobiological resources are important to science in three ways:

1. Organic artifacts are rare, and offer a window into prehistoric lifeways that complements information provided by more commonly preserved archeological remains, such as stone tools;
2. Ancient upper elevation activities are less commonly documented by archeologists, due to the lack of accessibility and the lack of development activities (e.g., road construction) that would require compliance archeology; hence our understanding of ancient lifeways in alpine and subalpine zones could be biased or incomplete, and;
3. Both archeological and paleobiological organic items can provide important information on climate change, since they record the timing of human, animal, and plant presence at upper elevations and demonstrate how long ice patches have existed until the present warming.

For tribal communities, archeological resources are more than scientific specimens. They represent a direct link to ancestors and a source of inspiration, pride, and traditional knowledge for the modern tribal community. Some of these items maintain significant cultural and ceremonial value and need to be handled in a culturally appropriate manner for the protection of the artifact and the tribal community. The Salish, Kootenai, and Blackfeet tribes expressed a need to work as equal partners in the effort to identify, preserve and protect these heritage resources as a way of perpetuating tribal culture today and into the future.

GLACIER CULTURAL RESOURCE MANAGEMENT GROUP (CRMG)

The Glacier Cultural Resource Management Group (CRMG) was formed by the project to serve as a forum for the discussion of cultural resources-related work and research in a culturally-sensitive atmosphere in which the outcomes of work and research were enriched and made meaningful through dialogue. Not a substitute for consultation, the CRMG served as a planning and communication forum to identify issues worthy of formal consultation and to elevate them to the appropriate procedures. The CRMG resulted in the creation of cultural protocols for the ice patch project that governed how archaeological materials would be treated. This protocol has been shared with other national parks and offices, e.g., Rocky Mountain National Park; Gates of the Arctic National Park; NPS Intermountain Region Office; NPS Washington, DC Office (see Appendix A).

Climate change-related phenomena are new and critical concerns for Native Americans who have ancient heritage links with what is now Glacier National Park. Glaciers and snowscapes are integral parts of tribal creation stories. The alpine zones are important special areas for hunting, gathering, and ceremonial use. Culturally significant plants, minerals, and animals were procured in these unique environmental settings. Recent dramatic changes brought to these alpine and subalpine areas have caused an imbalance to a natural ecological system used and maintained by tribal ancestors since time immemorial, threatening permanent loss of cultural and natural resources.

Unfortunately, this reservoir of archeological and paleobiological information and heritage value is endangered by the very warming that makes it accessible. Once exposed by melting snow and ice, organic remains do not last long. If they are not stolen or disturbed by park visitors, or impacted by animals, organic items will decay. Anecdotal evidence from other areas where artifacts have been exposed by melting suggest an arrow's fletching, for example, becomes detached within a year of exposure, sinew shortly thereafter. Wood deteriorates in four or five years, and bone or antler within 10 years.

At the time of project inception, in 2010, ongoing studies measured changes in glaciers in Glacier NP, but no effort had been made to determine what dramatic environmental change has had on cultural resources associated with ice patches. Increasingly rapid ice and snowmelt in Glacier National Park created a critical cultural resource issue that the park decided must be addressed in a timely and comprehensive manner. Thorough examination and evaluation of impacts are the first steps to address endangered cultural and scientific resources and knowledge. Cultural resource studies focused on areas newly exposed by receding ice and snow fields provide insights about prehistoric lifeways in alpine and subalpine zones, as well as essential information on ancient climates and recent changes that are critical for evaluating the historical context of recent man-made habitat shifts. In addition, monitoring of ice and snow fields and exposed artifacts is critical. Such efforts must be coordinated among Native American tribes, environmental scientists, and archeologists to ensure consideration of issues, values, synergy between different domains of knowledge, and compliance with federal laws governing stewardship of cultural resources (36 CFR Part 800, Sections 110 and 106 of the National Historic Preservation Act, Sacred Sites [EO 13007], the Native American Graves Protection and Repatriation Act (43 CFR Part 10), the Archeological Resources Protection Act, and others).

Project Objectives

The "Ice Patches as Sources of Archeological and Paleoecological Data in Climate Change Research in Glacier National Park" project took place over a five-year period (2010 through 2015) and involved a partnership between Glacier National Park, the University of Wyoming (UWY), the Institute for Arctic and Alpine Research at the University of Colorado, Boulder (INSTAAR), the Confederated Salish and Kootenai Tribes of the Flathead Reservation (CSKT), and the Blackfeet Nation (BN). The project's overall objectives were:

- To work collaboratively with scientists from the University of Wyoming and INSTAAR to investigate and document ice/snow patches in Glacier National Park in order to identify archeological, ethnographic, and paleobiological resources endangered by recent climate change and to recover archeological and paleoecological data relevant to global warming research.
- To work collaboratively with the Confederated Salish and Kootenai Tribes of the Flathead Nation and the Blackfeet Nation to develop and implement culturally appropriate protective and conservation measures for sensitive cultural sites, features, and objects at risk from snowmelt.
- To enhance cultural resource stewardship and protection at Glacier National Park through public education and interpretation about climate change impacts on cultural resources and resident indigenous communities.
- To develop a strategy and methodology for assessing and mitigating impacts to cultural resources from glacial and snow/ice field recession that can serve as a model for other parks, agencies and entities in the United States and throughout the world.

PROJECT INFRASTRUCTURE

Principal Investigators (PI's)

Robert L. Kelly, Dept. of Anthropology, University of Wyoming, Laramie, WY 82071

Craig M. Lee, Institute of Arctic and Alpine Research (INSTAAR), University of Colorado, Boulder, 450 UCB, Boulder, Colorado 80309-0450

Tribal Expertise

Confederated Salish and Kootenai Tribes of the Flathead Nation (CSKT), Tribal Preservation Department

Blackfeet Tribal Business Council (BN)

Government Expertise

National Park Service, GNP

Rocky Mountains Cooperative Ecosystems Study Unit (RM-CESU)

Climate Change Response Program

PROJECT DELIVERABLES COMPLETED

1. The PI's and NPS developed Cooperative Agreements with the BN and CSKT regarding project implementation and funds transfer.
2. The project partners established a cultural resource management group (CRMG) that was the project's planning body throughout the project's lifespan.
3. The CRMG created a Plan of Action for the inadvertent discovery of Native American burials or other items covered under NAGPRA during project activities (Appendix A).
4. Ethnographic study of tribal traditional cultural use of GLAC including archival, and oral history research focusing on identifying cultural use areas, Native American trails, ethnobotanical resources, and place names within the study area. (See Zedeño Appendix C).
5. A GIS database plotting the location of target ice patches. This information was used to create a list of ice patches ranked in terms of their potential for the recovery of artifacts and paleobiological materials. Note: Copies of database held by CSKT and NPS.
6. A special protocol for culturally appropriate documentation, preservation in place, recovery, and curation of organic prehistoric artifacts that meets or exceeds federal standards (Sections 106 and 110 of the National Historic Preservation Act, the Archeological Resources Protection Act, and 36 CFR Part 79: Curation of Federally-

Owned and Administered Archeological Collections) is included in the technical report and as a handbook to be shared widely with other national parks (Appendix A).

7. Numerous presentations at professional conferences such as the Society for American Archaeology's annual meeting, and an article published in a special issue of the Society for American Archaeology's Archaeological Record.
8. The NPS was to seek additional funding for an interactive cultural resource management system (CRMS) for the project in a web-based format, designed for use by non-technical GLAC managers. This task would be performed by the CSKT. Note: In the absence of definitive archaeological material identified in association with ice patches, this was not pursued by the NPS.

FIELDWORK

ICE PATCH IDENTIFICATION

Glacier National Park contains hundreds of ice patches; however, not all of these have an equal probability of preserving organic artifacts and paleobiological (PB) materials in a recoverable state due to their aspect, ease of access, relative proximity, etc. Using virtual globes, e.g., Google Earth, and other publically available imagery Lee identified 46 locations with some similarity to archaeologically and/or paleobiologically productive ice patches elsewhere in North America, e.g., Alaska (Dixon et al. 2005) and the Greater Yellowstone Area (Lee 2010, 2012, 2013), based on *a posteriori* criteria. The locations were selected and assigned a letter grade, A, B, or C, based on their potential relative to each other following the protocols laid out in the proposal. Three additional points were added based on traditional tribal knowledge. The initial 49 locations were: (a) accessible on foot (ones inaccessible by foot would not have been used in ancient times), (b) still existed in high melt years based on the dated imagery available, and (c) had a relatively flat forefield (downslope from the ice patch)–while artifacts and paleobiological materials may be exposed in ice patches without a flat forefield, such material is rapidly transported downslope and destroyed by meltwater and summer rainfall. At the close of the 2010 field season we learned of and began trying to access imagery of GNP obtained by the United States Geologic Survey (USGS) during a period of extensive melting in mid-September 1998. The USGS obtained the imagery to study GNP's retreating glaciers and fortuitously captured some of the ice patch locations we were targeting as well.

USGS Image Orthorectification and Refined Ice Patch Identification

Although the USGS had previously digitized the imagery onto several hundred compact discs, the files we needed were corrupt. Thankfully, the prints and diapositives—essentially 10" x 10" slides—were still available. The images were used to refine our initial selection of ice patches. Of the 46 initial targets, 18 were thrown out because they lacked permanent snow and ice and showed no obvious organic remnant suggesting the locations had previously held organic-rich ice when examined with a 10x magnification loupe. Of the remainder, 20 fit the criteria noted previously with a relative ranking of "B" or better. Because of the potential for inter-annual snow cover to occlude the areas of more permanent ice that could be exposed during periods of maximum melting, as well as portions of the forefield below the target locations, we decided it would be beneficial to incorporate the USGS images into our GIS for use in the field. Specifically, we determined a polygon of the ice patch perimeter would be useful for knowing our position in the field relative to the areas of old ice and the intermittently snow-covered areas of the forefield. The USGS images would also provide a data point for the Park, CSKT and BN to monitor climate change at ice patch locations into the future.

To incorporate the images into our study they needed to be orthorectified, which involves geospatial processing to remove distortions inherent in the scanned frames due to the position and orientation of the camera, properties of the camera lens, and especially the topographic relief of the area. INSTAAR's Quaternary GIS laboratory (QGIS) accomplished the orthorectification of 27 frames of the 1998 photography into nine mosaics in GeoTIFF format with a common projection and datum (UTM zone 12, NAD83) and a resolution of 0.3 m (1 ft) (Figure 1). QGIS sent the orthorectified images to CSKT-GIS and Martin Zobel at CSKT-GIS created polygons of the minimum ice patch extents. Although there were technical issues with some of the digitized images in the field, 11" x 17" printouts of the target ice patches showing the minimum ice extents were useful, and in 2013 the shapefile helped us to accurately target our coring activities (see Ice Patch Coring section). Rectified images and metadata were transmitted to all project partners, including the NPS, CSKT and BN by October 13, 2012. A detail image from one of the bundle blocks appears on the project website.

Pedestrian Survey

Pedestrian survey took place in late August and early September in 2010, 2012, and 2013 when snow melt is generally at its maximum for the year (Lee et al. 2009; Seifert et al. 2009).

Fieldwork dates were: August 27 – September 8, 2010; August 21 – September 6, 2012; August 19 – August 28, 2013.

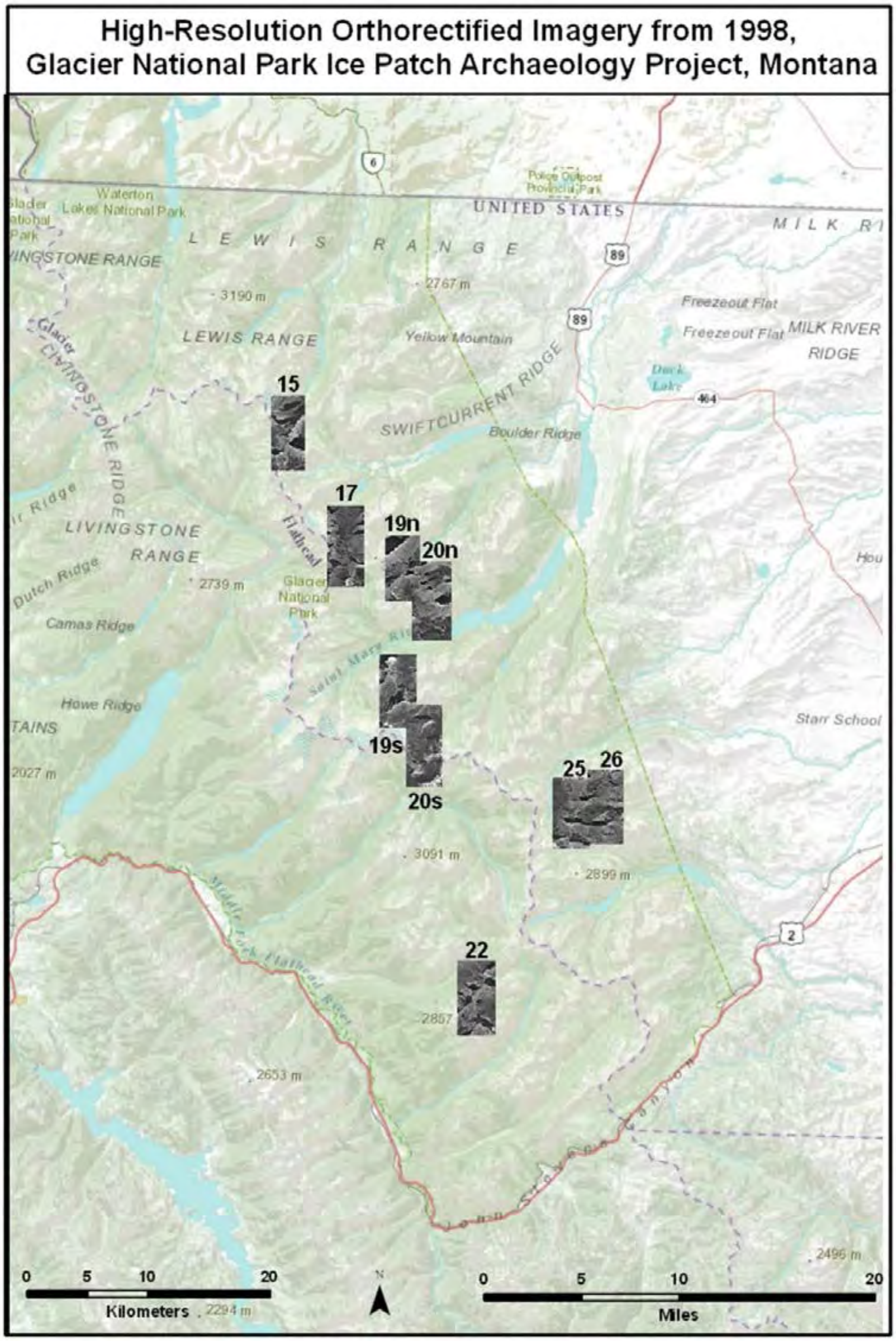

Figure 1: QGIS Orthorectification Bundle Blocks

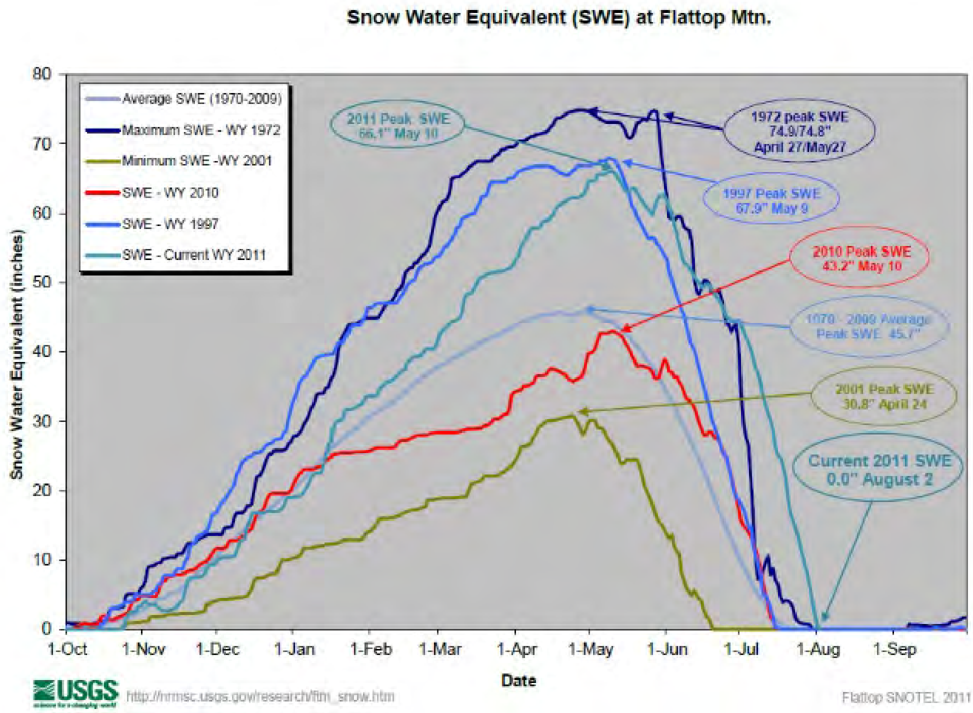

Figure 2: Peak snowfall levels for Flattop Mountain SNOTL, which served as a proxy for snow levels in the Park during the project; the winter of 2010/2011 was the third highest snow year logged at the Flat Top Mountain SNOTEL (https://www.nwrfc.noaa.gov/snow/snow_peak_hist.php?id=FTMM8)

No artifacts were recovered during the survey; however, we did encounter a lithic site near Red Eagle Pass (Figure 3), details of which were conveyed to CSKT, BN and GNP July 12, 2015 via email.

The project also recovered a number of paleobiological materials (Table 2, Table 3). The most faunal materials were recovered from ice patches 16 and 35 (Table 3). It was at patch 35 that we recovered several well-preserved pieces of bison that were buried but being exposed by erosion. This included a skull and several long bone pieces; some of the highly weathered pieces collected might belong to the same animal, with the difference in weathering being a product of differential exposure to sunlight. Project collaborator Dr. Beth Shapiro and her team at University of California Santa Cruz were able to recover DNA from the femur of the bison; that report is included as Appendix D.

Figure 3. Location of archeological site in Red Eagle Pass. On right, site is located in foreground; left shows a portion of the trail where material was exposed.

All materials were located using a GPS instrument, photographed (both close-up and showing the specimen's location relative to the ice patch), and collected in a labeled plastic bag. A few pieces were stabilized on sturdy plastic sheeting. All locational data in 2010 were recorded by CSKT fieldworkers; in 2012 and 2013 data were collected by Kelly and were transmitted to the CSKT GIS office. In the lab, wood specimens were identified, and bone (all animal) were identified to genus and/or species. All wood samples were AMS dated. No obsidian artifacts were located.

All materials are curated at the Billings Curation Center in Billings, Montana (accession number 1714), and the disposition of field data (notes, photographs, logs, sketch maps, etc.) at Glacier NP.

Survey Results

We collected 42 pieces of wood, about 96 pieces of bone and horn (3 from GLAC-16, 2 from GLAC-20, 3 from GLAC-34, 38 from GLAC-35 and one from GLAC-38A, not including assorted cranial fragments from GLAC-35). Among the GLAC-35 remains were those of a bison found clustered together (including skull, femur, two vertebrae), just below the surface and in the process of being exposed. Once exposed, bone quickly degrades due to ultraviolet radiation so we elected to recover it. We discussed the possibility in the field that the skull could be a ritual object. Unfortunately, we had no tribal members with us. We finally decided that since the skull was in direct, jumbled contact with a variety of post-cranial remains that it was not a ritual object. Upon returning to our vehicle, we took the skull to Park authorities and had it examined by a tribal representative, Mr. Francis Auld; he concurred that it was unlikely to be a ritual object. A 3D interactive image of the skull appears on the project website (http://glaciericepatch.org).

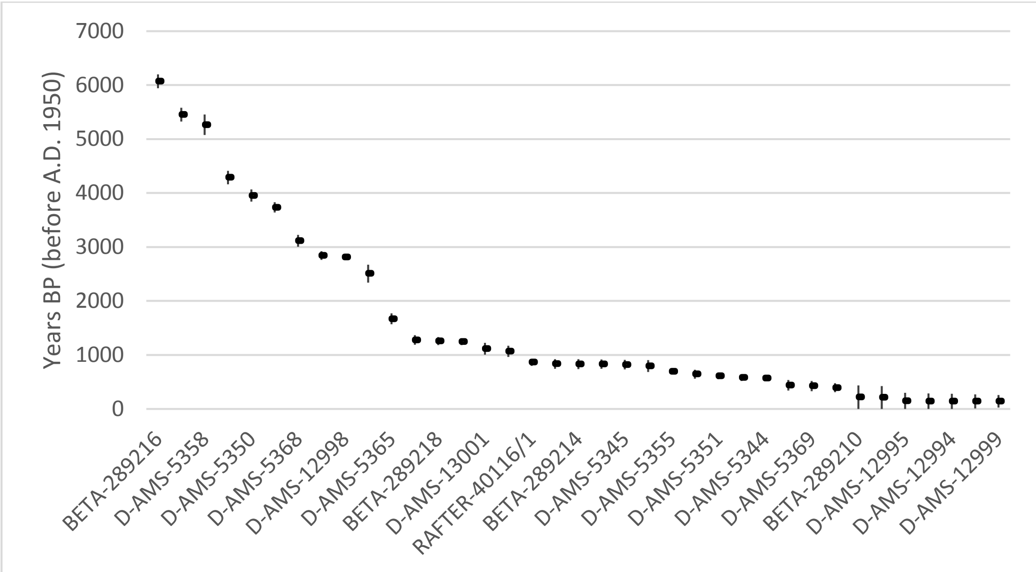

Figure 4: Calibrated (OxCal, IntCal13) ^{14}C dates (N = 37) from Glacier National Park (paleobiological material, no artifacts).

We obtained 48 dates (Table 2; Figure 4) from materials recovered in ice patch forefields. Of these, three fell within ~70 years prior to A.D. 1950 and cannot be calibrated (they are probably early 20th century dates) and 8 were determined to be "modern" (post A.D. 1950) by the labs (leaving 37 calibrated dates). In addition, we obtained 12 dates from the Siyeh ice patch cores, three of which were modern (more than 12 samples were submitted from the ice cores, but several were too small for measurement).

Twenty-one of the paleobiological dates fall within the 1000 calibrated years prior to A.D. 1950 (note that two of these dates are re-dated samples: GLAC-38A-1 and GLAC-41-4; the two dates from GLAC-41-4 are statistically the same; those from GLAC 38A-1, run by the same lab, Direct-AMS, are significantly but not greatly different); the others fall more or less evenly between 1000 and 6000 cal B.P. This distribution suggests: (a) that while the dates are expectably biased toward younger materials as a straightforward function of organic decay, (b) materials up to 1000 cal years old are highly likely to be preserved in an ice patch context, and (c) materials up to 6000 cal years old are possible to be recovered from ice patch contexts. Additionally, the lack of materials dating older than 6000 cal years supports a hypothesis that most snow and ice in GNP melted out prior to 600-yers-ago with any entrained organic materials held in them completely decaying before the ice patches were re-established ~6000 years ago.

This interpretation is further supported by the findings of the ice patch coring project (see Ice Patch Coring).

Collected wood samples were identified by Kathryn Puseman (PAST, LLC). Some specimens were also initially identified by Rick Weathermon (University of Wyoming) and Claire Alix (University of Paris-Sorbonne, University of Alaska-Fairbanks). Puseman verified all of the identifications by Alix; Weathermon tentatively identified some specimens as yew but neither Puseman nor Alix could confirm these. Table 2 contains only the identifications made by Puseman and the basis of the identifications. We have not made a careful comparison of the identified wood specimens with the current vegetation, but the species identified (*Abies* or Fir; *Picea* or Spruce; *Pinus monticola* or western White Pine; *Tsuga* or Hemlock; and *Pseudotsuga* or Douglas Fir) are common in GNP today. Some of the rooted specimens may reflect changes in treeline. Although we have not made careful study of modern tree line relative to the dated specimens, the data presented here easily permit such a study (Table 2). Ice patch PB remains were recovered between 6500 and 8200 feet and date between 5300 radiocarbon years and "modern." There is no relationship between elevation and the age of PB remains ($r = 0.003$, $p > 0.05$).

<u>Ice Patch Coring</u>

We devoted the first four days of fieldwork in 2012 to coring ice patches 40 (Piegan Pass) and 37 (Siyeh Pass). Our goal was to obtain materials suitable for ^{14}C dating from the ice patch itself in order to see the relationship between the age of recovered/exposed material and what might still be contained in the ice. We decided to test this approach at Piegan Pass and Siyeh Pass in part because those patches are accessible via established trails, and the coring procedure requires backpacking heavy and cumbersome equipment.

Prior to the field season, we consulted with the U.S. Ice Drilling Design and Operations (IDDO) Center at the University of Wisconsin (http://www.icedrill.org/) as to whether it was feasible to core these temperate ice patches, and, if so, what instrument should be used. Following their recommendation, we settled on a PICO hand auger. We found the device very difficult to use in the field, and noticed that the last line in the instructions stated that this device should not be used on temperate ice (ice at or near 0 degrees centigrade, which describes GNP's ice patches). The Park's automotive shop helped us modify the coring barrel, but this effort failed to yield a better result. We called the Ice Drilling program, and also consulted in person with Lou Albershardt, an individual with 28 years of coring experience in Antarctica and Greenland (she confirmed that we were using the device properly). In brief, despite several attempts we were unable to retrieve more than about 1.5 m of core, all of which was undoubtedly compact snow from the heavy winter of 2010/2011 (Figure 2). We determined that mid-latitude coring likely required a coring device with a sleeve to keep the coring device from binding fast to the shavings produced by the coring action.

Accordingly, in 2013 we revisited our coring objectives with IDDO. In short, the goal of the coring operation was to identify and recover organic material in the ice, such as lag surfaces that might have concentrated organic materials from previous periods of melting. In essence, the lags are concentrations of diffuse organic material comprised of windblown organic and inorganic material as well as animal feces held in the matrix of the snow during decadal or even century-long periods of snow accumulation. When major melting occurs, this material begins to concentrate and eventually collects in a gradually thickening organic lag. Depending on past climate cycles, numerous lags can be present in a given ice patch. The lag samples are amenable to a variety of analyses, including composition analysis by paleobotanists and age characterization using radiocarbon dating; while a given lag may consist of material from a variety of time periods, if more than one lag is present at an ice patch, they are chronostratigraphically ordered.

Following discussions with IDDO we decided to use the "Prairie Dog" coring device and the "Sidewinder" platform (Figure 5). The Prairie Dog is driven by a ¾ horsepower electric drill connected to an external generator via a rheostat. The ca. 2m long core barrel consists of a ca. 5" wide internal barrel with flights to carry ice chips away from the ca. 6" wide, fluted cutting head, and a ca. 6" wide smooth external core barrel, which serves to isolate the chips produced by the cutting head from the exterior walls of the borehole. This configuration allows for the device to be more easily removed from the borehole after cutting a length of core. (The absence of the external barrel was our undoing with the PICO hand auger as the cut ice chips adhered to the borehole walls when we tried to extract it, effectively freezing it in place.) The sidewinder mounts to the coring platform and allows for the drill to "winch" the coring device out of the borehole; a significant advantage when working at depth after multiple extensions are added to the core barrel.

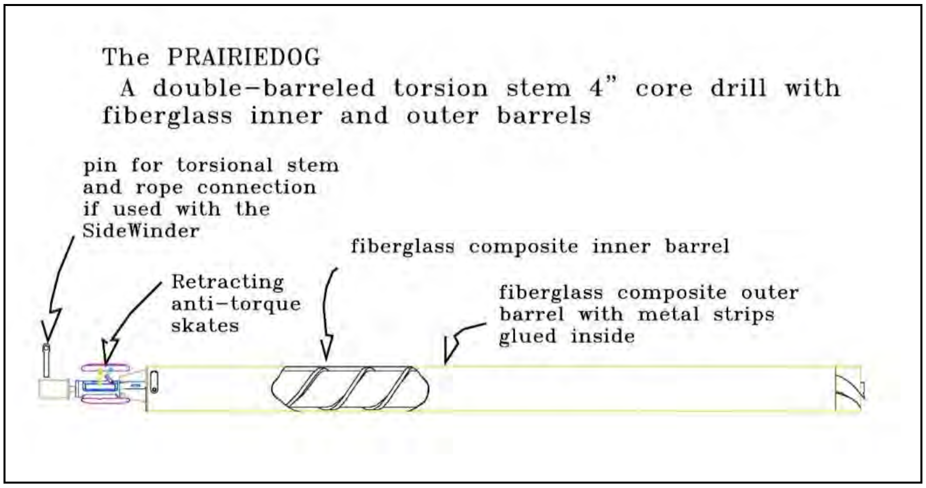

Figure 5: The 'PrairieDog', a Double-Barreled Torsion Stem Drill (adapted from Kyne and McConnell 2007).

This device was significantly more complex than the PICO, requiring the participation of an IDDO-trained operator, Mr. Jay Kyne, for the 2013 field season. With years of coring experience in Greenland and Antarctica, as well as an engineering background, including the design and manufacture of the anti-torque device which stops the external barrel from spinning, Mr. Kyne's assistance was mission-critical. In addition to the Prairie Dog, Mr. Kyne also brought a ca. 3.5" diameter "thermal drill," which uses a ceramic element similar to a heating element on a classic electric stove to melt through snow and ice. The generator was slightly underpowered for this unit, but as it turns out, this piece of equipment was critical to melt us through a layer of small gravel when we reached an impasse with the Prairie Dog unit in the second borehole. We were ultimately successful at extracting two cores from the Siyeh Pass ice patch, the second of which we are fairly confident reached the bottom of the ice patch (Figure 6).

We were not able to save the entire core but instead recovered organic lag deposits that appear as obvious black layers in an otherwise white or clear core of snow and ice (Table 4). The approximate depth of these organic deposits was recorded in the field and the core cut a few inches above and below the lag deposit, rinsed, and placed in a wide-mouthed plastic

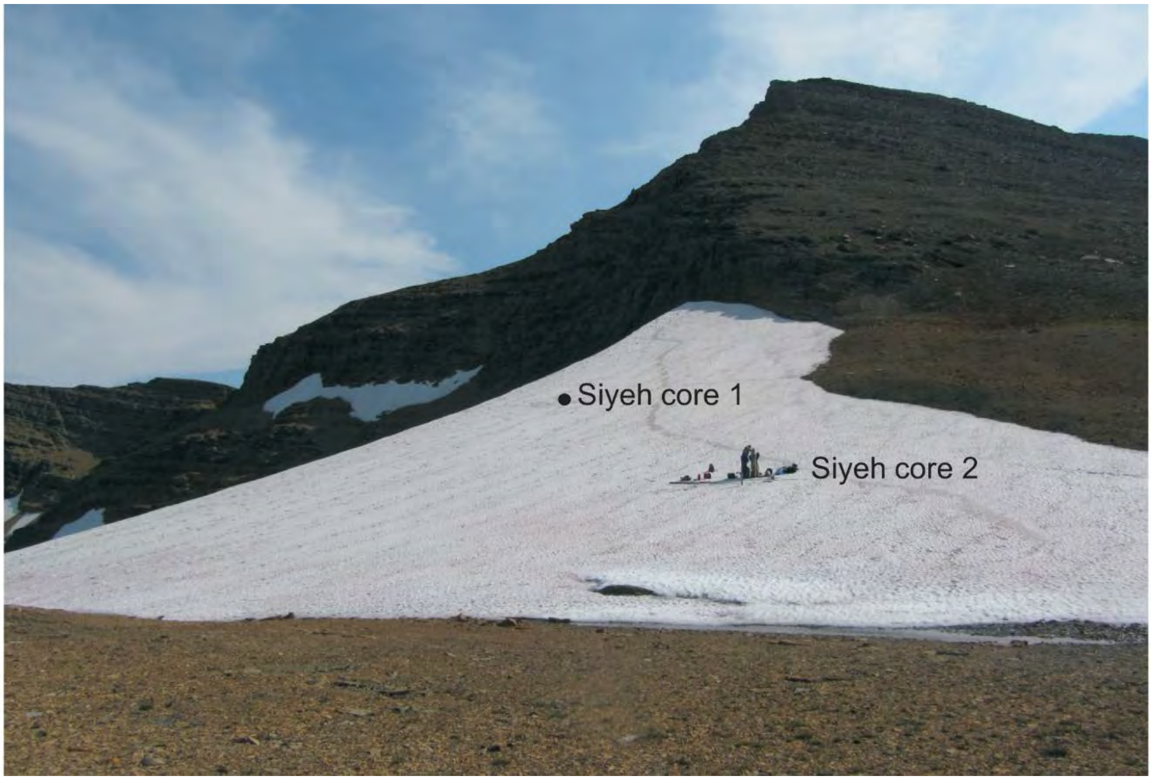

Figure 6: Siyeh Pass Ice Patch with coring locations, facing S.

container for transport. After the deposit melted it was passed through a #230 geologic screen, allowed to dry, and bagged.

The first core reached a maximum depth of 8.2m, we suspect it did not reach the underlying ground surface, but instead hung up on a rock. We moved the coring device downslope (see Figure 6), where, using CSKT’s GIS data, we estimated the ground surface lay at 6.5m below the surface of the snow; the device struck a heavy layer of sediment with organic material at 6.4m. We believe this is the underlying ground surface and three dates from the material recovered in the core produce an age of ~6500 cal B.P. for the underlying ground surface.

Interestingly, at about 6m an organic lag deposit returned at age of ~6060 cal B.P., and at about 5.5m an age of 3988 cal B.P. Two organic lag deposits between 4 and 5m below the ice patch’s surface provided modern ages. In other words, about 4.5m of the Siyeh ice patch consists of snow that fell since A.D. 1950, and, given the high melt years of the early 2000s, probably fell only in the few years before A.D. 2013. The Siyeh Ice patch was within a meter of reaching a minimally ~4000-year-old surface, and within two meters of the ice patch’s bottom, a bottom that has probably not been exposed for the past 6500 years (Figure 7).

In the first core, we struck an organic lag deposit at nearly 8m below the ice patch's surface that returned an age of ~6735 cal B.P. – about the same age as the base of core 2, and may be evidence that core 1 was close to the underlying ground surface. Above this lag deposits was another at ~7.4m that returned discordant ages of 3365 and 290 cal B.P. We suspect the material that provided the younger age was carried downward by the coring process. Despite the fact that we rinsed off the lag-containing segments of the core, this lag deposit still contained black plastic shavings from the core equipment. Note: these shavings are quite abundant in a lag deposit at 5m that provided a modern age; possibly, then, organic material could have been carried downward by the drill, material that then quickly refroze and adhered to the core's surface. In the future, such samples should perhaps be rinsed and even lightly scraped to remove any material carried downward by the core.

Core 1 also returned an age of ~4410 cal B.P. at 6.7m, above the 3365 cal B.P. lag deposit. We cannot explain this reversal but point out that the taphonomy of ice patch deposits is virtually unknown. Above this lag deposit, at 5m we obtained a modern age.

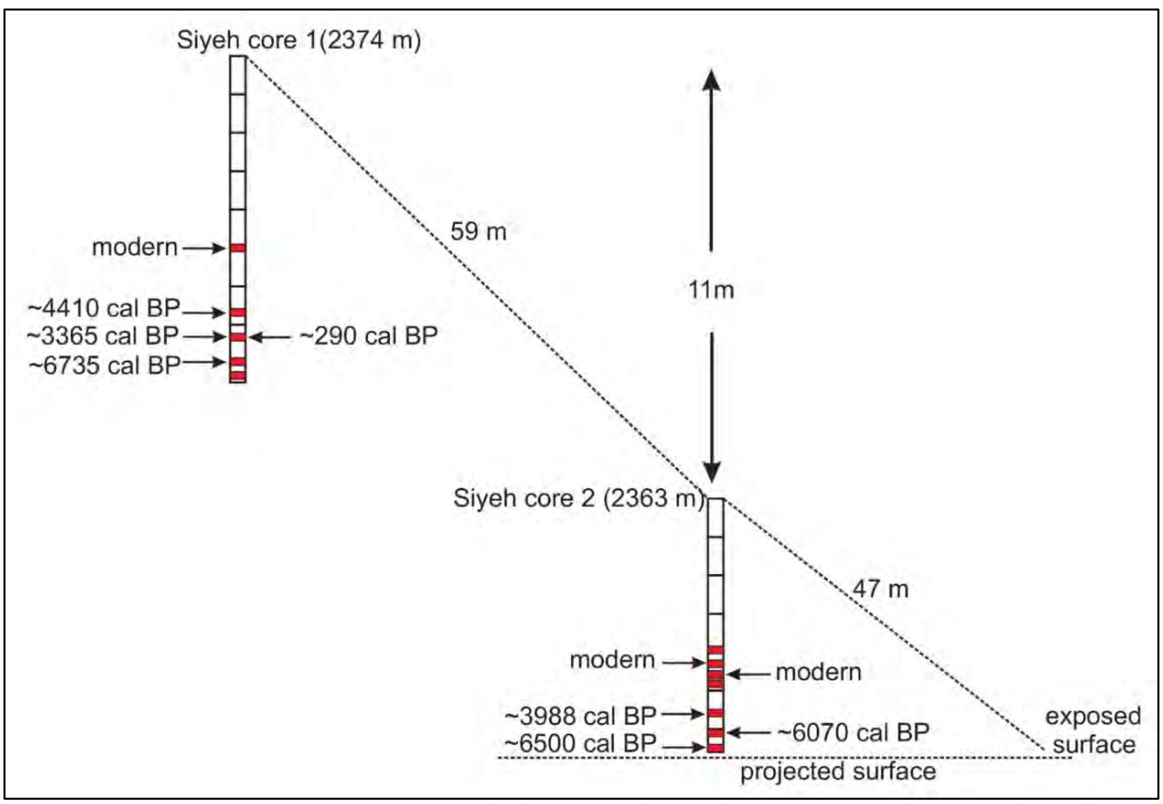

Figure 7: Graph of Siyeh Ice Patch Lags and ^{14}C dates.

In sum, Cores 1 and 2 both suggest that the Siyeh ice patch most likely did not exist, or was considerably smaller prior to ~6700 cal B.P. and much of the snow comprising this patch fell after A.D. 1950 and perhaps as late as after the early 2000s. We suggest that such coring of other ice patches in the Park could provide significant data on when ice patches were present, when they underwent significant melt episodes, and by extension evidence on climate change of at least the past 6000 – 7000 years.

ICE PATCH EXTENT ANALYSIS

During the course of the project, it was apparent our pedestrian survey did not encounter the minimum historic ice extents captured by the 1998 USGS images (see Refined Ice Patch Identification & USGS Image Orthorectification section). To assess the difference in ice extent we compared the margin position recorded by GPS in the field relative to dated/processed imagery available in Google Earth for several of the target ice patches (Figure 8). After the close of the fieldwork portion of the project, Google Earth released images dated/processed

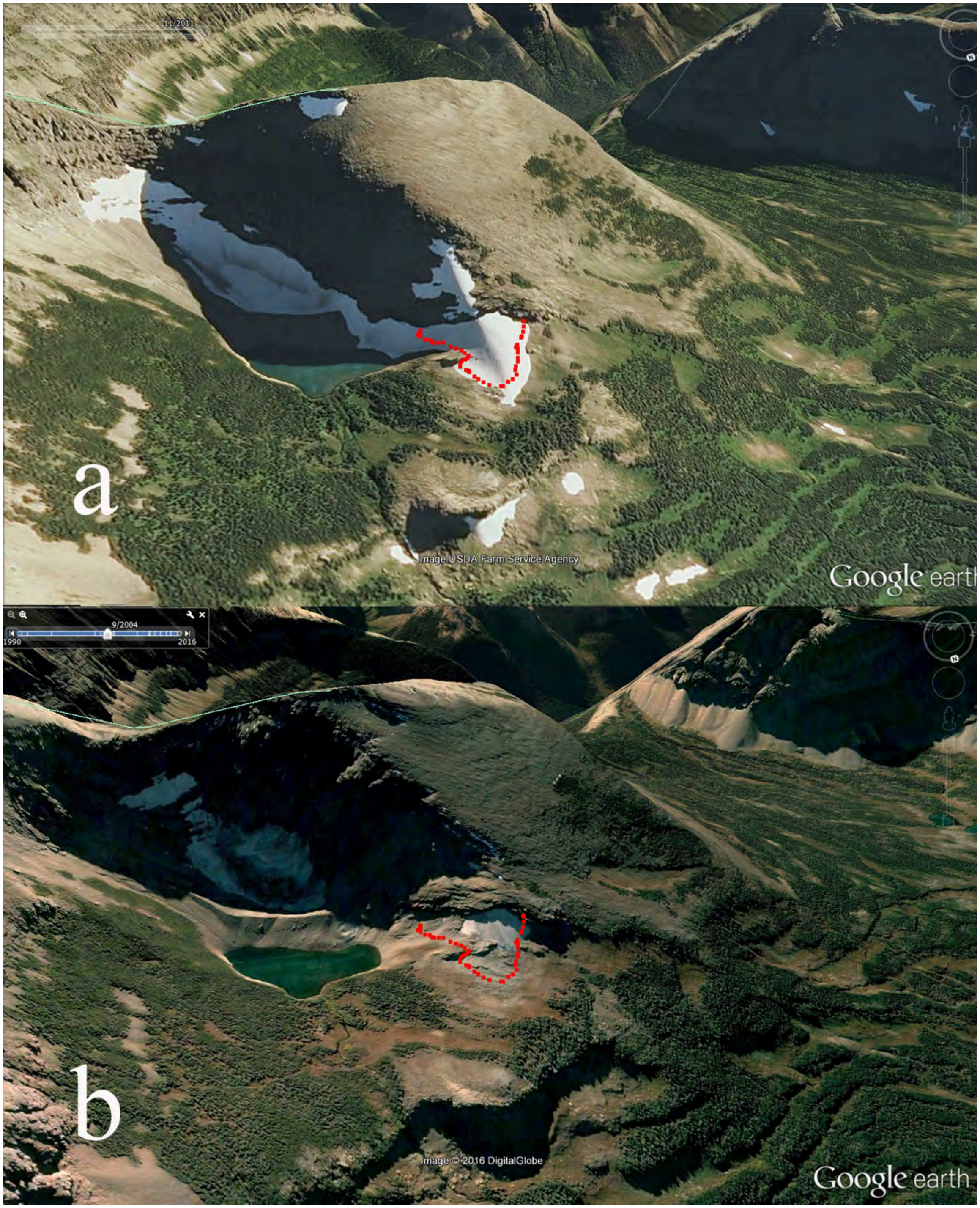

Figure 8: Ice patch margin at GLAC 30 (Red Eagle Pass) recorded by GPS during pedestrian survey on September 5, 2012 overlain on: (a) Google Earth image dated/processed August 2011 and (b) Google Earth image dated/processed September 2004 (see Footnote 1).

November 2011, which more clearly approximated the ice extents we encountered (Figure 8).[1] The ice extents revealed in the 1998 USGS images are invariably reduced beyond those illustrated in Figure 3b (see USGS Image Orthorectification & Refined Ice Patch Identification).

In contrast to mass balance measurements such as at Sperry Glacier in GNP, which show a trend toward melting,[2] the ice patch extents we observed revealed interannual variability in GNP ice patch extents (Figure 9). Ice patches "breathe" at a different rate than glaciers, and their extent and thickness can be dramatically altered by major and minor snowfall events depending on wind direction and velocity (Lee 2013).

Although the survey conditions were not optimal because of extensive late-lying snow, or snow from recent storms, if a significant volume of archaeological material was present at the target ice patches, it seems probable the project would have encountered something. The volume of dated paleobiological material attests to the fact that we encountered ancient material in the forefields (Table 2).

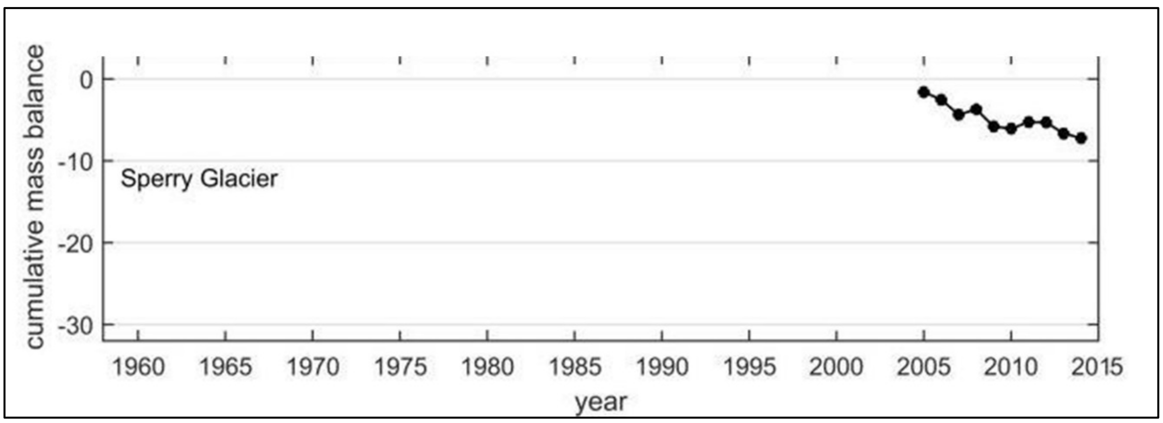

Figure 9: Glaciological (direct) measurement of cumulative mass balance in 'meters of water equivalent' at Sperry Glacier, GNP, a USGS Benchmark Glacier (adapted from: https://www2.usgs.gov/climate_landuse/clu_rd/glacierstudies/results.asp).

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[1] The images were not taken in November 2011, but were processed/posted to Google Earth then. The "Imagery Date" shows the oldest date in the possible range, so that a date is never newer than the actual image collection date (https://support.google.com/earth/answer/6327779?hl=en).

[2] The mass balance of a glacier is the difference between the snow accumulated in the winter and the snow and ice melted over the summer. If the mass of snow accumulated during the winter exceeds the mass of snow and ice lost during summer, the mass balance is positive; if the snow and ice lost during summer exceeds what was gained during the previous winter, the mass balance of the glacier is negative.

Aerial Survey

Oblique aerial photography (OAP) is an effective method for assessing ice patch conditions because the image acquisition can be optimized to coincide with maximum annual snow melt, as well as optimal light conditions. For example, mid-morning light tends to minimize shadows. OAP is also more revealing of local topography than vertical images obtained from satellites (Lee 2013, 2014a, 2014b). Based on the minimum ice extents of the ice patches revealed in the 1998 USGS images (see Refined Ice Patch Identification & USGS Image Orthorectification section), it was clear the pedestrian surveys did not directly observe the areas of more permanent ice exposed during periods of maximum melting.

To assess late-season snow conditions (post-pedestrian-survey) at the target ice patches, the project contracted with Chris Boyer, Kestrel Aerial Services (KAS), to photograph up to 13 of them in early to mid-September. In addition to the photos of the target locations, CSKT partners requested photos of the mountain scenery as well as a video conveying the grandeur of the area. Heavy, late-summer snow events forced cancelation of the flight in 2013 and 2014. The aerial photography was finally accomplished in 2015 in two separate flights. The first flight, which occurred on September 2, was truncated after only three sites were visited due to winds in excess of 30 knots and severe downdrafts (pers. comm., Boyer 2015). By the time the second flight occurred on September 10, light snow had fallen. Despite the trace of fresh snow, in concert with the 1998 USGS images, the KAS images helped refine the rankings for the ice patches targeted by the project (see Table 1/Appendix X) and to make attendant management recommendations.

Contact sheets for the KAS images are included in Appendix E. The images were transmitted to all project partners, including the NPS, CSKT and BN, on Oct. 20, 2015. Some of these images and the video appear on the project website.

PROJECT VIDEO AND WEBSITE

From the outset there was interest on the part of all parties to share the information with the public, and toward that end, the project participants worked collaboratively to produce a video with Salish Kootenai College Media/KSKC Public TV. The result of the effort is streamed through YouTube via the following link:
www.youtube.com/watch?v=w1Vgs9IMixY&feature=youtu.be

Additionally, the project worked with a webpage designer to create a virtual project platform to release updates about the fieldwork and later analyses. Importantly, the webpage was set up to live on until at least 2020 after the conclusion of the project. The webpage has become a centralizing source for ice patch related projects through the "Ice Patch Research Worldwide" tab: http://glaciericepatch.org/

PROJECT RECOGNITION

In 2013, the project was recognized by the Secretary of the Interior with a *Partnerships in Conservation Award* (Figure 10). The award honors organizations that have achieved exemplary

Figure 10: Partners in Conservation Award Ceremony October 18, 2012 with notable project participants Pei-Lin Yu (second from left) and Kevin Askin (second from right).

conservation results through public-private cooperation and community engagement. According to Deputy Secretary of the Interior David J. Hayes, "The Partners in Conservation Awards offer wonderful examples of how America's greatest conservation legacies are created when communities from a wide range of backgrounds work together. These awards recognize dedicated citizens from across our nation who collaborate to conserve and restore America's great outdoors; to encourage youth involvement in conservation; and to forge solutions to complex natural resource challenges." The award citation notes the project has directly engaged Native Americans in National Park Service cultural and natural resource stewardship in an era of climate change.

DISSEMINATION

2010 Lee, Sam and Yu made a presentation at the National CESU Meeting, Washington, DC on June 24.

2010 Lee presented a brief prepared by all on the planning and completion of YR1 fieldwork for the Second International Glacial Archaeology Symposium (Frozen Pasts), Trondheim, Norway. October 5-7, 2010

2011 Lee, C., R. L. Kelly, I. Matt, R. Reckin and M. Pablo. Alpine Snow and Ice as a Source of Archaeological and Paleoecological Data in the Rocky Mountains. Paper presented at the 76th annual meeting of the Society for American Archaeology, Sacramento. April

2011 Lee, C., and R.L. Kelly presented *Alpine Snow and Ice as a Source of Archaeological and Paleoecological Data in the Rocky Mountains* for Salish Kootenai College, Johnny Arlee/Victor Charlo Theater, Polson, MT; video copies were provided to the GCRMG group.

2011 Rachel Reckin, Ira Matt, Robert L. Kelly, Craig Lee, Marcia Pablo, and Pei-Lin Yu. Alpine Snow and Ice as a Source of Archaeological and Paleoecological Data in Glacier National Park. Paper presented at the 2011 Rocky Mountain Conference, Missoula, MT.

2012 Craig Lee, Pei Lin Yu and Ira Matt shared a project update with the Salish Culture Committee at St. Ignatious, MT on May 2, 2012. A brief recap of the meeting appeared in the Char-Koosta News (Official Newspaper of the Salish and Kootenai).

2012 Craig Lee and Kevin Askin shared a project update with the Kootnei Culture Committee at Elmo, MT on May 9, 2012.

2012 Craig Lee and Frank Tyro team presented the paper contributed to by all “Mid-Latitude Ice Patch Research in North America: Progress in Glacier National Park and the Rocky Mountain West,” which included our nine-minute video product on research in Glacier National Park at Frozen Pasts: 3rd International Glacial Archaeology Conference, Whitehouse, Yukon, Canada. June 2012. Project participants agreed via email in June to share the video

2012 Craig Lee and Ira Matt shared a presentation titled “Ice Patch Archaeology and Paleoenvironmental Research in Glacier National Park and Vicinity” at the 9th Annual Waterton-Glacier Science and History Day, Waterton Alberta, Canada, July 26, 2012. The presentation was attended by staff and visitors from both Parks.

2014 Lee, Craig, R.L. Kelly, Rachel Reckin, Ira Matt, and Pei-Lin Yu. Ice Patch Archaeology in Western North America. *Society for American Archaeology Archaeological Record* 14(2): 17-21.

2015 Pei-Lin Yu, Craig Lee, Robert Kelly, Ira Matt, Francis Auld, Kevin Askan, John Murray, Maria Nieves Zedeno, Frank Tyro, David Rockwell. Ice Patch Archeology and Paleoecology in Glacier National Park: Emerging from the Ice *National Park Service, Archeology in Parks* http://www.nps.gov/archeology/sites/npsites/glacierIcePatch.htm.

2015 Lee, Craig, R.L. Kelly, K. Puseman, R. Reckin, I. Matt, and P-L Yu. Ice cores from ice patches: a novel paleoclimate proxy for the Rocky Mountain region. Presented at the 12th Biennial Rocky Mountain Anthropological Conference, Steamboat Springs, Co.

2016 Yu, Pei-Lin, R.L. Kelly, Craig Lee, Ira Matt, and John Murray. Climate Change, Archaeology, and Native Expertise: An Ice Patch Success Story. Paper presented at the 81st Society for American Archaeology Conference, Orlando, Florida.

2016 Craig M. Lee, Kelly, R.L., Rachel Reckin, Ira L. Matt, and Pei-Lin Yu. Frozen Pasts: Ice Patch Archaeology in the Glacier National Park Crown of the Continent and Greater Yellowstone Ecosystem e-magazine. http://crown-yellowstone.umt.edu/.

MANAGEMENT RECOMMENDATIONS

The project "Ice Patches as Sources of Archeological and Paleoecological Data in Climate Change Research" was a qualified success. The team surveyed the ice patches in GNP with the greatest archaeological potential based on the *a posteriori* characteristics gleaned from archaeologically productive ice patches elsewhere, and the project was unique in its collaborative nature. The creation of the CRMG is a lasting resource for the Park and a model for others. Although the survey conditions were not optimal because of extensive late-lying snow and/or snow from late summer storms, if a significant volume of archaeological material had been present at the target ice patches, it seems probable something would have encountered.

In general, the alpine topography of GNP is characterized by steep-sided arêtes, which contrast sharply with the rolling plateau country where archaeologically productive ice patches have been identified elsewhere in the coterminous US, e.g., the Greater Yellowstone. Ice patches tend to occur at the lowest elevations where permanent snow and ice can exist in a given area; in

GNP this is between 6500 and 8200 feet. (For contrast, most ice patches in the Greater Yellowstone occur between 10,000 and 10,500 feet [Lee 2013].) The lower elevation of the GNP ice patches also supports the growth of copious vegetation wherever the angle of repose and soil allows, which complicates survey, but may increase the volume of biota captured in an ice patch.

The ten 'A' ranked resources described in Table 1, including GLAC Ice Patches: 38 and 38A (Siyeh Pass); 40 and 41 (Peigan Pass); 13 (Mt. St. Nicholas); 35 and 36 (Otokomi Lake); 16, 17 (Lonely Lakes); 30 (Red Eagle Pass), should continue to be monitored for emergent archaeological and paleobiological material during periods of extreme melting. Additionally, KAS photographs of GLAC Ice Patches 4 and 25 suggests they too should/could be visited when major melting occurs (Appendix E). Appendix F mirrors advice given to Rocky Mountain and Yellowstone national parks and posits steps to take when/if inadvertent discoveries occur. Note: The dialogue fomented by the CRMG should be maintained to help in this regard.

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Table 1: Ice patches visited.

Ice patch number	Field Recon. Date	Approximate location	Recovery	Patch Rank Original/Revised USGS/Revised KAS*	Comments
no number, practice ice patch	8/28/10	Hidden Lake, near Visitor Center	None		visibility poor due to heavy snowfall on day of survey; considerable stream running from patch; patch ends partially in a stream-filled gorge; merits a re-survey in future under better conditions
15	8/30/10	Mad Wolf Mountain	Two PB specimens	A/F	Very large ice patch; visibility also poor due to snowfall; merits coring in future; vegetation along sides but not at top of patch; significant steam running along much of the edge; may actually be a glacier, multiple crevasses
19	9/3/10	Morning Star Lake	One PB, from top of ice patch	C/F	Flat forefield, very active stream running laterally a few meters from patch edge; specimen #1 is spruce, possibly root; clustered with 20 and 21, no permanent snow; no organic remnant
20	9/3/10	Morning Star Lake	Two PB, one possibly rooted wood	B/B	Large patch; there are small spruce trees above the patch; flat, but not wide forefield; specimen #2 is spruce; tiny patch in swale on lee of ridge
20A	9/3/10	Morning Star Lake	Two animal vertebrae	B/B	Patch not in original sample, limited albeit flat forefield
21	9/3/10	Morning Star Lake	none	B/F	Patch almost gone
38	9/7/10	Siyeh Pass	One PB	A/A	Patches 38 and 39 are a single continuous patch this year; they were separate in 2003; 38 has a steep, rocky forefield; very large patches
38A	9/7/10	Siyeh Pass	Three PB	A/A/A	Two additional pieces of modern wood (specimens 38A-3 and 38A-4), possibly old trail signs were located and photographed but not collected. Active stream running from patch, but wide flat forefield.
39	9/7/10	Siyeh Pass	None	A/A/B+	Large patch but forefield is very constrained with active stream running from patch

Ice patch number	Field Recon. Date	Approximate location	Recovery	Patch Rank Original/Revised USGS/Revised KAS*	Comments
40	9/5/10	Peigan Pass	Four PB specimens	A/A-/B+	On east side of pass, near established trail; steep forefield and difficult to survey.
41	9/5/10	Peigan Pass	Five PB specimens	B/A-	On west side of pass, about 1000 feet below, near, but not on established trail; one piece of modern backpack noted; wide flat forefield with small active stream running from patch
13	8/30/12	Mt. St. Nicholas	Seven wood specimens	B/A/A	lee of a hilltop; Krumholtz in area, so these could all be recent; organic rich ice/sediment observed in 1998 photo from small lobe of ice near the top
33, 34, 35, 36	8/27/12	Otokomi Lake	Bison remains, including much of the skull, partially buried; in excellent condition; GLAC 34-2, 3 possible birch; GLAC 35-5 wood; nothing recovered from GLAC 33 or 36	C/D(33), A/B+ (34), A/A-/A (35-36)	GLAC 34 and 35 had numerous faunal remains in their forefields, more than we had observed at other ice patches in GNP. These come from at least two species, mountain goat and bison. We initially thought that some of the other remains might be elk or horse, but analysis of the collected specimens and photos of the others taken in the field suggest that many are of the bison. Birch would suggest artifacts. Some krumholtz in area, but none directly above 34 and 35; photos show some possible organic staining at bottom of 35; both very steep ice patches.

Ice patch number	Field Recon. Date	Approximate location	Recovery	Patch Rank Original/Revised USGS/Revised KAS*	Comments
9, 16, 17	9/1-2/12	Lonely Lakes	GLAC 17-1, wood; GLAC 16-2,3 rooted wood	A/F (9), A/A+/A (16-17)	Krumholtz in area, especially above 16, so wood specimens are suspect; however, the rooted wood points to a drier, warmer climate when trees could take root in a forefield normally covered with snow/ice the better part of the year. GLAC 9 has no permanent ice/snow; no organic remnant; GLAC 17 is a tiny patch near lake, flat forefield with darkish ice; GLAC 16 has flat forefield, some dark organic staining, sitting off point of a ridge; GLAC 17 is tiny patch near lake; darkish ice from organics or sediment on photos, flat forefield
30	9/5/12	Red Eagle Pass	GLAC 30-1 through 4 wood; GLAC 30-5 large piece charred wood	A/A+/A	We thought that GLAC 30 was a good candidate for human use since it is close to Red Eagle Pass, which was an important travel corridor according to ethnographic data. Charred wood might signal the presence of humans; there is a lot of krumholtz above GLAC 30 today, so the wood specimens might be suspect. We did note the presence of archaeological remains on the pass itself; no collections were made, but the information was passed along to the park. Relatively flat forefield, low elevation
40	8/23/12	Piegan Pass	GLAC 40-4,5 wood specimens	A/A-	GLAC 40 was surveyed previously, in 2010. While ice coring we noted two additional pieces of wood, and given that this patch revealed a 5300 year old piece in 2010, we thought it wise to collect these; relatively steep forefield.
38	8/20/2013 to 8/23/13	Siyeh Pass	Two ice cores drilled	A/A	Drilled to 8.2m in core 1 and 6.4m in core 2; believe that we reached ground surface in core 2; three samples sent for 14C dating from base of core 2. Resurveyed base of GLAC 38, recovering one historic piece of wood.
1	8/24/13	Mt. Ellsworth	Surveyed, specimens GLAC 1-1,2,3,4	B/A-/B	Recovered 4 pieces of possibly rooted wood. Of note: There was a healthy stand of trees on the cliff face above the ice patch. The ice patch forefield is contrained by a protalus rampart

Ice patch number	Field Recon. Date	Approximate location	Recovery	Patch Rank Original/Revised USGS/Revised KAS*	Comments
32	8/27/13	Gunsight Pass	no finds	B/B-	noted presence of possible tent/cabin foundation near base of patch, next to large boulder. Location was recorded by NPS seasonals. Small forefield.
43	8/25/13	Ahern Pass (Iceberg Peak)	no finds	B/B+/B	forefield constrained by protalus rampart, possible Little Ice Age moraine? Or avalanche debris field; black ice present in photos

*In addition to the ice patches noted above, KAS photographed Ice Patches 4, 18, 25 and 31. Number 18 is at the head of the Lonely Lakes Valley; we observed it from a ridge. Number 31 is above a scarp/cliff band in Virginia Creek that we could not scale without technical gear. Numbers 4 and 25 are addressed in the management recommendations.

Table 2: Radiocarbon dates and wood identifications.

Field Number	Elev. (ft)	Lab No.	Material	$\delta^{13}C$ ‰	Conventional Age (uncal BP)	Percent Modern Carbon (pMC)	Plant ID	Comments (Wood identifications)
GLAC 1-1	7140	D-AMS-12995	Wood	-25.5	195 +/- 26	97.60 +/- .31	*Picea* sp.	Resin canals, piceoid cross-field pitting, no helical (spiral) thickenings
GLAC 1-2	7140	D-AMS-12997	Wood	-25.5	73 +/- 26	99.09 +/- .32	*Picea* sp.	Resin canals, piceoid cross-field pitting, no helical (spiral) thickenings
GLAC 1-3	7140	D-AMS-12999	Wood	-28.0	86 +/- 26	98.93 +/- .32	Conifer	Too deteriorated to determine
GLAC-1-4-1	7140	D-AMS-5344	Wood	-24.0	534 +/- 27	93.57 +/- .32	*Picea* sp.	Resin canals, piceoid cross-field pitting, no helical (spiral) thickenings, spiral checking
GLAC-13-1-1	8127	D-AMS-5345	Wood	-27.0	891 +/- 29	89.5 +/- .32	*Abies* sp.	No resin canals, taxodioid cross-field pitting, nodular end walls (in radial view). Thin-section has spiral checking
GLAC-13-2-1	8155	D-AMS-5346	Wood	-27.4	MODERN	136.4 +/- .42	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-13-3-1	8025	D-AMS-5347	Wood	-26.6	MODERN	110.06 +/- .36	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-13-4-1	8048	D-AMS-5348	Wood	-24.2	MODERN	121.52 +/- .41	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-13-5-1	8127	D-AMS-5349	Wood	-19.6	2377 +/- 32	74.39 +/- .30	cf. *Tsuga heterophylla*	No resin canals, apparent piceoid/cupressoid cross-field pitting, low rays, spiral checking
GLAC-13-6-1	8080	D-AMS-5350	Wood	-25.3	3620 +/- 30	63.72 +/- .24	*Pseudotsuga menziesii*	Resin canals, piceoid cross-field pitting, true helical (spiral) thickenings

Field Number	Elev. (ft)	Lab No.	Material	$\delta^{13}C$ ‰	Conventional Age (uncal BP)	Percent Modern Carbon (pMC)	Plant ID	Comments (Wood identifications)
GLAC-13-7-1	8182	D-AMS-5351	Wood	-23.1	638 +/- 28	92.36 +/- .32	*Abies* sp.	No resin canals, taxodioid cross-field pitting, nodular end walls (in radial view). Thin section has spiral checking
GLAC-15-1-1	7241	D-AMS-5352	Wood	-13.9	MODERN	124.78 +/- .49	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC 15-2	7241	BETA-289210	Wood	-23.2	250 +/- 40	**	*Abies* sp.	No resin canals, taxodioid cross-field pitting, nodular end walls
GLAC 16-1-1	7111	D-AMS-13001	horn, sheep?	-21.6	1190 +/- 29	86.23 +/- .31		
GLAC-16-2-1	7102	D-AMS-5353	Wood, rooted	-22.1	1131 +/- 27	86.87 +/- .29	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-16-3-1	7095	D-AMS-5354	wood, rooted	-21.6	907 +/- 31	89.32 +/- .34	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-17-1-1	7023	D-AMS-5355	Wood	-18.2	735 +/- 30	91.26 +/- .34	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC 19-1	6939	BETA-289211	Wood	-23.3	920 +/- 40	**	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC 20-1	6940	BETA-289212	Wood	-24.0	850 +/- 40	**	*Abies* sp.	No resin canals, taxodioid cross-field pitting, nodular end walls (in radial view). Thin section has spiral checking
GLAC 20-2	6940	BETA-289213	Wood, possibly rooted	-23.7	710 +/- 40	**	*Abies* sp.	No resin canals, taxodioid cross-field pitting, nodular end walls (in radial view), ray height consistent with fir (very tall rays)

Field Number	Elev. (ft)	Lab No.	Material	$\delta^{13}C$ ‰	Conventional Age (uncal BP)	Percent Modern Carbon (pMC)	Plant ID	Comments (Wood identifications)
GLAC 30-1	6958	D-AMS-12996	Wood	-34.9	MODERN	124.07 +/- .34	*Abies* sp.	No resin canals, taxodioid cross-field pitting, no resin canals, nodular end walls, ray height consistent with fir.
GLAC-30-2-1	6986	D-AMS-5356	Wood	-23.7	19 +/- 30	99.76 +/- .37	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-30-3-1	6986	D-AMS-5357	Wood	-21.7	3458 +/- 31	65.02 +/- .25	*Abies* sp.	No resin canals, taxodioid cross-field pitting, nodular end walls, ray height consistent with fir (very tall rays)
GLAC-30-4-1	6986	D-AMS-5358	Wood, many growth rings	-16.2	4599 +/- 33	56.41 +/- .23	*Abies* sp.	Taxodioid cross-field pitting, no resin canals, occasional biseriate ray, rays somewhat short but some tall ones consistent with fir. Thin section has spiral checking
GLAC-30-5-1	6986	D-AMS-5359	Wood, burnt	-22.5	4731 +/- 32	55.49 +/- .22	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-34-2-1	7696	D-AMS-5360	Wood	-17.1	442 +/- 31	94.65 +/- .36	*Pinus monticola*-type	Resin canals, window-like cross-field pitting. Thin-section slide has what appears to be spiral thickenings in a double coil like many of those Weahtermon ID'd as yew. This is spiral checking (separations of the cell wall) and possibly the result of having been frozen in the ice, then thawed

Field Number	Elev. (ft)	Lab No.	Material	$\delta^{13}C$ ‰	Conventional Age (uncal BP)	Percent Modern Carbon (pMC)	Plant ID	Comments (Wood identifications)
GLAC-34-3-1	7692	D-AMS-5361	Wood	-22.9	MODERN	121.77 +/- .5	*Pseudotsuga menziesii*	Resin canals, faint helical thickenings
GLAC-35, BISON	7690	RAFTER-40116/1	Bison femur	-18.1	967 +/- 15			
GLAC 35-1-1	7690	D-AMS-13000	Horn, sheep?	-17.2	556 +/- 29	93.31 +/- .34		
GLAC 35-5	7690	D-AMS-12998	Wood	-22.3	2721 +/- 27	71.27 +/- .24	*Abies* sp.	No resin canals, taxodioid cross-field pitting, ray height consistent with fir (very tall rays). Wood exhibits spiral checking
GLAC-35-5 (re-date as check)	7692	D-AMS-5362	Wood	-17.6	2743 +/- 32	71.07 +/- .28	*Abies* sp.	Taxodioid cross-field pitting, no resin canals, some biseriate rays, rays somewhat short but some tall ones consistent with fir. Thin section has spiral checking
GLAC-38-1	7701	D-AMS-5363	Wood	-20.3	3873 +/- 30	61.75 +/- .23	*Abies* sp.	Taxodioid cross-field pitting, no resin canals, ray height consistent with fir. Thin section has spiral checking
GLAC-38A-1	7701	D-AMS-5364	Wood	-18.6	338 +/- 29	95.88 +/- .35		Sample missing
GLAC 38A-1 (redate of D-AMS-5364)	7593	D-AMS-12994	Wood	-24.6	153 +/- 24	98.11 +/- .29	*Pinus* sp.	Resin canals, pinoid cross-field pitting
GLAC 38A-2	7593	BETA-289214	Wood	-25.3	910 +/- 40	**	*Abies* sp. / *Thuja plicata*	No resin canals, taxodioid cross-field pitting, short rays, some spiral checking

Field Number	Elev. (ft)	Lab No.	Material	$\delta^{13}C$ ‰	Conventional Age (uncal BP)	Percent Modern Carbon (pMC)	Plant ID	Comments (Wood identifications)
GLAC 38 2013	7701	D-AMS-12993	Wood, probably historic signage	-23.0	5 +/- 25	99.94 +/- .31	*Pseudotsuga menziesii*	Resin canals not obvious in cross-section, but has fusiform rays with horizontal resin canals, true helical (spiral) thickenings
GLAC 40-1	7529	BETA-289215	Wood	-21.9	220 +/- 40	**	*Pseudotsuga menziesii*	Resin canals not obvious in cross-section, but has fusiform rays with horizontal resin canals, true helical (spiral) thickenings
GLAC 40-2	7529	BETA-289216	Wood	-23.0	5300 +/- 40	**	*Abies* sp.	No resin canals, taxodioid cross-field pitting, tall rays, spiral checking
GLAC-40-3	7529	D-AMS-5367	Wood	-25.2	121 +/- 28	98.51 +/- .34	*Abies* sp.	Taxodioid cross-field pitting, no resin canals, ray height consistent with fir
GLAC-40-4-1/2010	7529	D-AMS-5365	Wood	-23.1	1759 +/- 29	80.33 +/- .29	*Abies* sp.	Taxodioid cross-field pitting, no resin canals, ray height consistent with fir
GLAC-40-4-1/2012	7529	D-AMS-5366	Wood	-20.0	MODERN	151.9 +/- .50	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-40-5	7529	D-AMS-5368	Wood	-18.6	2968 +/- 29	69.11 +/- .25	*Pinus monticola*-type	Resin canals, window-like cross-field pitting
GLAC-41-1	6507	D-AMS-5369	Wood	-28.1	409 +/- 29	95.04 +/- .34	*Abies* sp.	Taxodioid cross-field pitting, no resin canals, nodular end walls (in radial view)

Field Number	Elev. (ft)	Lab No.	Material	$\delta^{13}C$ ‰	Conventional Age (uncal BP)	Percent Modern Carbon (pMC)	Plant ID	Comments (Wood identifications)
GLAC 41-2	6507	BETA-289217	Wood	-24.7	160 +/- 40	**	*Abies* sp.	Taxodioid cross-field pitting, no resin canals, ray height consistent with fir, thin section has spiral checking
GLAC 41-3	6507	BETA-289218	Wood	-23.4	1350 +/- 40	**	*Picea* sp.	Resin canals, piceoid cross-field pitting, no true helical (spiral) thickenings
GLAC 41-4	6507	BETA-289219	Wood	-23.7	1380 +/- 40	**	*Pseudotsuga menziesii*	Resin canals not obvious in cross-section, but has fusiform rays with horizontal resin canals, true helical (spiral) thickening
GLAC-41-4 Redate of BETA-289219)	6507	D-AMS-5370	Wood	-20.8	1336 +/- 28	84.68 +/- .30	*Pseudotsuga menziesii*	same as 41-4 (split sample)
GLAC-41-5-1	7589	D-AMS-5371	Reed	-17.9	MODERN	106.34 +/- .38	Poaceae stem	
GLAC-38 ice core dates								
GLAC-C2-5.65M-1		D-AMS-5372	Fecal pellet (sheep?)	-28.8	3653 +/- 32	63.46 +/- .25		
GLAC-C2-6.41m-3		Beta-362258	Leaf (unknown)	-27.3	5710 +/- 30	**	unknown	
GLAC-C2-6.41m-2		Beta-362257	Leaf (dwarf birch?)	-25.9	5310 +/- 30	**	Dwarf birch?	
GLAC-C2-6.41m-1		Beta-362256	Fecal pellet (sheep?)	-25.8	5610 +/- 40	**		
GLAC-C1-5m		Beta-373864	Abies needle	-26.4	MODERN	128.4 +/- 0.3	*Abies* sp.	
GLAC-C1-6.7m		Beta-373865	Dryas stem		3920 +/- 30	**	*Dryas* sp.	
GLAC-C1-7.3m		Beta-373866	Dryas leaves	-26.3	3130 +/- 30	**	*Dryas* sp.	
GLAC-C1-8m		Beta-373867	Dryas leaves	-26.6	5910 +/- 30	**	*Dryas* sp.	

Field Number	Elev. (ft)	Lab No.	Material	$\delta^{13}C$ ‰	Conventional Age (uncal BP)	Percent Modern Carbon (pMC)	Plant ID	Comments (Wood identifications)
GLAC-C2-4.27m		Beta-373869	Dryas leaves		MODERN	123.9 +/- 0.3	*Dryas* sp.	
GLAC-C2-4.54m		Beta-373870	Dryas leaves		MODERN	120.7 +/- 0.3	*Dryas* sp.	
GLAC-C2-6.16m		Beta-373872	Dicot twig with bud	-25.1	5300 +/- 30	**	unknown	
GLAC-C1-7.3m-B		Beta-403486	Unknown stem base	*	230 +/- 30	*	unknown	

* - sample too small for accurate measurement

** - values not reported except for modern samples

Table 3: Faunal remains recovered from GLAC 16 and 35.

Number	Element	Portion	Segment	Side	Fusion	Species
GLAC 16-1-1	HC	FR	FR	US	-	
GLAC 16-1-2	HC	FR	FR	US	-	
GLAC 16-4[1]	RA	CO	CO	Left	F	Large Ungulate
GLAC-35[2]	FM	CO	CO	Left	F	Bison
GLAC-35	IM	CO	No PB	Left	F	Bison
GLAC-35-3	TTH	Lower	M3	Left	-	Bison
GLAC-35-2	TTH	FR	FR	US	-	US
GLAC-35-4	CE	CO	CO	US	UF	US
GLAC-35	RB[3]	DF	PR+DSH	Left	-	US
GLAC-35	TH	CO	CO	US	UF	Bison
GLAC-35	TH	CO	CO	US	UF	Bison
GLAC-35	SAC	CR	CR	US	F	Bison
GLAC-35	CRN	ZGO	CO	R	UF	Bison
GLAC-35	CRN	ZGO	CO	L	UF	Bison
GLAC-35	TH	EP	CR	US	UF	Bison
GLAC-35	RB	DF	PR	L	F	Bison
GLAC-35	TH	EP	CA	US	UF	Bison
GLAC-35	CRN	FN	MD	R	UF	Bison
GLAC-35	CE	EP	CR	US	UF	Bison
GLAC-35	TH	EP	CA	US	UF	Bison
GLAC-35	CS	CO	CO	US	US	Bison
GLAC-35	RB	FR	FR	US	US	Bison?
GLAC-35	RB	FR	FR	US	US	Bison?
GLAC-35	CS	CO	CO	US	US	Bison
GLAC-35	RB	FR	FR	US	US	Bison?
GLAC-35	INV	IN	ME	L	US	Bison
GLAC-35	INV	IN	ME	R	US	Bison
GLAC-35	VT	FR	FR	US	US	Bison
GLAC-35	CA	CO	CO	US	US	Bison
GLAC-35	AC	IL	FR	L	UF	Bison
GLAC-35	65 unid.[4]					Bison?

[1] GLAC-16 had an NISP of 3. Based on these remains there appears to have been 1 *Bison bison* present. There was also a large left radius that was badly weathered and possibly from an elk (*Cervus canadensis*). It seems to be too small to have come from a *B. bison*, but its condition makes it difficult to determine.
[2] GLAC-35 had an NISP of 92 fragments. Based on these remains it appears that there was only 1 *Bison bison* present. Many of the fragments are extremely small pieces derived from the large skull that was recovered.
[3] Split down middle, left half present.
[4] Mostly cranial fragments

Table 4: Macrobotanical materials recovered from lag deposits in Siyeh (GLAC 38) Cores 1 and 2.

	modern	4410 cal BP	3365 & 290 cal BP	6735 cal BP			modern	modern		3988 cal BP	6070 cal BP	6500 cal BP
	Core 1					Core 2						
Depth below surface (m)	5	6.7	7.3	8	8.22	3.93	4.27	4.54	4.75	5.65	6.16	6.41
<u>Floral Remains:</u>												
Abies needle - charred fragment	-	-	1	1	-	-	-	2	-	-	-	-
Abies needle - uncharred whole	-	-	-	-	-	-	-	-	-	9	-	18
Abies needle - uncharred fragment	1	4	3	2	1			2		46	2	100
Asteraceae seed	-	-	-	-	-	-	1	-	-	1	-	-
Crepis seed	-	-	-	-	-	-	1	-	-	-	-	-
Carex perigynium	-	-	-	-	-	-	-	-	-	-	-	3
Carex seed	-	-	-	-	-	-	-	-	-	-	-	5
Dryas stem	-	1	-	s	1	-	-	-	-	10	-	205*
Dryas leaf - uncharred whole	-	-	-	-	-	-	-	1	-	20	-	56
Dryas leaf - uncharred frag.		19	326*	131*	36*		53*	41*	2	2984*	6	6282*
Dryas leaf - charred fragment	-	1	1	-	-	-	-	-	-	-	-	-
Dryas-type seed	-	-	-	-	-	-	-	-	-	-	-	-
Epilobium seed	-	1	-	-	-	-	-	-	-	-	-	-
Fabaceae seed	-	-	-	-	-	-	-	-	-	-	-	2
Picea needle - charred fragment	-	-	2	-	-	-	2	-	-	5	-	-
Picea needle - uncharred	-	-	2	-	-	-	-	-	-	1	-	-
Pinus needle	-	-	1	-	-	-	-	-	-	4	-	11
Poaceae stem/leaf	-	3	1	-	-	-	6	7	2	52*	-	19
Poaceae inflorescence	-	-	-	-	-	-	-	-	-	-	-	6
Poaceae floret, whole	-	1	-	-	-	-	3	-	-	1	-	2
Poaceae floret, fragment	-	1	-	1	-	-	2	1	-	4	1	6
Koeleria-type floret, fragment	-	-	-	-	-	-	-	-	-	-	-	8
Poa floret, whole	-	-	-	-	-	-	-	-	-	-	-	1
Polygonum seed, fragment	-	-	1	-	-	-	-	-	-	-	-	-
Potentilla seed, whole	-	-	-	-	-	-	-	-	-	2	-	1
Potentilla seed, fragment	-	-	-	-	-	-	-	-	-	-	-	3
Salix fruit, whole	-	-	-	-	-	-	-	-	-	2	-	4
Salix fruit, fragment	-	-	-	-	-	-	1	-	-	16*	-	14
Salix seed	-	-	-	-	-	-	-	-	-	-	-	5
Dicot root	-	-	-	-	-	-	-	-	-	7	-	8
Dicot twig	-	-	-	-	-	-	-	-	-	19	1	224*
Monocot/Herbaceous dicot stem	9	-	-	-	-	-	-	-	-	1	-	-
Moss branch/leaf	2	3	6	-	-	-	-	3	5	3	-	4
Unidentified C inflorescence	-	-	-	-	-	-	-	-	-	-	-	2

	modern	4410 cal BP	3365 & 290 cal BP	6735 cal BP			modern	modern		3988 cal BP	6070 cal BP	6500 cal BP
Unidentified S inflorescence	-	-	-	-	-	-	-	-	-	-	-	1
Unidentified H leaf, whole	-	-	-	-	-	-	-	-	-	2	-	2
Unidentified H leaf, fragment	-	-	-	-	-	-	-	-	-	-	-	1
Unidentified L leaf, whole	-	-	-	-	-	-	-	-	-	5	-	-
Unidentified L leaf, fragment	-	-	-	-	-	-	-	-	-	5	-	-
Unidentified P leaf, whole	-	-	-	-	-	-	-	-	-	1	-	3
Unidentified P leaf, fragment	-	-	-	-	-	-	-	-	-	59*	-	52
Bud, whole	-	-	-	1	-	-	-	-	-	2	-	-
Bud, fragment	-	-	-	-	1	-	1	1	-	5	-	96*
Flower	-	-	-	-	-	-	-	-	-	2	-	2
Fruit	-	1	-	-	2	-	1	-	-	-	-	3
Leaf, charred fragment	-	-	-	-	-	-	-	-	-	1	-	-
Leaf, uncharred whole	-	-	-	-	-	-	-	-	-	-	-	5
Leaf, uncharred fragment	-	-	-	244*	28*		31*	121*	6	1432*	2	5720*
Stem base	-	-	-	-	-	-	-	-	-	3	-	1
Stem	-	-	82*	8*	-	-	13	3	-	95*	4	979*
Stem/Rootlet	-	-	-	-	-	-	-	-	-	48*	-	874*
Root bark	-	-	-	-	-	1	-	-	-	97*	-	-
Rootlet	-	-	65*	16*	-	-	1	-	-	Few	-	Few
Sap/Resin	-	-	-	2	-	-	-	-	-	-	-	-
<u>Charcoal:</u>												
Periderm (bark)	-	-	-	-	-	-	-	-	-	1	-	-
Conifer	-	-	2	-	-	-	-	-	-	4	-	-
Pseudotsuga menziesii	-	1	1	-	-	-	-	-	-	-	-	2
Quercus	-	-	-	-	-	-	-	-	-	-	-	4
Salicaceae	-	-	-	-	-	-	-	-	-	-	-	1
Unidentified hardwood - small	-	-	-	-	-	-	-	-	-	-	-	2
<u>Non-Floral Remains:</u>												
Black plastic shavings	-	225*	-	3	11	-	-	-	-	-	-	-
Hair	-	-	-	-	-	-	-	-	-	X	-	-
Insect chitin	4	17	37	8	13		3	7	2	45		57
Insect puparium	-	-	-	-	-	-	-	-	-	4	-	-
Rock/Gravel	X	X	X	X	X		X	X	X	X	X	X
Sediment clumps	-	-	-	-	-	-	-	-	X	-	-	-
Ungulate fecal pellet	1	-	-	-	2	-	-	-	-	6	-	2

* Includes an estimated frequency
X present

APPENDIX A: GLACIER CULTURAL RESOURCE MANAGEMENT GROUP (CRMG)

Starter Protocol for Field, Lab/Analysis, and Transport Protocols

(Curation not yet included)

Glacier Ice Patch Archeology Project

Version 8/6/10

Background

In 2010, Glacier National Park (GLAC) received climate change grant money to document, recover, analyze, and interpret cultural items that may be exposed due to melting of ancient snow and ice fields. The project, hereafter called the Ice Patch Archeology Project, is funded through two task agreements with the Rocky Mountain Cooperative Ecosystem Studies Unit (RM-CESU). One agreement is with the University of Wyoming (UWY) with sub-agreements to the Blackfeet Nation (BN) and the Confederated Salish and Kootenai Tribes, (CSKT). The other agreement is with Colorado University/Boulder (CUB).

Goals and Objectives

The goal of the Glacier Ice Patch Archeology Project is to collect artifacts used by ancestral groups for hunting, gathering, processing, and other settlement and subsistence activities, as a means to preserve the items and shed light on prehistoric lifeways. One of project's unique strengths is the creation of a protocol for handling of artifacts that are culturally sensitive. In May and August 2010, representatives from the park, the BN, CUB, the CSKT, RM-CESU, and UWY formed the Glacier Cultural Resources Management Group (GCRMG) as a forum for planning and communication pertaining to this major project (no formal consultations will be conducted by this group but will be referred to appropriate personnel). The first task for the GCRMG is to create a protocol that sets culturally and scientifically appropriate guidelines for the handling and collection of artifacts in the field, analysis and documentation in the lab, and transportation associated with the Ice Patch Archeology Project. Curation guidelines will be added later in the project or developed separately in the event archaeological materials are collected.

This protocol will serve as an example for future cultural resource projects at GLAC. Further, the protocols and the means used to arrive at them will be widely disseminated to other park units and the CRMG anticipates they will be useful to other park/tribal/researcher partnerships for cultural resources-related projects. Below are initial protocols agreed-upon by the GCRMG. Note that safety, communication, and backcountry practices are not covered by this protocol.

Procedures in the Field

All crews shall be accompanied by a supervisor and carry a copy of the field protocols and the field collection procedures.

1. Locating Items

Artifacts are most frequently encountered along the downslope margin of the ice patch and in the off-ice area immediately below the ice patch - the forefield. Artifacts collect here as they slide off the ice and/or are transported by fluvial action. If an ice patch has a large, relatively low-slope surface, artifacts can occasionally be found directly on the ice. In these instances the artifact will usually be in association with other organic material, including animal feces and windblown detritus.

Ice patches with dark staining in late summer and early fall hold the most potential for discoveries. The runoff channels below ice patches are another location where cultural material can be recovered. In general, the further away from the ice an artifact is encountered, the more degraded it will be as a result of exposure to water, wind and sun.

The project is collecting data on changes in ice patch sizes and shapes over time. Points along the forefield portion (the downslope edge) shall be mapped using a GPS unit and shooting with offset may help delineate a large patch. Where feasible (if the patch is small or easy to walk around the edge), the entire patch shall be mapped. Because organic material is a lag deposit, be sure to record GPS points for every discovery.

2. Documenting and Handling Items

a. Artifacts

First, take some context photos of your find. When documenting an area of permanent ice, take overview photos of the location from far enough away to allow the extent of the ice to be compared year-to-year. Record the presence of windblown organic material, animal feces, etc., present at the ice patch. Take a few area photos as well. Look for stone alignments, cairns, or vision-quest related structures nd/or breast works/hunting blinds, as well as chipped stone artifacts. Keep an open mind about what you might encounter and expect that preservation will be variable. If you are at or above tree line and encounter a piece of wood that may be an arrow or dart shaft (e.g., the right shape and size but with no obvious modifications such as nock or hafting elements), consider collecting it to provide a contextual basis for subsequent discoveries.

Newly discovered items shall be mapped as accurately as possible (preferably with a GPS unit to sub-meter resolution). Items shall be photographed *in situ* and a sketch map created if there are multiple items or other need to document site structure. Photograph items *in situ* with a scale and north arrow or compass, and take several overview/context photos. Between 6 and 8 megapixels is a good target resolution. Always record your shots in a photo log, if there is no log available take notes at minimum describing the photographer, date, location, subject, compass bearing for the heading/facing, and anything else that describes the object and its setting. Note the GPS coordinates of the object(s) photographed and of the location where the photograper is standing.

Excavation shall not be conducted except in cases where an appropriate decision has been made to remove an object and small amounts of sediment or snow must be displaced.

A1: Sensitive Items

Human remains, associated funerary objects, sacred objects, and objects of cultural patrimony are protected by the Native American Graves Protection and Repatriation Act (NAGPRA). This law requires procedures that are outside the authority and capability of the Ice Patch Archeology Project. The below language covers actions that can be taken by Ice Patch field crews so that NAGPRA can be implemented by the park.

Spiritual and/or Ceremonial Artifacts (e.g., Sacred Objects and Objects of Cultural Patrimony)

The goal of the Glacier Ice Patch Archeology Project is to collect artifacts used by ancestral groups for hunting, gathering, processing, and other settlement and subsistence activities, as a means to preserve the items and shed light on ancient lifeways. However, a different class of artifacts that might be encountered during the field survey may be associated with sensitive spiritual and/or ceremonial activity. In some instances, removal and analysis of these special-sensitive materials would be inconsistent with cultural norms and practices for those modern tribal groups who hold historical attachments to an area because these items were purposely left in the area as offerings or were brought to the area to be "put away" after ceremonial use with the intent that they would naturally decay in the that specific location away from human interference. In some instances sensitive items should never be touched, even to move them to safety).

Artifacts that qualify under the category of "special-sensitive artifacts" may include portions of, or intact, medicine bags; eagle bone whistles; pipe bowls and stems; buffalo stones; items fully covered with red ochre (as opposed to partial marks); isolated buffalo skulls; and ceremonial offerings directly associated with vision quest structures. These artifacts should be photographed, documented and mapped as described above, but participating Native Americans may request that such items be left in place or safely secured out of harm's way as near as possible to the original discovery location until consultation with tribal cultural and spiritual leaders can be completed. Both the discovery location and the new secure location shall be mapped with GPS. It may be necessary to request that the park temporarily block access to certain trails.

If the consultation with tribal cultural leaders and spiritual practitioners suggests that the items should be left on-site without collection, that request shall be honored by the park. If tribal cultural leaders determine that collection and removal of the special sensitive artifact(s) is culturally appropriate, the item may be collected by the Project team with the participation of tribal representatives. Under some circumstances, special conditions for removal of artifacts may be requested by participating tribes, such as leaving an offering behind, or conduct of on-site cultural activities.

Inadvertent Discovery of Burials (Human Remains or Associated Funerary Objects/AFO's)

Human remains and shall not be photographed, although the context of their location may be photographed from a distance. These items shall be left *in situ* unless they are immediately threatened by destruction or theft. The original discovery location shall be mapped using a GPS, with a sketch map depicting the area. If destruction or theft are a real danger, they may be placed in a more secure location as near as possible to their original resting place and the new location mapped with GPS. The remaining actions required by NAGPRA shall be carried out separately from this project.

3. Collection and Transport of Fragile Artifacts

Depending on the state of preservation, some artifacts; including fragile bone items, wood, shell or fiber material; are expected to be very fragile and will require special care for field recovery and stabilization. When collecting and transporting fragile artifacts (e.g., arrow shafts), use lightweight portable materials. "Coroplast" (www.coroplast.com) and other fluted plastic board flexes slightly and can help to cushion artifacts during transport. It can also be scored and folded to make archival boxes. It is recommended that you carry at least one ca. 36" by 24" sheet folded on the long axis. Artifacts can be held in place with rolled cotton bandages. It is recommended that you carry three 2" x 60" rolls. To stabilize an artifact, cut the board several inches longer and wider than the size of the artifact being collected. Score the edge of the board and "web" the artifact onto the board using the bandages. Other supplies include a variety of Ziploc bags, garbage bags and strips of unbleached cotton muslin to shore up splitting artifacts.

If an organic artifact is dry, keep it dry. If it is wet, consider wrapping it in plastic after field stabilization for transport to a freezer (see conservation below).

b. Lithics/stone

The focus of this project is organic/perishable items. However, the BN and CSKT are interested in sourcing of lithic raw material for understanding ancient trade, migration, and technology. If field crews discover scatters of lithic tools and debitage (by-products of tool manufacture or repair), field crews may collect small representative samples of un-modified debitage (typically small flakes that show no sign of additional working) for sourcing (which shall be funded under a different source. The location of the collected item(s) shall be GPS'ed as well as a datum point and sketch map for the site. No further documentation shall take place. It is anticipated that archaeologists and tribal culture specialists shall return to lithic sites in the future for actual recordation and/or return of analyzed lithics. Note: the collection of small unmodified lithics and their return to point of origin is outside the park's usual non-collection policy.

c. Paleobiological/non-cultural items

It may not be necessary, practical, or even feasible to collect every piece of wood or bone that you encounter. Do your best to ascertain if the material has cultural significance (e.g., Is that bone spirally fractured? Is that piece of wood purposefully shaped?). If you do not find anything cultural but you discover paleobiological material, consider collecting a few small samples for radiocarbon dating. If the material is old, it might help make your case for future efforts. Share your observations as widely as possible (e.g., with biologists, ecologists, rangers, contacts at local universities, etc.). Animal scat or other items that are deemed non-cultural will be treated as paleobiological samples and will not require culturally sensitive handling protocols.

Procedures in the Lab

a. Storage

Labs and other locations for temporary storage of artifacts must be secure, e.g. locked with limited access and/or protected by coded entry. The space should be temperature and humidity-controlled. If the artifacts are dry, put them into a stable, safe space. Try to support them with shims if they are warped, e.g., an arrow shaft that may be curved as a result of warping should be supported in multiple places. Wet organic artifacts can be dried, but there is a risk of warping and splitting. Some alteration is inevitable, but best practice to minimize damage should be followed: If a damp artifact begins to split, wrap it snugly with fabric strips such as Tyvek or unbleached muslin (see Figure 6). Place the wet artifact into a bag or container with a relatively small opening and put it in the freezer. This will allow the moisture to slowly evaporate from the artifact through ablation. Depending on how wet the object is, you can modify how well-wrapped it is in order to change the rate of ablation.

If the artifact is too large to fit in your available freezer, you can create a make-shift humidification chamber. Put the artifact in a moisture-proof case, such as a large cooler or under-the-bed Rubbermaid storage container. Ensure the artifact is well supported, and put a small bowl of water into the container. Put the lid on but leave it slightly ajar by 1-2 cm. Note: If you recover a leather artifact (e.g., a moccasin) a professional conservator will need to assist you with stabilization. Not all conservators are qualified to do this. The GCRMG will discuss next steps; possible experts include Objects Conservators at major museums such as the Denver Museum of Nature & Science. In the meantime, keep the artifact frozen!

b. Analysis

For cultural items, the type of analysis shall be agreed upon by the CRMG. It is anticipated that most analysis shall be non-destructive except where approved by the GCRMG. Of course, destructive analysis of cultural items requires tribal consultation; where destructive analysis is agreed upon, micro-sampling shall be conducted (for example, using AMS techniques for radiocarbon dating).

At this time, the following is written into the Project Scope and may be modified by the CRMG:

"Wood specimens will be identified as to genus at the University of Wyoming by Rick Weathermon, a Univ. of Wyoming Anthropology staff member experienced in the analysis of wooden artifacts. Organic materials will be AMS (accelerated mass spectrometry) radiocarbon-dated (as funding permits) through INSTAAR's radiocarbon lab or elsewhere at a discounted rate. AMS dating of wood requires only minute samples that can be removed with a coring device at the University of Wyoming. Obsidian samples will be sent to Dr. Richard Hughes at the Geochemical Research Lab, Portola, California for edXRF (energy dispersive x-ray fluorescence) to determine geographic source. Following identification, other paleobiological materials, such as animal feces and non-artifactual wood will be analyzed as deemed useful in reconstructing past environments; analyses will likely include stable isotope analysis and/or aDNA recovery."

For non-cultural paleobiological items, laboratory analysis shall be non-destructive where feasible and minimize the sample size if it is destroyed. No cultural concerns are noted for these items.

Items shall remain ‘under study’ status for no longer than three years after the time of recovery unless otherwise specified by the GCRMG.

Best Data Management

All parties agree that documentation containing locational or highly sensitive cultural information shall be kept in password-protected files, and hardcopies in secure, limited access facilities.

Note: Site forms shall be filled out and sent to MT SHPO for all sites. However, SHPO records are available to the public and the GCRMG shall review these forms to ensure that sensitive information is redacted as needed prior to distribution.

Curation Protocols will be determined by the Cultural Resources Management Group

The GCRMG shall determine the best location for long-term curation of cultural items. Note: at the end of the project, all non-cultural samples, collections, and copies of records, data, photographs, and other documents resulting from the work will be delivered to the appropriate repository official at GLAC (Deirdre Shaw) or the Billings Curation Center.

The Living Protocol: Communication, Development, Revision

This protocol was initiated and refined in face to face meetings between representatives from all partners; while the meeting was taking place, a note-taker recorded talking points for the protocol and later turned them into a basic listing. Details and adjustments were implemented and tracked through email and phone correspondence, but the major work effort was conducted in person. The GCRMG anticipates that the protocol will be re-visited and adjusted further as new developments happen in the field and the lab.

It is anticipated that this protocol, with a current version tailored for the Ice Patch Archeology Project, will be useful for future cultural resource projects undertaken by the GCRMG. It is intended to be a living document that can serve as a starting point for issues that commonly arise in cultural and heritage-related projects. As new projects arise, the GCRMG will revise the protocol in a consultative process that blends in-person and remote communication methods. While face to face is always most effective, ‘remote’ meetings may work for smaller revisions to the protocol.

The BN and CSKT shall circulate this protocol to their Cultural Committees as they deem necessary and the GCRMG shall revise as needed.

The State of Montana is not yet a member of the GCRMG. This protocol may become a Memorandum of Agreement in the future, which will require State of Montana participation.

The GCRMG shall review this protocol on an as-needed basis. In the event that the GCRMG decides to use an MOA, a review schedule might be set at that time.

Glossary of Terms

Artifact: An object that has been made or modified by a human being. This could be tools, clothing, or other functionally obvious items, as well as the byproducts of their manufacture or repair.

***In situ*:** In the place where it was first found, in its original spatial context.

Fluvial action: gravity-influenced water action, as with slope wash, rivulets, creeks, or larger drainages.

Lag deposit: In which the layers of sediment (snow, sand, soil, etc) that usually accumulate between episodes of deposition (human or natural) have been removed. This causes layers of materials to ‘lag’ or collapse on top of each other, so that they may appear as a single layer deposited all at the same time.

Paleobiological: Non-human in origin. Animal, plant, geological remains, and so forth.

Radiocarbon dating: Also called C-14 dating. A process by which the actual calendar age of an item may be calculated within a certain margin of error. Organic items such as animal or plant materials, or charcoal flecks, are suitable for this kind of analysis. The ratio of two different isotopes of carbon is measured in the lab. This process is destructive, but using AMS (accelerator mass spectrometry) techniques the samples can be very small (the size of a fingernail clipping).

Shim: A small piece of wood or other firm material used for support, usually in association with binding.

APPENDIX B: ANNUAL LETTER REPORTS, 2010—2014

Glacier National Park Ice Patch Survey Report
September, 2010
Robert L. Kelly
University of Wyoming (UW)
DOINPS40433

Collaborators:
Craig Lee, Ph.D., University of Colorado, Institute for Arctic and Alpine Research (INSTAAR)
Confederated Salish and Kootenai Tribes (CSKT)
Blackfeet Nation (BN)
National Park Service, Glacier National Park (GNP)

Preface

Archaeological discoveries in high latitude and sub-alpine environments reveal that melting ice patches and glaciers expose well preserved yet fragile cultural materials. The cultural and scientific value of these fragile artifacts is immeasurable but fragile items quickly deteriorate if they are left exposed to the elements, animals, or collectors. Climate change-related phenomena are new and critical concerns for Native Americans who have ancient heritage links with what is now Glacier National Park. Glaciers and snowscapes are integral parts tribal creation stories. The alpine zones are important special areas for hunting, gathering, and ceremonial use. Important cultural plants, minerals, and animals were procured in these unique environmental settings. Recent dramatic changes brought to these alpine and subalpine areas have caused an imbalance to a natural ecological system used and maintained by tribal ancestors since time immemorial, threatening permanent loss of heritage cultural and natural resources.

Increasingly rapid ice and snowmelt in Glacier National Park creates a critical cultural resource issue that must be addressed in a timely and comprehensive manner. Thorough examination and evaluation of impacts are the first steps to address endangered cultural and scientific resources and knowledge. Cultural resource studies focused on areas newly exposed by receding ice and snow fields provide insights about prehistoric lifeways in alpine and subalpine zones, as well as essential information on ancient climates and recent changes that are critical for evaluating the historical context of recent man-made habitat shifts. In addition, monitoring of ice and snow fields and exposed artifacts is critical. Such efforts must be coordinated among Native American tribes, environmental scientists, and archeologists to ensure consideration of issues, values, synergy between different domains of knowledge, and compliance with federal laws governing stewardship of cultural resources (36 CFR Part 800, Sections 110 and 106 of the National Historic Preservation Act, Sacred Sites [EO 13007], the Native American Graves Protection and Repatriation Act (43 CFR Part 10), the Archeological Resources Protection Act, and others).

Overall Project Objectives

The “Ice Patches as Sources of Archeological and Paleoecological Data in Climate Change Research in Glacier National Park” project will take place over a three-year period and involves a partnership between Glacier National Park, the University of Wyoming, the Institute for Arctic and Alpine Research at Colorado University Boulder, the Confederated Salish and Kootenai Tribes of the Flathead Reservation, and the Blackfeet Nation. The project's overall objectives are

1) To work collaboratively with scientists from the University of Wyoming and INSTAAR/Colorado University, Boulder to investigate and document ice/snow patches in Glacier National Park in order to identify archeological, ethnographic, and paleobiological resources endangered by recent climate change and to recover archeological and paleoecological data relevant to global warming research.

2) To work collaboratively with the Confederated Salish and Kootenai Tribes of the Flathead Nation and the Blackfeet Nation to develop and implement culturally appropriate protective and conservation measures for sensitive cultural sites, features, and objects at risk from snowmelt.

3) To enhance cultural resource stewardship and protection at Glacier National Park through public education and interpretation about climate change impacts on cultural resources and resident indigenous communities.

4) To develop a strategy and methodology for assessing and mitigating impacts to cultural resources from glacial and snow/ice field recession that can serve as a model for other parks, agencies and entities in the United States and throughout the world.

Field Research, 2010

The research team met with Lon Johnson and other park officials on August 27 to finalize details for fieldwork. Field camp was established on August 28 at the St. Mary campground. The core research team consisted of:

Robert L. Kelly, PI (UW)
Craig Lee (INSTAAR)
David Schwab (CSKT, Preservation Office)
Ira Matt (CSKT, CSKT Preservation Office)
Don Sam (CSKT, Preservation Office)
Rachel Reckin (UW graduate student)

We were also joined for one or more days by Kevin Askan (CSKT), Joe Rivera (BN), John Murray (BN) and Pei-Lin Yu (NPS), John Kinsler (NPS), Alex _____ (NPS), and Frank Tyro (CSKT videography consultant). The CSKT was responsible for the GIS and video components of the project (Appendix A). Prior to fieldwork, the team consulted via teleconference on a Protocol for fieldwork, collection procedures, lab/analysis, and curation (Appendix B).

Glacier contains hundreds of ice patches. Not all of these, however, have a high probability of preserving in a recoverable state organic artifacts and paleobiological (PB) materials. Therefore, prior to fieldwork, Lee used Google imaging of GNP from multiple years to locate ice patches with a higher probability of offering such material for recovery. Lee defined 46 such points, and 3 were then added at the beginning of the field season for a total of 49. More may be defined in the future. The majority of the 49 points are located in the southern half of the park (south of Going to the Sun Road). From Google imagery, Lee selected those ice patches that (a) are accessible on foot (ones inaccessible by foot would not have been used prehistorically), (b) that still existed in the high melt year of 2003, and (c) that offered a flat forefield (below the ice patch); patches without a flat forefield could reveal artifacts and paleobiological materials, but these objects would be rapidly transported downslope by meltwater and summer rainfall.

The majority of the field time was spent hiking to the ice patches, even those located near established trails. We photographed each patch from a georeferenced point so that it could be re-photographed in the future for comparison. The lower edge of all patches were mapped using a GPS (see Appendix A); the complete edge of smaller patches were so mapped. The team then surveyed the forefield for some 20m out from the current edge for artifacts and paleobiological materials. In addition, any stream, if present, running from the ice patch was also surveyed for 50 or more meters (depending on the gradient). All PB specimens were located using a GPS instrument, photographed (both close-up and showing the specimen's location relative to the ice patch), and (except for two modern specimens on patch 38A) collected in a labeled plastic bag. A few pieces were stabilized on sturdy plastic sheeting. All photos taken by all crew members are being compiled by CSKT.

Fieldwork was hampered by severe weather conditions; however, all but one of the targeted patches for this year were surveyed. In addition, we surveyed two other small patches that we determined were good prospects upon encountering them in the course of surveying targeted patches (table 1). In all, we were able to examine 11 patches. Work this year was furthered hampered by the fact that while 2009-2010 was a modest snowfall year, the summer of 2010 was cool, and snow did not melt back; snow was in fact falling on several days of fieldwork. As a result, all patches were larger than depicted in September 2003 Google imagery, and any materials exposed in the immediate ice patch forefields during the high melt year of 2003 were covered in 2010.

We did not locate any definite artifacts. This is to be expected as the recovery rate on ice patches elsewhere in the world is below 10 percent. We did recovery a number of paleobiological specimens; only one of these appears to be from a rooted tree. These are being identified at the University of Wyoming and several will be submitted for radiocarbon dates.

Fieldwork ended on September 7; the team had a end-of-session meeting with park officials on September 8 in West Glacier.

Ice patch number	Approximate location	Recovery	Comments
Hidden Lake 1 8/29/2010	**Hidden Lake, near Visitor Center**	**None**	**visibility poor due to heavy snowfall on day of survey; considerable stream running from patch; patch ends partially in a stream-filled gorge; merits a re-survey**
15 8/30/2010	**Mad Wolf Mountain**	**Two PB specimens**	**Very large ice patch; visibility also poor due to snowfall; merits coring in future; vegetation along sides but not at top of patch; significant steam running along much of the edge**
19 9/3/2010	**Near Morning Star Lake**	**One PB, from top of ice patch**	**Flat forefield, very active stream running laterally a few meters from patch edge; specimen #1 is spruce, possibly root**
20 9/3/2010	**Near Morning Star Lake**	**Two PB, one possibly rooted wood**	**Large patch; there are small spruce trees above the patch; flat, but not wide forefield; specimen #2 is spruce**
20A 9/3/2010	**Near Morning Star Lake**	**Two animal vertebrae**	**Patch not in original sample, limited albeit flat forefield**
21 9/3/2010	**Near Morning Star Lake**	**none**	**Patch almost gone**
38 9/7/2010	**Siyeh Pass**	**One PB**	**Patches 38 and 39 are a single continuous patch this year; they were separate in 2003; 38 has a steep, rocky forefield**
38A 9/7/2010	**Siyeh Pass**	**Three PB**	**Two additional pieces of modern wood (specimens 38A-3 and 38A-4), possibly old trail signs were located and photographed but not collected. Active stream running from patch, but wide flat forefield.**
39 9/7/2010	**Siyeh Pass**	**None**	**Large patch but forefield is very constrained with active stream running from patch**
40 9/5/2010	**Peigan Pass**	**Four PB specimens**	**On east side of pass, near established trail; steep forefield and difficult to survey; specimen #2 is yew.**
41 9/5/2010	**Peigan Pass**	**Five PB specimens**	**On west side of pass, about 1000 feet below, near, but not on established trail; one piece of modern backpack noted; wide flat forefield with small active stream running from patch; specimen #3 is Douglas fir**

Appendix A

Confederated Salish and Kootenai Tribes Glacier National Park 2010 Research Summary

Introduction. This report summarizes the activities of the Confederated Salish and Kootenai Tribal Historic Preservation Department (CSKT) for implementation of the Ice Patches as a Sources of Archaeological and Paleoecological Data in Glacier National Park Research Project. This work is being conducted under the National Park Service's Rocky Mountain Cooperative Ecosystems Studies Unit Agreement Number H1200090004. For the project, the CSKT is under subcontract to the University of Wyoming, Dr. Robert L. Kelly, Principal Investigator. This report is broken down into four sections reflecting project responsibilities of the CSKT

Guidelines for Research Prioritization, Field Methods and Collection Protocols. The CSKT staff worked closely with Drs. Kelly and Lee to target specific ice sheets for field examination and to plan access routes, logistics, and the itinerary for the field season. Through a series of email exchanges and telephone meetings, a field plan and itinerary for the 2010 field season was completed in early August.

The CSKT also participated in a series of telephone and face-to-face meetings concerning the development of a protocol for the implementation of the project. This work was conducted as part of a GNP Cultural Resource Management Group organized for this project. Of particular concern to the CSKT was that the field methodology, especially artifact and specimen collection, was conducted respectfully and with sensitivity to tribal cultural values. The staff reviewed and contributed to several versions of the protocol. The revised document was approved by the CSKT and finalized in August prior to the initiation of field work.

Tribal staff also participated in telephone conferences and reviews of a project statement concerning the treatment of artifacts that may qualify under the Native American Graves Protection and Repatriation Act by the project.

Geographic Information System Development. Development of the project Geographic Information System (GIS) was initiated in July after the contract with the University of Wyoming was initiated. CSKT conducted a full review of available data and incorporated the following georeferenced data layers for the Glacier National Park GIS prior to field surveys: 1) 30 & 10 meter Digital Elevation Models, 2) GNP cultural resource site data, 3)Aerial imagery from National Aerial Photography Program (NAPP), 4)7.5 Minute USGS maps, 5)Kootenai Place Names, 6)GNP and USGS Glacier and Ice Sheet data from the NPS GIS portal, 7) Historic Trails. In addition, Google Earth images and ice sheet target locations developed by project researchers were transferred from .kml to ESRI ArcGIS format using the BEBEL protocol and then entered into the project GIS. Oblique images of all the target ice sheets showing variation over several seasons of photographic documentation were printed, organized and used in the field for identification and analysis.

On August 4, CSKT staffers Don Sam, Dave Schwab and Ira Matt met with Richard Menicke, GNP's GIS Coordinator to discuss available layers for incorporation into the GIS. Menicke indicated the USGS mapped glaciers and permanent snow features off of original 24K scale topo maps. This imagery was subsequently obtained by CSKT through the NPS portal. Year 2005 is the last season for comprehensive park wide measurements of snow and ice features. The USGS have mapped a handful of specific glaciers since then but nothing park wide. In 1998, USGS flew the park and photographed the Glacial covered areas of GNP. From the photographs they developed their own Ortho-imagery. These data are still being finalized but they are of high value for the ice patch archaeology project because they are very high resolution and are from a particularly low snow year. The CSKT have made arrangements to obtain these data from the USGS during the fall of 2010.

Prior to the 2011 field season, CSKT staff plan to conduct research of NPS resources, GNP archives, academic sources and the Montana State Natural Resource Information System for information that could be incorporated into the project GIS. Natural Resource investigation mapping that might be obtained would include maps identifying land-type classifications, game animal calving and gathering areas, wildlife migration corridors, Tribal economic plant communities (White Pine, Camas, Bitterroot, etc.). If necessary, these map data would need to be georeferenced by scanner or hand digitized for inclusion in the project GIS. In addition, land form analysis will be conducted using the DEM data to map slope, aspect, and curvature features as a means to assess target ice sheets for future study.

Oral history interviews and tribal archival research will be initiated in the fall of 2010 and winter and spring of 2011 to identify cultural hunting areas, plant gathering locations, historic trails systems, Salish and Kootenai Place Names, camping and gathering areas, and important hunting locations. Analysis of natural resource, landform, and tribal cultural information in the GIS will provide a foundation for researchers to identify the highest potential permanent snow and ice fields for field study in the upcoming two field seasons and will serve as a foundation for a Glacier National Park Cultural Resource Management System that will hopefully be developed with outside funding sources in the future.

Global Position System Field Mapping. Tribal staff ranging from 2-4 individuals participated in all phases of the field work from late August through early September of 2010. The CSKT team of Don Sam, Ira Matt, Dave Schwab, and Kevin Askan conducted GPS field mapping during different phases of the field investigations. The primary GPS units employed were the DeLorme Earthmate PN-40 and PN-60. As a backup, a Garmin Etrex Legend unit was employed. These units have a GPS accuracy ranging from 5 to 10 feet depending on field conditions and satellite availability. Detailed USGS geo-referenced map coverages and aerial photography were downloaded into the units to provided highly accurate real time geographic locations in the field. These were helpful in distinguishing research targets in the back country.

Prior to visitation to target ice-sheets, analyses were conducted using the GPS units and integrated software to determine the most efficient and cost effective routes to the targets. These analyses combined with map research conducted by the project investigators resulted in some revised planning in the course of field work and changes from the initial plan of action.

During the field work, the team mapped routes into each of the investigated ice sheets, mapped the exterior sides and lower perimeters of the ice sheets, and individually mapped collection samples and other pertinent features identified by researchers. These data have been processed and will be incorporated into the project GIS. Map data of ice sheets will assist in monitoring changes in the target ice sheets over the next several years.

Prior to the 2011 field season, the CSKT will be acquiring additional GPS units and investigate improving GPS accuracy by use of antennas, software processing, and reference ground base stations. The goal of the new GPS units will also include satellite communications that will provide the ability to make contacts to key Tribal and NPS office personnel and staff in case of significant discoveries or emergencies in the back country.

Interpretive Product, Digital Video, and Still Photography. Two digital video cameras were used during the Field investigations, a Canon GL1 DV a Sony HDV high definition unit. Video interviews were conducted with the project team at several times during the course of the study. These interviews were undertaken both in the base camp and in the field. Unfortunately, inclement weather and precipitation impeded some use of the video cameras. The Canon GL1 camera was carried into the field and video was shot of the survey methods, ice sheet mapping, sample collections, terrain and conditions. Video interviews were undertaken with researchers during collection of samples. The Sony HDV camera was used for base camp interviews, landscape overview, and on one back country field trip to Siyeh Pass on September 7th.

On August 30th, Frank Tyro, director of the Salish Kootenai College Audio Visual program participated in the field work and documented the effort in with a Sony HDV high definition camera. Prior to the field tour, Tyro held several training sessions with CSKT staff on video camera techniques and operation. At total of 19 mini DV and mini HDV tapes were obtained (DV tapes = 7 , HDV = 12) .

The CSKT also documented the project using three digital still cameras, a Sony Cybershot 12.1 Mega Pixel camera, and two Olympus 10 mps cameras. A wide range of still images were captured including Ice sheet photo point identification shots, sample collection photos, individual and group survey photos, landscape shots and field crew pictures.

During the Fall and winter, CSKT staff will be busy conducting additional interviews with Tribal Elders, researchers, other project participants, and geological experts. We will also be busy cataloging all the media materials, downloading media to DVD ROM for backup and storage, sharing still imagery with project participants, and entering media information into a project media database in Microsoft Access.

Appendix B
Starter Protocol for Field, Lab/Analysis, and Transport Protocols: DRAFT
(Curation not yet included)
Glacier Ice Patch Archaeology Project
Started by Pei-Lin, 6/16/10

Background

In 2010, Glacier National Park (GLAC) received climate change grant money to document, recover, analyze, and interpret cultural items that may be exposed due to melting of ancient snow and ice fields. The project, hereafter called the Ice Patch Archaeology Project, is funded through two task agreements with the Rocky Mountain Cooperative Ecosystem Studies Unit (RM-CESU). One agreement is with the University of Wyoming (UWY) with subagreements to the Blackfeet Nation (BN) and the Confederated Salish and Kootenai Tribes, (CSKT). The other agreement is with Colorado University/Boulder (CUB).

Goals and Objectives

One of Ice Patch Archaeology Project's strengths is a the creation of a protocol for handling of artifacts that is culturally sensitive and scientifically valid. In May 2010, representatives from the park, the BN, CUB, the CSKT, RM-CESU, and UWY formed the Glacier Cultural Resources Management Group (GCRMG) as a forum for planning and communication pertaining to this major project (no formal consultations will be conducted by this group but will be referred to appropriate personnel). The first task for the GCRMG is to create a protocol that sets culturally and scientifically appropriate guidelines for the handling and collection of artifacts in the field, analysis and documentation in the lab, and transportation associated with the Ice Patch Archaeology Project. Curation guidelines will be added later in the project or developed separately. This protocol will serve as an example for future cultural resource projects at GLAC. Further, the protocols and the means used to arrive at them will be widely disseminated to other park units and the CRMG anticipates they will be useful to other park/tribal/researcher partnerships for cultural resources-related projects.

Below are initial protocols agreed-upon by the GCRMG. Note that safety, communication, and backcountry practices are not covered by this protocol. All parties agree that documentation containing locational or highly sensitive cultural information shall be kept in password-protected files, and hardcopies in secure, limited access facilities.

Field Protocols

All crews shall be accompanied by a supervisor.

Newly discovered items shall be mapped as accurately as possible (preferably with a GPS unit to sub-meter resolution). Items shall be photographed *in situ* and a sketch map created if there are multiple items or other need to document site structure. A photographic log will document the date, location, compass bearing, photographer, and a brief description of the item.

Because the focus of this project is organic/perishable items, lithics, features, or other non-organics shall be documented and left in place unless the crew supervisor judges that the item is at high risk of loss through theft/collection (e.g., Clovis spearpoint). Documentation shall include GPS location data, photography, and sketch map for GLAC to follow up in subsequent visit.

The following characteristics may indicate an offering: x, y, and z. Discoveries of potential offerings shall be mapped and left in place pending a decision to offer tribal elders an opportunity to view them in place. However, if these items are in immediate danger of looting or other loss, they may be collected after documentation.

Animal scat or other items that are deemed non-cultural will be treated as paleobiological samples and will not require culturally sensitive handling protocols.

Collected cultural items are expected to be very fragile and potentially of high spiritual and/or cultural value. These items shall be handled with care and respect (additional language here?)

For discoveries of items that may be subject to the Native American Graves Protection and Repatriation Act, please follow steps outlined the Memorandum of Agreement (attached).

Lab/analysis Protocols

Items shall be kept in secure laboratory spaces.

For cultural items, analysis shall be non-destructive except where approved by the GCRMG. Destructive analysis of cultural items will likely require full tribal consultation; the GCRMG shall determine whether to continue to that point.

For non-cultural paleobiological items, laboratory analysis shall be non-destructive where feasible or minimize the sample to be destroyed. No cultural concerns are noted for these items.

Items shall remain 'under study' status for no longer than three years after the time of recovery unless otherwise specified by the GCRMG.

Curation Protocols will be determined by the Cultural Resources Management Group

The GCRMG shall determine the best location for long-term curation of cultural items.

Note: at the end of the project, all non-cultural samples, collections, and copies of records, data, photographs, and other documents resulting from the work will be delivered to the appropriate repository official at GLAC.

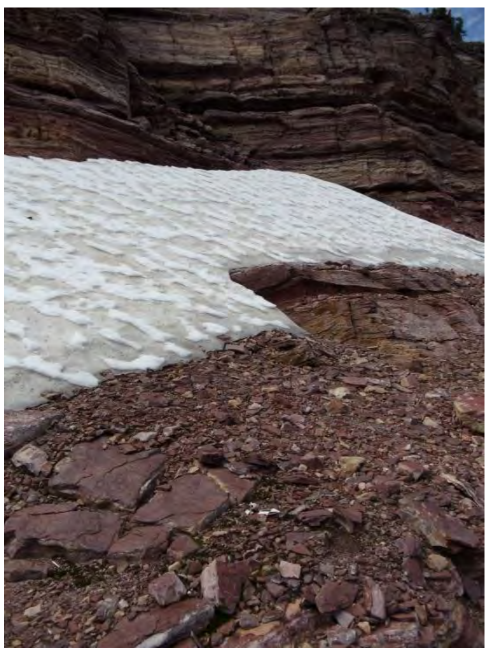
Glossary of Terms (to be developed)

Hidden Lake 1.

Patch 15.

Patch 20.

Patch 21.



Patch 20A.

Patch 40.

Patch 41.

Patches 38 and 39.

Patch 38A.

Example of in situ photograph. Patch 41, object 5 (lower left, to right of north arrow).

University of Colorado – INSTAAR Contribution to Glacier National Park's 2010 Letter Report

Major activities and product dates

1) Meeting with Cultural Resource Management Group, West Glacier, MT, 24 May;
2) Presentation at National CESU Meeting, Washington, DC, 24 June;
3) Identification of potential survey points in Glacier National Park - kmz file sent by email 18 July;
4) Selection of target points for 2010 field season with field schedule - sent by email 1 August (points/schedule later revised with input from partners);
5) Glacier National Park fieldwork and travel, 26 August – 9 September;
6) Submitted an abstract for a paper presentation titled "Alpine Snow and Ice as a Source of Archaeological and Paleoecological Data in the Rocky Mountains" for the organized session "Crown of the West: Mountain Archaeology from the Sierra Nevada to the Rocky Mountains" at the Society for American Archaeology meeting in Sacramento, California (March 2011). Coauthors: Craig Lee (presenter), Robert Kelly, Ira Matt, Rachel Reckin and Marcia Pablo;
7) INSTAAR's contribution to the 2010 Annual Letter Report (sent by email 14 October 2010).

Narrative

Year one resulted in the formation of the GCRMG and the introduction of tribal and park partners to the field of "ice patch archaeology." Forty-six locations with archaeological potential were selected following the protocols laid out in the proposal (see also Lee 2010). Points were assigned a letter grade, A, B, or C, based on *a posteriori* criteria and intuition. The points were largely uninformed with regard to traditional tribal knowledge due to the rapid scheduling required for the 2010 field season. I communicated with Pei Lin Yu regarding what the "metadata" identified in the INSTAAR agreement might entail on 27 May (and at other times), and I am under the impression the kmz file and emails sent regarding the starter points is sufficient; CSKT will construct the project GIS products, which will include details about the locations we visit and the specifics of any high resolution imagery consulted. Of the initial 46 points, a short list of target locations were selected for the 2010 field season, including three points selected in part with information provided by the CSKT and BN. The 2010 field season was a qualified success, with all of the target locations being reached by the team; however, inclement weather played a role in shaping the schedule, and visibility at several locations was marginal. Although we did not find any cultural material directly associated with ice patches, we did collect a number of paleobiological samples. The samples were field stabilized and transported to University of Wyoming. Following genus/species identification, a selection will be submitted for radiocarbon dating. Field conditions are subject to local and regional variability, and I believe we should continue to aim for late summer early fall surveys, i.e., early September.

For Year 2 we will have the benefit of the USGS proprietary imagery taken during an extremely high melt year as well as the time necessary for CSKT and BN to consider the integration of traditional knowledge to survey locations. I've already been to the *2nd Biennial Frozen Pasts Conference* in Trondheim, Norway and presented on mid-latitude ice patch research in North America. The *3rd Biennial Frozen Pasts Conference* will be held in Whitehorse, Yukon in 2012. It will coincide with the opening of the Kwanlin Dün Heritage Center. This meeting would be an ideal place to share future project results.

Reference Cited:

Lee, Craig M.
2010 *Ice on the Edge: Methods and Recommendations for Conducting Ice Patch Surveys in Rocky Mountain National Park*. Report on file with National Park Service, Rocky Mountain National Park, Estes Park, Colorado and Rocky Mountains Cooperative Ecosystem Studies Unit, Missoula, Montana.

UNIVERSITY OF WYOMING

Department of Anthropology
1000 E. University Box 3431
College of Arts and Sciences
Laramie, WY 82071-3431
(307) 766-5136 • fax (307) 766-2473 • www.uwyo.edu/anthropology

Lon Johnson
Cultural Resource Specialist/Historical Architect
Division of Science and Resources Management
Glacier National Park
West Glacier, Montana 59936

November 30, 2011

Re: RM-CESU Cooperative Agreement Number H1200090004

Lon,

This was a bit of a frustrating year for the Ice Patch Archaeology project as record snow levels in the park prevented us from fieldwork. We had arranged to rent a manual coring device to take some samples from the snow fields themselves and to date the basal ice layers to obtain an idea of their maximum ages; we hope to pursue that aspect of the research next year.

In the meantime, we made some progress on the aerial imagery, video, and ethnographic components.

Major activities and product dates:

1) October 5-7, 2010, Lee prepared/presented a brief on the planning and completion of YR1 fieldwork for the 2nd International Glacial Archaeology Symposium (Frozen Pasts), Trondheim, Norway. The project brief delivered at the 2nd International Glacial Archaeology Symposium (Frozen Pasts) in Trondheim, Norway was well received. The single session format was attended by nearly 70 participants working on similar problems throughout Europe and North and South America.
2) Phone conference call of all participants as fieldwork follow-up, November 15, 2010.
3) Phone conference call of all participants as fieldwork follow-up, February 7, 2011.
4) March 30-April 3, 2011, prepared/presented a project paper coauthored by GCRMG participants Craig Lee, Robert Kelly, Ira Matt, Rachel Reckin and Marcia Pablo for an invited session at the 76th Annual Meeting of the Society for American Archaeology, Sacramento, California; this was a national stage for the GCRMG and the project's collaborative formulation.
5) March-May, 2011, completed independent budgets and associated paperwork for YR2 and YR3.
6) Maria Nieves Zedeño from the University of Arizona joined the Ice Patch Project in 2011 to assist the Blackfeet Tribal Historic Preservation Officer, John Murray (BTHPO) in developing a research strategy for this project and conducting background research and ethnographic fieldwork. John Murray and Maria Nieves Zedeño discussed names of elders who are familiar with the geography of Glacier National Park as well as knowledgeable about the cultural significance of the park's places and resources. Maria

Nieves Zedeño and her assistant have begun to compile background information on park use that may be mapped onto the project GIS layers. Thankfully there are two important reports (Campbell and Foor 2002; Reeves and Peacock 2001) commissioned by the park that may be incorporated into the database as well as Claude Shaeffer's (1934) unpublished manuscripts, which are available electronically through Glenbow Museum archives, plus sundry publications that will be combed for relevant information.

7) June 4-7, 2011, all members of GCRMG attended a meeting with GCRM Group, Kwataqnuk, Polson, MT.
8) June 6, 2011, as part of the community outreach aspect of the project, Lee and Kelly presented *Alpine Snow and Ice as a Source of Archaeological and Paleoecological Data in the Rocky Mountains* for Salish Kootenai College, Johnny Arlee/Victor Charlo Theater, Polson, MT; video copies were provided to the GCRMG group.
9) March- September, Lee worked to identify remotely sensed data (e.g., aerial overflights) that could refine the ice patch targets selected in YR1 based on geographic characteristics, including consultation with USGS, Maps, CSKT, Quaternary GIS Lab, and ERDAS. This imagery may be critical to assessing the degree of melt occurring at the ice patches selected for survey based on geographic characteristics; however, we encountered two issues: (a) A few personnel changes in the mid-winter at CSKT slowed our collective effort to work with the remotely sensed imagery obtained by the USGS. However, Pete Gilleard and Martin Zobel of the CSKT GIS Department has picked up the mapping effort. He has been working the planning and ethnographic maps for this project for the CSKT; (b) Throughout the spring and summer we attempted to work with/access extant digital copies, but unfortunately they are corrupt. Consequently, we are now gauging a path forward by examining the original 9" x 9" diapositives.
10) The CSKT were able to create a Golden Eagle nest layer created by the park and added it to the overall map. This was in response to the hypothesis that golden eagles might be responsible for the transport of the paleobiological materials recovered and dated in 2010. Kelly had consulted with some UW raptor specialists and decided that if a raptor was a vector for the movement of sticks to the ice patches from lower elevations, that golden eagles were the most likely species. However, there is all but no overlap between modern golden eagle nests and ice patches. While the past could have been different, the modern data shows no preference for nesting near ice patches by golden eagles and reduces the likelihood that raptors were responsible for the wood samples collected; this increases the likelihood that the samples reflect changes in the elevational distribution of the tree species.
11) The ethnographic section of the mapping is moving as well. The place name layer was added as well as Paul David's journey through the area. Using historic accounts, Martin Zobel has digitized a preliminary route used by David's family in his quest to meet the Peigan (Blackfeet) Tribe in an effort to carry a message of peace from the Salish/ Kootenai Tribes.
12) April -July, Lee and Kelly worked to identify Ice Core Drilling Services and the PICO hand auger as the portable ice coring platform to assess depth, stratigraphy and age of GLAC ice patches.
13) October 2010-September 2011 (various dates), phone conferences regarding project goals, logistics, GIS, field scheduling, planned culture committee meetings/presentations, project video component, etc.; for YR3 we have a planned culture committee

meeting/presentation and are looking forward to further integration of traditional knowledge with respect to our survey locations.

Sincerely,

Robert L. Kelly
Professor
Director, Frison Institute
RLKELLY@uwyo.edu

REFERENCES

Campbell, Gregory R., and Thomas A. Foor. 2002. An Ethnohistorical and Ethnographic Evaluation of Blackfeet Religious and Traditional Cultural Practices in East Glacier National Park and the Surrounding Mountains. The University of Montana, Missoula. Submitted to Glacier National Park.

Reeves, Brian O.K., and Sandra Peacock. 2001. "Our Mountains are Our Pillows": An Ethnographic Overview of Glacier National Park. Submitted to Glacier National Park.

Glacier National Park Ice Patch Survey Report
September, 2012
Robert L. Kelly
University of Wyoming (UW)
DOINPS40433
RM-CESU Cooperative Agreement Number H1200090004

Collaborators:
Craig Lee, Ph.D., Co-PI, University of Colorado, Institute for Arctic and Alpine Research (INSTAAR)
Confederated Salish and Kootenai Tribes (CSKT)
Blackfeet Nation (BN)
National Park Service, Glacier National Park (GNP)
University of Arizona, BARA (UA)

Preface

Archeological discoveries in high latitude and sub-alpine environments reveal that melting ice patches and glaciers expose well preserved yet fragile cultural materials. The cultural and scientific value of these fragile artifacts is immeasurable but fragile items quickly deteriorate if they are left exposed to the elements, animals, or collectors. Climate change-related phenomena are new and critical concerns for Native Americans who have ancient heritage links with what is now Glacier National Park. Glaciers and snowscapes are integral parts of tribal creation stories. The alpine zones are important special areas for hunting, gathering, and ceremonial use. Important cultural plants, minerals, and animals were procured in these unique environmental settings. Recent dramatic changes to these alpine and subalpine areas have caused an imbalance to an ecological system used and maintained by tribal ancestors since time immemorial, threatening permanent loss of heritage cultural and natural resources.

Increasingly rapid ice and snowmelt in Glacier National Park creates a critical cultural resource issue that must be addressed in a timely and comprehensive manner. Thorough examination and evaluation of impacts are the first steps to address endangered cultural and scientific resources and knowledge. Cultural resource studies focused on areas newly exposed by receding ice and snow fields provide insights about prehistoric lifeways in alpine and subalpine zones, as well as essential information on ancient climates and recent changes that are critical for evaluating the historical context of recent man-made habitat shifts. In addition, monitoring of ice and snow fields and exposed artifacts is critical. Such efforts must be coordinated among Native American tribes, environmental scientists, and archeologists to ensure consideration of issues, values, synergy between different domains of knowledge, and compliance with federal laws governing stewardship of cultural resources (e.g., 36 CFR Part 800, Sections 110 and 106 of the National Historic Preservation Act, Sacred Sites [EO 13007], the Native American Graves Protection and Repatriation Act (43 CFR Part 10), the Archeological Resources Protection Act).

Overall Project Objectives

The "Ice Patches as Sources of Archeological and Paleoecological Data in Climate Change Research in Glacier National Park" project will take place over a three-year period and involves a partnership between Glacier National Park, the University of Wyoming, the Institute for Arctic and Alpine Research at Colorado University Boulder, the Confederated Salish and Kootenai Tribes of the Flathead Reservation, and the Blackfeet Nation. The project's overall objectives are:

1) To work collaboratively with scientists from the University of Wyoming and INSTAAR/Colorado University, Boulder to investigate and document ice/snow patches in Glacier National Park in order to identify archeological, ethnographic, and paleobiological resources endangered by recent climate change and to recover archeological and paleoecological data relevant to global warming research.
2) To work collaboratively with the Confederated Salish and Kootenai Tribes of the Flathead Nation and the Blackfeet Nation to develop and implement culturally appropriate protective and conservation measures for sensitive cultural sites, features, and objects at risk from snowmelt.
3) To enhance cultural resource stewardship and protection at Glacier National Park through public education and interpretation about climate change impacts on cultural resources and resident indigenous communities.
4) To develop a strategy and methodology for assessing and mitigating impacts to cultural resources from glacial and snow/ice field recession that can serve as a model for other parks, agencies and entities in the United States and throughout the world.

Preliminary Meeting, May 2012

The research team, with representation of all parties, met at the University of Montana in May, 2012 to discuss the upcoming field season and to present a rough cut of the video product. Presentation of the video was open to the public.

Culture Committee Meetings, May 2012

Craig Lee, Pei Lin Yu and Ira Matt shared a project update with the Salish Culture Committee at St. Ignatious, MT on 5/2/2012. A brief recap of the meeting appeared in the *Char-Koosta News* (Official Newspaper of the Salish and Kootenai). Craig Lee and Kevin Askin shared a project update with the Kootnei Culture Committee at Elmo, MT on 5/9/2012.

Presentation at Frozen Pasts Conference, June 2012

Frozen Pasts' – the 3rd International Glacial Archaeology Conference was held in June 2012 in Whitehouse, Yukon, Canada (www.frozenpasts.com). The conference was hosted by Kwanlin Dün First Nation and the Government of Yukon and included more than 30 papers presented on the global phenomenon of prehistoric and historical materials melting from frozen contexts. Craig Lee and other members of the team presented the paper "Mid-Latitude Ice Patch Research in North America: Progress in Glacier National Park and the Rocky Mountain West," which included our nine-minute video product on research in Glacier National Park. Project participants agreed via email in June to share the video which can be accessed online here: http://youtu.be/ifmdf2RHsK8.

Presentation at 9th Annual Waterton-Glacier Science and History Day, July 2012

Craig Lee and Ira Matt shared a presentation titled "Ice Patch Archaeology and Paleoenvironmental Research in Glacier National Park and Vicinity" at the 9th Annual Waterton-Glacier Science and History Day, Waterton Alberta, Canada, July 26, 2012. The presentation was attended by staff and visitors from both Parks.

Initial Ice Patch Identification

Glacier contains hundreds of ice patches. Not all of these, however, have a high probability of preserving in a recoverable state organic artifacts and paleobiological (PB) materials. Therefore, prior to fieldwork, Lee used Google Earth and other publicly available imagery of GNP from multiple years to locate ice patches with a higher probability of offering such material for recovery. Prior to the 2010 field season Lee defined 46 such target ice patches with 3 additional points added by CSKT for a total of 49. (More may be defined in the future.) The majority of the 49 points are located in the southern half of the park (south of Going to the Sun Road). From Google Earth imagery, Lee selected those ice patches that: (a) are accessible on foot (ones inaccessible by foot would not have been used prehistorically), (b) that still existed in the high melt years visible in Google Earth (e.g., 2003), and (c) that offered a relatively flat forefield (below the ice patch), which is where we would expect to see artifacts and paleobiological materials strand if any had melted out in previous years -- meltwater and summer rainfall would rapidly transport and destroy materials downslope from ice patches with a steep forefield.

Refined Ice Patch Identification and Image Orthorectification

At the close of the 2010 field season we learned of, and began trying to access, imagery of GNP obtained by the United States Geologic Survey (USGS) during a period of extensive melting in mid-September 1998. The USGS obtained the imagery to study GNP's retreating glaciers and fortuitously captured our target ice patch locations as well. Although the USGS had previously digitized the imagery onto several hundred compact discs, the files we needed were corrupt. Thankfully the prints and diapositives (essentially 10" x 10" slides) were still available. Dan Fagre and Lisa McKeon of the USGS loaned these to CSKT's GIS department in Polson, MT in the fall of 2011. Craig met with CSKT-GIS in Polson to identify the prints and diapositives corresponding to our target ice patches. The images were used to refine our initial selection of ice patches. Of the 49 initial targets, 21 were thrown out because they lacked permanent snow and ice based on the 1998 imagery. Of the remainder, 20 appeared to fit the criteria outlined above. To incorporate the images into our GIS for use in the field they needed to be orthorectified, which involves geospatial processing to remove distortions inherent in the scanned frames due to the position and orientation of the camera, properties of the camera lens, and especially the topographic relief of the area. Orthorectified images and (polygons derived from them in a GIS) would allow us to see in real-time our location in the ice patch forefield relative to the minimum ice extents and to accurately target our coring activities. CSKT's GIS department determined it was outside of their ability to orthorectify the images with the accuracy needed. We solicited a bid from INSTAAR's Quaternary GIS laboratory (QGIS) to accomplish the orthorectification. QGIS created detailed map layers with UTM (or lat/long) coordinates from the diapositives. QGIS sent the orthorectified images to CSKT-GIS. Martin Zobel at CSKT-GIS created polygons of the minimum ice patch extents and revised them following input from Craig in July. The polygons as well as the orthorectified images were supposed to be loaded onto one of CSKT's high-end Trimble GPS units for use in the field this summer. Unfortunately, the image file and polygons loaded onto CSKT's GPS device were corrupt and unusable in the field. Thankfully, CSKT produced a variety of 11" x 17" printouts of the target ice patches showing the minimum ice extents for our use in the field.

Field Research, 2012

The research team met with Lon Johnson and other park officials/team members on August 21 to finalize details for fieldwork. Field camp was established on August 21 at the St. Mary campground. Fieldwork continued through September 6 (with only one rest day). The primary field team consisted of:

Robert L. Kelly, PI (UW)
Craig Lee (INSTAAR)
Rachel Reckin (USFS, Kootenai)

We were also joined for a few days by Robert Fyant (CSKT) and, for the final backcountry trip, by Clara Copp-Larocque, a recent graduate of the University of Wyoming. Circumstances conspired to prevent other participation from the CSKT and BN. This is unfortunate since CSKT had the stored images and GPS tracks of ice patch edges in low melt years. We had intended to have these in the field with us to determine whether the surveyed patches were today covering portions terrain that had been exposed in previous high-melt years.

The BN, however, prior to the field season did submit a preliminary ethnographic report on ice patch uses; this has already been submitted to GNP.

Ice Patch Coring
We devoted the first four days of fieldwork to an effort to core ice patches 40 (Piegan Pass) and 37 (Siyeh Pass). Our goal here was to obtain materials suitable for 14C dating from the ice patch itself in order to see the relationship between the age of recovered materials and the actual age of the ice. We decided to test this approach at Piegan Pass and Siyeh Pass in part because those patches are accessible via established trails, and the coring procedure requires backpacking heavy and cumbersome equipment – equipment that would be impossible to transport off-trail in GNP.

Prior to the field season we consulted with the U.S. Ice Drilling program (http://www.icedrill.org/) as to whether it was feasible to core these temperate ice patches, and, if so, what instrument should be used. Following their recommendation we settled on a PICO hand auger. However, we found the device very difficult to use in the field, and noticed that the last line in the instructions stated that this device should not be used on temperate ice (ice at or near 0 degrees centigrade – which describes GNP's ice patches). The Park's automotive shop helped us modify the coring barrel, but this effort failed. We called the Ice Drilling program, and also consulted in person with an individual with 28 years of coring experience in Antarctica and Greenland (she confirmed that we were using the device properly). In brief, despite several attempts we were unable to retrieve more than about 1.5 m of core. We determined that this effort may require a coring device that uses a sleeve; the amount of barrel and sleeve required, however, may not be possible to transport by people. We will evaluate whether we wish to pursue the coring with a more appropriate device for next year.

Ice Patch Survey
The majority of the field time was spent hiking to the ice patches, even those located near established trails. We photographed each patch, and mapped the perimeter to the extent possible with an Oregon 450 GPS. The team then surveyed the forefield for some 20m or more out from

the current edge for artifacts and paleobiological materials. In addition, any stream, if present, running from the ice patch was also surveyed for 50 or more meters (depending on the gradient). All collected paleobiological (PB) specimens were located using a GPS instrument, photographed (both close-up and showing the specimen's location relative to the ice patch), and collected in a labeled plastic bag. A few pieces were stabilized on sturdy plastic sheeting. All photos taken by all crew members are compiled and available in the project Drop box.

Fieldwork was hampered by the difficulty of accessing the more remote ice patches. We originally had selected 11 targets for this field season. We were able to examine 9 of these patches, GLAC 9, 16, and 17, near Lonely Lakes; 13, near Mt. St. Nicholas; 30, near Red Eagle Pass; and 33, 34, 35, and 36 near Otokomi Lake; we also collected two wood specimens from GLAC 40 (Piegan Pass), which had been surveyed in 2010. Dense vegetation off-trail and an insurmountable cliff face prevented our reaching GLAC 31, near the head of Virginia Creek. We observed from a distance that GLAC 18, near Running Crane Lake had no forefield between itself and the lake, and so we ignored it this season. While 2011-12 was a normal snow year, work was hampered by the fact that many patches still contained snow from the record 2010-11 winter, which prevented fieldwork in September 2011. Located in the backcountry, several days were needed for some patches; GLAC 30, near Eagle Pass, for example, required 3 full days – two of those devoted to 15 mile hikes in and out of base camp.

We did not locate any definite artifacts (see table); however, we did collect a number of paleobiological materials, including a bison skull and associated skeletal elements from GLAC 35. Given that bison skulls are one of the items mentioned in the protocol that might be considered sacred items, we deliberated in the field as to whether we should collect the bison remains or not. We unfortunately did not have a tribal member with us. We decided that since the skull was accompanied by numerous other skeletal elements, including a femur, innominate, sacrum, ribs, and vertebrae, that the skull was most likely there as a result of a natural death, and not as a sacred item. We collected it and many of the other skeletal remains. As soon as we were within cell range, we notified the Park and our tribal participants of the find. Francis Auld (CSKT) examined the remains at the end-of-season meeting.

Two of the wood specimens from GLAC 16 were from rooted trees. All wood specimens are being identified at the University of Wyoming and several will be submitted for radiocarbon dates. A sample of the bison remains (a portion of the femur) has been submitted to the Rafter Radiocarbon Lab in New Zealand for carbon, nitrogen and radiocarbon analysis.

Fieldwork ended on September 6; the team had an end-of-session meeting with park officials on that day (immediately after walking out from GLAC 30) in West Glacier.

Award
This project was nominated for and will receive a WASO Partnerships in Conservation Award from the Secretary of the Interior in October 2012.

Future Efforts
Although the project has not yield any definitive archaeological material, it has generated numerous paleobiological specimens which are relevant to understanding alpine paleoecology

and climate change. The project will be able to share the results of these observations with the scientific community and public. We also plan to compare the spatial extents of the ice patches we recorded in the field in 2012 with the minimum ice extents documented in the 1998 imagery to ascertain the relative degree of melting (or growth) occurring in recent years.

Ice patch number	Approximate location	Recovery	Comments
13	Mt. St. Nicholas	Seven wood specimens	Krumholtz in area, so these could all be recent.
33, 34, 35, 36	Otokomi Lake	Bison remains, including much of the skull, partially buried; in excellent condition; GLAC 34-2, 3 possible birch; GLAC 35-5 wood; nothing recovered from GLAC 33 or 36	GLAC 34 and 35 had numerous faunal remains in their forefields, more than we had observed at other ice patches in GNP. These come from at least two species, mountain goat and bison. We initially thought that some of the other remains might be elk or horse, but analysis of the collected specimens and photos of the others taken in the field suggest that many are of the bison. Birch would suggest artifacts Some krumholtz in area, but none directly above 34 and 35
9, 16, 17	Lonely Lakes	GLAC 17-1, wood; GLAC 16-2,3 rooted wood	Krumholtz in area, especially above 16, so wood specimens are suspect; however, the rooted wood points to a drier, warmer climate when trees could take root in a forefield normally covered with snow/ice the better part of the year.
30	Eagle Pass	GLAC 30-1 through 4 wood; GLAC 30-5 large piece charred wood	We thought that GLAC 30 was a good candidate for human use since it is close to Eagle Pass, which was an important travel corridor according to ethnographic data. Charred wood might signal the presence of humans; there is a lot of krumholtz above GLAC 30 today, so the wood specimens might be suspect. We did note the presence of archaeological remains on the pass itself; no collections were made, but the information was passed along to the park.
40	Piegan Pass	GLAC 4,5 Two wood specimens	GLAC 40 was surveyed previously, in 2010. While ice coring we noted two additional pieces of wood, and given that this patch revealed a 5300 year old piece in 2010, we thought it wise to collect these.

Figure 1. GLAC 40, Piegan Pass, coring.

Figure 2. GLAC 34 (left) and 35; excavators standing

near bison skull

Figure 3. GLAC 35, Kelly (left) and Reckin recovering bison remains.

Glacier National Park Ice Patch Survey Report
October, 2013
Robert L. Kelly
University of Wyoming (UW)
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RM-CESU Cooperative Agreement Number H1200090004

Collaborators:
Craig Lee, Ph.D., Co-PI, University of Colorado, Institute for Arctic and Alpine Research (INSTAAR)
Confederated Salish and Kootenai Tribes (CSKT)
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4) To develop a strategy and methodology for assessing and mitigating impacts to cultural resources from glacial and snow/ice field recession that can serve as a model for other parks, agencies and entities in the United States and throughout the world.

Major Activities & Product Dates, 2013:

- October 2012–August 2013 (various dates), worked with University of Wisconsin's Ice Drilling Design and Operations (IDDO) center to arrange for use of the "Prairie Dog" internal and external barrel coring platform to assess depth and stratigraphy of Siyeh Pass and Piegan Pass ice patches during 2013 field season. Due to ice depth and rate of progress we only cored at Siyeh Pass – see narrative below.
- November 8, 2012, prepared/presented nationally streamed webinar, "Out of Thin Ice: An Unparalleled Archaeological and Paleobiological Record from Our Nation's Parks and Forests" for Climate Change Response Program's webinar series, "Climate Change in America's National Parks."
- January–September 2013 (various dates), worked with Chris Boyer, Kestrel Aerial Services, Bozeman, MT to set up late-season oblique aerial photo documentation of high-ranked ice patch targets. We anticipated the flights would occur prior to a major snow event but on or after September 25, 2013 to ensure maximum seasonal melt. Snow came earlier than expected. Assuming a reasonable melt during summer 2014, we will attempt the flight in 2014 before September 15 – see narrative below.
- March 12, 2013, prepared/presented an ice patch paper for an invited session at the 2013 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites in Denver, CO. Original session organizer was Marcy Rockman, but due to government travel restrictions the talk appeared in catchall session. *(No direct expenses for travel were incurred by project – this was an out-of-pocket contribution by co-PI Craig Lee).*
- March 2013 (various dates), worked with Robert Kelly to select targets for 2013 field season. We settled on Mt. Ellsworth (GLAC 1), Iceberg Peak (GLAC 43) and Gunsight Pass (GLAC 32).
- April 22, 2013, conference call regarding webpage and upcoming field season.

- May 9, 2013, all-hands meeting in Missoula, incl. rough-out of field season logistics, e.g., camps
- May-October,2013 (various dates), contacted parties interested in working toward a scientific paper regarding the male bison remains recovered at Otokomi Pass in 2012, incl. Robert Kelly, Pei-Lin Yu, Mary Meagher, and Michael Wilson.
- May through August 2013, worked with CU and UW to set up a sub-agreement from UW to allow for continued effort on the project. Due to effort in 2011 when the field season was canceled and work with USGS images, INSTAAR's original portion of the agreement would have been exhausted during the 2013 field season. Sub-agreement funding formally arrived at INSTAAR on October 23, 2013.
- August 18–30, 2013, fieldwork in Glacier National Park.
- September – October 2013 (various dates), emails and meetings regarding project goals, website, and scientific products, including identifying Kathy Puseman, paleobotanical specialist, for examination of lags.
- October 23-27, 2013 visited with fellow GLAC researcher Martha Apple regarding paleobotanical results (sent copy of 2011 SAA paper).

Narrative

Major projects/accomplishments through the 2013 field season included: 1) renting a Prairie Dog coring device that would work with the temperate snow and ice that we now know to be characteristic of mid-latitude ice patches, and 2) orchestrating late-season oblique aerial photo reconnaissance by Chris Boyer, Kestrel Aerial Services, of target ice patches with a ranking of "B" or higher following refinement with the orthorectified USGS imagery. (See Kelly et al. 2012 for details about the rectification work.) Unfortunately, snow hit the park earlier than expected in mid-September and the aerial photography had to be cancelled. Additional 2013 accomplishments, including the project brief delivered as a part of the Climate Change Response Program's webinar series, "Climate Change in America's National Parks," are noted in the "Major Activities" section above.

Coring. After an unsuccessful coring attempt in 2012 using a PICO hand auger (Kelly et al. 2012), we revisited our coring objectives with the Ice Drilling Design and Operations (IDDO) Center at the University of Wisconsin (http://www.icedrill.org/). In short, the goal of the coring operation was to identify and recover any lag deposits present in the target ice patches that might have formed during previous periods of melt. In essence, the lags are concentrations of diffuse organic material comprised of windblown organic and inorganic material as well as animal feces held in the matrix of the snow during decadal or even century-long periods of snow accumulation. When major melting occurs, this material begins to concentrate and eventually collects in a gradually thickening organic lag. Depending on past climate cycles, numerous lags can be present in a given ice patch. The lag samples are amenable to a variety of analyses, including composition analysis by paleobotanists and age characterization using radiocarbon dating; while a given lag may consist of material from a variety of time periods, if more than one lag is present at an ice patch, they are chronostratigraphically ordered.

Following discussions with IDDO we decided to use the “Prairie Dog” coring device and the “Sidewinder” platform. The Prairie Dog is driven by a ¾ horsepower electric drill connected to an external generator via a rheostat. The ca. 2m long core barrel consists of a ca. 5” wide internal barrel with flights to carry ice chips away from the ca. 6” wide, fluted cutting head, and a ca. 6” wide smooth external core barrel, which serves to isolate the chips produced by the cutting head from the exterior walls of the borehole. This configuration allows for the device to be more easily removed from the borehole after cutting a length of core. (The absence of the external barrel was our undoing with the PICO hand auger as the cut ice chips adhered to the borehole walls when we tried to extract it, effectively freezing it in place.) The sidewinder mounts to the coring platform and allows for the drill to “winch” the coring device out of the borehole; a significant advantage when working at depth after multiple extensions are added to the core barrel.

This device was significantly more complex then the PICO, requiring the participation of an IDDO-trained operator, Mr. Jay Kyne, for the 2013 field season. With decades of coring experience in Greenland and Antarctica, as well as an engineering background, including the design and manufacture of the anti-torque device which stops the external barrel from spinning, Mr. Kyne’s assistance was mission-critical. In addition to the Prairie Dog, Mr. Kyne also brought a ca. 3.5” diameter “thermal drill,” which uses a ceramic element similar to a heating element on a classic electric stove to melt through snow and ice. The generator was slightly underpowered for this unit, but as it turns out, this piece of equipment was critical to melt us through a layer of small gravel when we reached an impasse with the Prairie Dog unit in the second borehole. We were ultimately successful at extracting two cores from the Siyeh Pass ice patch, the second of which we are fairly confident reached the bottom of the ice patch. A radiocarbon date on the organic material recovered at the bottom should provide a limiting age for when the ice patch formed. (See results of preliminary analyses below.)

A note on logistics… IDDO shipped the gear to Bozeman, MT where it was received by Craig Lee. Lee transported the ca. 450 lbs. of gear by truck to St. Mary’s campground on 8/18 and then to the Glacier NP horse corrals early on 8/19. In-park logistics for this work were expertly provided by Glacier NP’s mule packing team. They transported the gear, including six 2 m long canvas wrapped bundles of coring tube extensions, the coring devices, generator, and tools to the Siyeh Pass ice patch on 8/19. They transported the gear down from the ice patch on 8/23. Lee drove the gear back to Bozeman, MT on 8/30, and after drying and repacking it, arranged for pickup and shipment back to IDDO on 9/4. As of 10/21, Krissy Dahnert (IDDO) said the project would receive an invoice for a figure close to the estimated amount in mid-November.

Oblique Aerial Photo Documentation. Following on a successful proof-of-concept with a separate and distinct ice patch project near the southeast corner of Yellowstone National Park in September 2012, we decided to employ an aerial photographic survey of snow conditions (extent of melt) at the high-ranked ice patch targets in GLAC. We anticipated the flights would occur prior to a major snow event, but on or after September 25 to ensure maximum seasonal melt was reached. Unfortunately, snow came earlier than expected and we were unable to obtain any of the desired images. Assuming a reasonable melt during summer 2014, we will attempt the flight in 2014 around the second week of September and before 9/15. The high-resolution, geo-tagged imagery will: 1) provide a permanent record of late season (post-survey) ice patch conditions for project partners and 2) offer an additional chance to refine the survey potential of the highest ranked target ice patches. If a major melt event occurs in the Park after the conclusion of the project, the aerial photos will provide important comparables/benchmarks to help guide officials and tribes to areas of critical concern.

Survey. After completing coring operations in week 1, we devoted the second week to survey of Mt. Ellsworth (GLAC 1), Iceberg Peak (GLAC 43) and Gunsight Pass (GLAC 32); GLAC 43 required a one-night stay in the backcountry, and GLAC 32 required a two night stay in the backcountry. Unfortunately, we recovered no archaeological remains, or paleobiological remains with the exception of four pieces of possibly rooted wood GLAC 1 (see table). These have not been identified or dated yet. For each of the three patches we used an Oregon 450 GPS to map its lateral and base margins, and we surveyed the forefields. These were lower ranked fields – more difficult to access, with smaller and/or less exposed forefields than some surveyed in previous years.

Video. Nearly 1,000 photographs were taken of two of the field sites in Glacier this year (2013) by Frank Tyro and others. Over an hour of high definition video was also acquired. One of the sites was where ice coring was accomplished. This provides a rich archive of material for inclusion in the website being developed by David Rockwell. It is anticipated that an overview video will be produced this winter for the website and that individual interviews or perspectives can also be included. Participants are developing materials that will be included as the website design progresses.

Participation. Besides the co-P.I.s and the drill operator, we had field participation from Kevin Askan and Ira Matt (CSKT), Greg Hall (Blackfeet Nation), Rachel Reckin (USFS), Brent Rowley and Sierra Mandelko (GNP seasonal archaeologists), and Frank Tyro (Salish-Kootenai College).

Table 1

Ice patch number	Approximate location	Recovery	Comments
38	Siyeh Pass	Two ice cores drilled	Drilled to 8m in core 1 and 6.4m in core 2; believe that we reached ground surface in core 2; three samples sent for 14C dating from base of core 2. Resurveyed base of GLAC 38, recovering one historic piece of wood.
1	Mt. Ellsworth	Surveyed, specimens GLAC 1-1,2,3,4	Recovered 4 pieces of possibly rooted wood. Of note: There was a healthy stand of trees on the cliff face above the ice patch.
32	Gunsight Pass	Surveyed, no finds	Nothing recovered; noted presence of possible tent/cabin foundation near base of patch, next to large boulder. Location was recorded by NPS seasonals. Small forefield.
43	Iceberg Peak	Surveyed, no finds	Nothing recovered, forefield constrained by boulder "dam"

Results of preliminary analyses. We dated three samples from the bottom of core 2 (Table 2), samples that were presumably resting on the ground surface beneath the ice patch, about 6.4 meters below the patch's surface. Once calibrated, these three samples, all different source materials, place the age of the bare surface at ~6500 years ago. This comports well with current estimates of when the park's glaciers began to form following the early Holocene warm period. It also tells us that this ice patch, GLAC 38, has not melted back to a pre-6500 BP size (whatever that was) in the past 6500 years since we would expect material as delicate as sheep feces and minute leaves to have disintegrated or been blown or washed away.

Table 2.

Beta Analytic Sample number	Field number	Material	13C/12C (‰)	Conventional Age (BP)	Calibrated Ages (cal BP)
362258	**G38C2-6.41m3**	**Leaf (unknown)**	**-27.3**	**5710 ± 30**	**6600-6590, 6560-6430, 6430-6410**
362257	**G38C2-6.41m2**	**Leaf (dwarf birch?)**	**-25.9**	**5310 ± 30**	**6190-5990**
362256	**G38C2-6.41m1**	**Feces (sheep?)**	**-25.8**	**5610 ± 40**	**6470-6300**

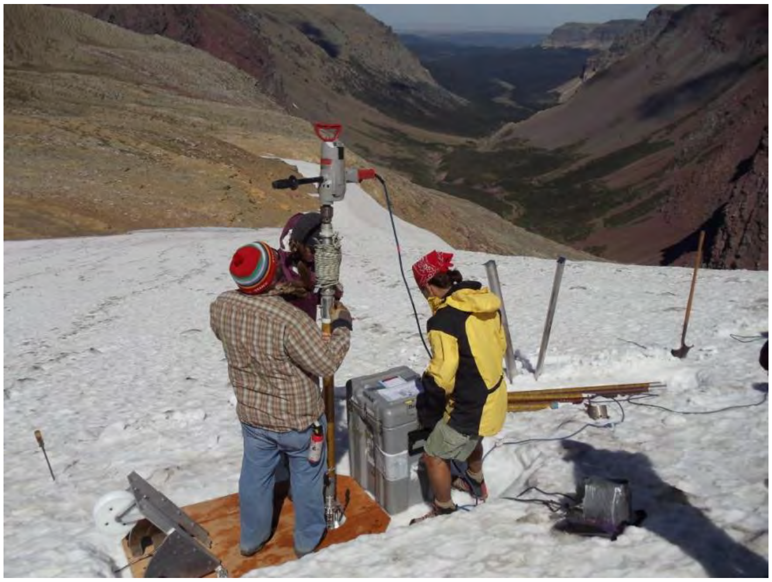
Figure 1. Core 1 in process at GLAC 38, Siyeh Pass.


Figure 2. GLAC 1, Mt. Ellsworth, view to west

Figure 3. GLAC 43, Iceberg Peak, view to south

Figure 4. GLAC 32, Gunsight Pass, view to south.

Figure 5. Comparison of GLAC 38 (left side of photos) and 39 (right side) in 2010 (top) and 2013 (bottom). In 2013 the patches were still enlarged by extensive 2011 winter snow (view to north).

Kelly, R.L., and Craig Lee. Glacier National Park Ice Patch Survey Report, September, 2012. Report filed with Glacier National Park, RM-CESU Cooperative Agreement Number H1200090004.

Glacier National Park Ice Patch Survey Report
December, 2014
Robert L. Kelly
University of Wyoming (UW)
DOINPS40433
RM-CESU Cooperative Agreement Number H1200090004

Collaborators:
Craig Lee, Ph.D., Co-PI, University of Colorado, Institute for Arctic and Alpine Research (INSTAAR)
Confederated Salish and Kootenai Tribes (CSKT)
Blackfeet Nation (BN)
National Park Service, Glacier National Park (GNP)
University of Arizona, BARA (UA)

Preface

Archeological discoveries in high latitude and sub-alpine environments reveal that melting ice patches and glaciers expose well preserved yet fragile cultural materials. The cultural and scientific value of these fragile artifacts is immeasurable but fragile items quickly deteriorate if they are left exposed to the elements, animals, or collectors. Climate change-related phenomena are new and critical concerns for Native Americans who have ancient heritage links with what is now Glacier National Park. Glaciers and snowscapes are integral parts of tribal creation stories. The alpine zones are important special areas for hunting, gathering, and ceremonial use. Important cultural plants, minerals, and animals were procured in these unique environmental settings. Recent dramatic changes to these alpine and subalpine areas have caused an imbalance to an ecological system used and maintained by tribal ancestors since time immemorial, threatening permanent loss of heritage cultural and natural resources.

Increasingly rapid ice and snowmelt in Glacier National Park creates a critical cultural resource issue that must be addressed in a timely and comprehensive manner. Thorough examination and evaluation of impacts are the first steps to address endangered cultural and scientific resources and knowledge. Cultural resource studies focused on areas newly exposed by receding ice and snow fields provide insights about prehistoric lifeways in alpine and subalpine zones, as well as essential information on ancient climates and recent changes that are critical for evaluating the historical context of recent man-made habitat shifts. In addition, monitoring of ice and snow fields and exposed artifacts is critical. Such efforts must be coordinated among Native American tribes, environmental scientists, and archeologists to ensure consideration of issues, values, synergy between different domains of knowledge, and compliance with federal laws governing stewardship of cultural resources (e.g., 36 CFR Part 800, Sections 110 and 106 of the National Historic Preservation Act, Sacred Sites [EO 13007], the Native American Graves Protection and Repatriation Act (43 CFR Part 10), the Archeological Resources Protection Act).

Overall Project Objectives

The “Ice Patches as Sources of Archeological and Paleoecological Data in Climate Change Research in Glacier National Park” project will take place over a three-year period and involves a partnership between Glacier National Park, the University of Wyoming, the Institute for Arctic and Alpine Research at Colorado University Boulder, the Confederated Salish and Kootenai Tribes of the Flathead Reservation, and the Blackfeet Nation. The project's overall objectives are:

1) To work collaboratively with scientists from the University of Wyoming and INSTAAR/Colorado University, Boulder to investigate and document ice/snow patches in Glacier National Park in order to identify archeological, ethnographic, and paleobiological resources endangered by recent climate change and to recover archeological and paleoecological data relevant to global warming research.
2) To work collaboratively with the Confederated Salish and Kootenai Tribes of the Flathead Nation and the Blackfeet Nation to develop and implement culturally appropriate protective and conservation measures for sensitive cultural sites, features, and objects at risk from snowmelt.
3) To enhance cultural resource stewardship and protection at Glacier National Park through public education and interpretation about climate change impacts on cultural resources and resident indigenous communities.
4) To develop a strategy and methodology for assessing and mitigating impacts to cultural resources from glacial and snow/ice field recession that can serve as a model for other parks, agencies and entities in the United States and throughout the world.

Major Activities & Product Dates:

1) January 13–February 9, 2014, NPS/RM-CESU/UCB completion report for P12AC10324 / UCOB-94 (ice patch ortho-rectification project);
2) January 31, 2014, NPS news story "Ice Patch Archeology and Paleoecology in Glacier National Park;" a news story compiled by Pei-Lin Yu, NPS, with content provided by INSTAAR and others (http://www.nps.gov/archeology/sites/npSites/glacierIcePatch.htm);
3) January 2014–April 2014 (various dates), discussions with John Murray and Shelia Hall, both with the Blackfeet Nation (BN), regarding sharing project results in Browning, MT public schools. We are now trying for spring 2015;
4) January–December 2014 (various dates), website development, content contributions and multiple reviews (http://temporarypost1.org/index.html; link not yet public), worked w/ D. Rockwell, website designer, and indirectly w/A. Sandoval regarding original artwork for ice patches plus multiple iterations of the flash animation; provided content for ice patch research worldwide, incl. news stories, links, images with description, and content for younger audience; miscellaneous content based calls; discussions regarding alpine plants and tribal partners portion of website as well as academic partners; GCRMG ownership of site;
5) February–March 13, 2014, final reviews of "Ice Patch Archaeology in Western North America" for publication in *SAA Archaeological Record* , an un-refereed journal. Authors are Craig M. Lee, Robert L. Kelly, Rachel Reckin, Ira Matt, and Pei-Lin Yu. Article published in March (http://www.saa.org/Portals/0/SAA/Publications/thesaaarchrec/March_2014.pdf);
6) March–April 2014 (various dates), conversations with Bob Kelly, U. Wyoming, regarding GLAC ^{14}C samples (Beta vs. Direct AMS), etc.;

7) April 30–May 1, 2014, additional copies of ortho-rectified photos to GLAC (and to other partners) on DVD DL (dual layer) disc;
8) May 2014 (various dates), conversations regarding advancing the Glacier Cultural Resource Management Group (GCRMG);
9) May 22, 2014, interview and visit with Frank Tyro in Bozeman, MT regarding project outcomes from PI perspective;
10) May–June 2014 (various dates), submitting GLAC bison and comparatives to Dr. Beth Shapiro, U. California–Santa Cruz, for ancient DNA analysis (results received November 2014);
11) July–September 2014 (various dates), discussions with Chris Boyer, Kestrel Aerial Services, Bozeman, MT, regarding late-season oblique aerial photo documentation of high-ranked ice patch targets. We anticipated the flights would occur in 2013, but early snowfall precluded the work. We revised our plan and intended to have the work occur prior to a major snow event in 2014, but the persistent snowfall from the winter of 2013/2014 precluded the flights (http://www.nrmsc.usgs.gov/research/ftm_snow.htm). The money for this important work is encumbered at U. Wyoming for 2015;
12) August, 2014 (various dates), calls with John Murray, BN, and Confederated Salish & Kootenai Tribes (CSKT) regarding a request from the NPS's Washington Office to facilitate a CNN news story about climate change. Unfortunately, the GLAC interview(s) did not materialize ;
13) August–September 2014 (various dates), identifying a route to complete and maintain the webpage for the duration of the project. Solution: via direct invoice for last of the work from D. Rockwell to U. Wyoming.
14) December 2014 (various dates), completion of year-end report.

At no direct expense to the project, the Glacier National Park Ice Patch Project was acknowledged in several public presentations given by Craig M. Lee on ice patch archaeology in general, including:

Invited presentations

2014 Nationally streamed webinar, *Out of Ice: An Archaeology of Climate Change in North America and Beyond.* National Park Service's webinar series, "Archaeology in America's National Parks," November 13.

2014 Lecture in celebration of International Archaeology Day, *Out of Ice: An Archaeology of Climate Change in North America and Beyond*. Jackson Hole Museum and Mercill Archaeology Center, . Jackson, WY, October 18.

2014 Lecture for Dr. Dave McWethy's class in the Dept. of Earth Sciences, ERTH 212, September 4

2014 Lecture, *Rocky Mountain Ice Patches as a Rich Source of Archaeological and Paleoenvironmental Data*. In Session: Giving Latitude to Altitude (and Vice-Versa): The Archaeoecology of Human Settlement in Extreme Environmental Settings High Altitude and High Latitudes. 79th Annual Meeting of the Society for American Archaeology, Austin, Texas, April 24.

2014 Lecture, *Ice Patch Archaeology in the Rocky Mountains: A Silver Lining to 21st Century Climate Change*. Department of Earth Sciences Seminar Series, Montana State University, February 13.

2014 Lecture, *Archaeology at the Crossroads of Culture and Climate Change: Ice Patches as a Rich Source of Archaeological and Paleoenvironmental Data*. Boise State University, Department of Anthropology, February 21.

Contributed Presentations

2014 *Ice patch archaeology at the crossroads of culture and climate change in the Rocky Mountains*. Panel 2: Managing natural and cultural resources under a changing climate – moving forward in an uncertain future. 12th Biennial Scientific Conference on the Greater Yellowstone Ecosystem, Mammoth, WY, October 8. (with co-authors Halcyon LaPoint, Dave McWethy, Greg Pederson and Cathy Whitlock)

2014 *Ice Patches and Relict Wood: A Paleoclimate Proxy for The Rocky Mountain West*. In Holocene Climate of Western North America. Rocky Mountain (66th Annual) and Cordilleran (110th Annual) Joint Meeting, May 19. (with co-authors Greg Pederson, Jeff DiBenedetto, Halcyon LaPoint and Mike Bergstrom)

2014 *50 Years of Ice Patch Archaeology in the Greater Yellowstone Area*. 56th Annual Conference of the Montana Archaeological Society. Hamilton, MT, April 11-13.

2014 *Ice Patch Archaeology*. Colorado Council of Professional Archaeologists. Glenwood Springs, CO, March 20-23, 2014.

Narrative

The last season of planned fieldwork for the project was summer, 2013. Major activities in 2014 included: (1) work on the project's website with David Rockwell, website designer, (2) the extraction of ancient DNA from the GLAC bison and comparatives by Dr. Beth Shapiro, U. California–Santa Cruz, (3) further Siyeh ice core dating, (4) and attempt, again, at aerial photo documentation, and (4) more dates on paleobiological materials collected from the ice patch forefields.

Project Website. This has become a major, interpretive deliverable for the project. The link is not yet public: http://temporarypost1.org/index.html. The website contains major sections on the project, including background, the science of ice patches, partner statements, tribal perspectives, a massive image gallery, and links to ice patch research worldwide. There is also a page with content for children. Major enhancements include an incredible animation of an ice patch hunting scene that was rendered by Antoine Sandoval (Pend d'Oreille and Navajo) and animated by David Rockwell. The web site also includes a rotatable 3D image of the GLAC bison skull. We have assembled an impressive list of more than 25 colleagues to pre-review the website before its formal launch in the spring of 2015. We also have a mechanism in place to ensure the site will be maintained until the end of the project.

Ancient DNA. Following on the recovery of bison remains near a GLAC ice patch in 2012, we determined it would be beneficial to our interpretation to pursue genetic analysis of the specimen. An underlying question/motivation was to ascertain if the GLAC bison is a representative of "mountain bison," which may be a subspecies of *Bison bison*. The GLAC bison had previously been radiocarbon dated to 967 ± 15 BP. Dr. Shapiro conducted her analysis on the specimen for a flat fee of $1646. *At no direct expense to the project,* Dr. Shapiro also analyzed ice bison from Froze to Death Plateau, MT (^{14}C Age 775 ±25BP), Silver Run Plateau, MT (^{14}C Age 698 ± 23), and Iron Mountain, MT (^{14}C Age modern) for comparative purposes. Per an email from Dr. Shapiro (11/5/2014), all four specimens yielded high-quality, usable mitochondrial DNA (mtDNA). The attached relationship tree was generated using complete mitochondrial genomes. While the bison are in slightly different subsets, all of the Montana bison (highlighted in red) fall within the diversity of living bison. Alone, mtDNA cannot provide information about sex, but one of Dr. Shapiro's post-doctoral students is running the non-mtDNA through a script that assesses the ratio between X and Y chromosome data to make an educated guess about sex. Those results are pending. The mtDNA was a necessary first step to determine if viable genetic material was present. Per Dr. Shapiro, the GLAC bison and the other ice bison were extremely well preserved. A next step might be to examine the specimens for nuclear DNA which could reveal far more about the presence of subspecies. The project team will discuss this during a conference call in February 2015.

Siyeh Pass Ice Core Dating. Dating of the ice cores proceeds by dating single, prefereably identified items from organic "lag" deposits. When major melting occurs in an ice patch, organic materials trapped in the snow/ice move downward and eventually concentrate on the ice patch's new surface. If the deposit is reburied and not subsequently exposed, it forms a distinctive black band in an otherwise white to clear core of ice and snow. These materials could come from decadal or even century-long periods of snow accumulation. Depending on past climate cycles, numerous lags can be present in a given ice patch. The lag samples are amenable to a variety of analyses, including composition analysis by paleobotanists and age characterization using radiocarbon dating.

Our 2013 report noted that three dates from the bottom of core 2 suggest a severe melting of the ice patch about 6500 years ago (repeated in table 1; see also figure 2). Those dates came from what we believe to be the old ground surface, 6.4 meters below the 2013 ice patch surface. In 2014 we also dated a fecal pellet from a lag deposit at 5.65m in this core, which returned an age of ~3988 cal BP. We then dated two additional samples this ice core, at 4.27 and 4.54 m below the surface. These both returned "modern" ages, meaning that they were deposited sometime after AD 1945 (dates reported as "modern" reflect ^{14}C values artificially inflated by above-ground atomic testing so they date to sometime after AD 1945). This tells us that sometime in the last ~60 years the ice patch had melted to within ~2 meters of where it last melted out 6500 years ago. Ice patch retreat was severe in the early 2000s, and so much of the current 4.5 to possibly 6 m of snow has perhaps accumulated only since the winter of 2010-11, when the park saw record snowfalls and that photographic evidence suggests had expanded the Siyeh Ice patch since the summer of 2010 (see photos in the 2013 report).

We also dated two "lag" deposits in Siyeh Ice Core 1. Siyeh Core 1 went to 8.2m below the surface before it hit something impenetrable (possibly the bottom, but we are uncertain) and contained several organic lag deposits.

The lowermost lag deposit in Core 1 (8.2m) provided individual materials too small for dating. However, we were able to date single Dryas leaves from lag deposits at 8m and 7.3m. The lowermost lag deposit is very similar to age to the lowermost date from Core 2, about 6700 cal B.P. Both indicate severe warming at the same time (and the age of the Core 1 deposit may indicate that Core 1 nearly reached the old land surface below). Above this deposit, at 7.3m, is a deposit dating to about 3325 cal B.P., pointing to another severe warming interval; this deposit and that at 5.65m in Core 2 may be dating the same period of warming (since a lag deposit is comprised of materials deposited at different times, we expect some variation in the ages of those materials). We await dates on 1-2 of the lag deposits lying above this one (note: the date of 230 uncal BP was obtained after this report was completed).

Oblique Aerial Photo Documentation. We had intended to conduct aerial photography in September 2014 that we had postposed in 2013 due to the early snow accumulation. Unfortunately, snow accumulation was still high in September of 2014, and we were forced to postpone this task as well until 2015 – conditions permitting. The high-resolution, geo-tagged imagery will: 1) provide a permanent record of late season (post-survey) ice patch conditions for project partners and 2) offer an additional chance to refine the survey potential of the highest ranked target ice patches. If a major melt event occurs in the Park after the conclusion of the project, the aerial photos will provide important comparables/benchmarks to help guide officials and tribes to areas of critical concern.

Further dates on paleobiological materials. We obtained an additional 28 dates on paleobiological materials collected from the forefields of the ice patches from all field seasons (see attached letter from Direct AMS). Seven (25% of the dates were "modern" (see above for definition), but the other dates range from 19 to 4599 radiocarbon BP, or from early 20^{th} century to about 5300 cal BP. We will discuss an analysis of all 14C dates obtained in the final report.

Participation. Besides the co-P.I.s and the drill operator, we had field participation from Kevin Askan and Ira Matt (CSKT), Greg Hall (Blackfeet Nation), Rachel Reckin (USFS), Brent Rowley and Sierra Mandelko (GNP seasonal archaeologists), and Frank Tyro (Salish-Kootenai College).

Goals for 2015 include colleague review of the website, subsequent revision (if necessary) and a formal launch of the website. We will also draft and submit a manuscript on the GLAC bison and the project writ large to a peer-reviewed journal. Last, we will begin drafting a final report on the project.

Table 1. Radiocarbon dates from Siyeh Ice Cores.

Sample number	Field number	Material	$^{13}C/^{12}C$ (‰)	Conventional Age (BP)	Calibrated Ages (BP)
Beta 362258	G38C2-6.41m3	Leaf (unknown)	-27.3	5710 ± 30	6600-6590, 6560-6430, 6430-6410
Beta 362257	G38C2-6.41m2	Leaf (dwarf birch?)	-25.9	5310 ± 30	6190-5990
Beta 362256	G38C2-6.41m1	Fecal pellet (sheep?)	-25.8	5610 ± 40	6470-6300
Beta 373869	GLAC-C2-4.27m	Leaf (Dryas)	-28.2	Modern	
Beta 373870	GLAC-C2-4.54m	Leaf (Dryas)	-27.7	Modern	
D-AMS 005372	GLAC-38-C2-5.65m-1	Fecal pellet (sheep?)	-28.8	3653+/-32	3891-4085
Beta 373866	GLAC-C1-7.3m	Leaf (Dryas)	-26.3	3130 +/- 30	3400-3330, 3290-3255
Beta 373867	GLAC-C1-8m	Leaf (Dryas)	-26.6	5910 +/- 30	6790-6665
Beta 403486	GLAC-C1-7.3m-B	Unidentified stem base	NA	230 +/- 30	310 to 270
Beta 373872	GLAC-C2-6.16m	Dicot twig and bud	-25.1	5300 +/- 30	6185-5990; 5960-5955
Beta 373865	GLAC-C1-6.7m	Dryas stem	NA	3920+/-30	4425-4285; 4275-4250
Beta 373864	GLAC-C1-5m	Abies needle	-26.4	Modern	

Appendix C: Blackfeet Ethnographic Report

(Maria Nieves Zedeño)

2012

Blackfeet and Glacier Ice Patches Report

Samrat Clements
María Nieves Zedeño

Bureau of Applied Research in Anthropology - School of Anthropology
University of Arizona, Tucson

John R. Murray
Blackfeet Tribal Historic Preservation Office

Draft report prepared for the University of Wyoming, Laramie

CONTENTS

THE BLACKFEET AND GLACIER NATIONAL PARK

PROJECT BACKGROUND

In 2010, the Blackfeet Tribe was invited to join the Ice Patch Project, a National Park Service Climate Change initiative that involves anthropological and ecological perspectives. The Ice Patch Project seeks to investigate long-term human use of glacier remnants called "ice patches" that formed millennia ago and became permanent on mountain slopes. Humans are known to have used these patches during hunting expeditions. Given conditions for climate change, the Ice Patch Project aims to monitor the effects of such change in the ecological conditions and human use of these features along the eastern and western slopes of the Rocky Mountains on Glacier National Park.

The eastern slopes of the northern Rocky Mountains are within the aboriginal territory of the Blackfoot-speaking groups of Canada and the United States. Glacier National Park shares a boundary with the Blackfeet Tribe. The tribe has a deep-time history of association with the park, which is most clearly reflected in origin stories as well as traditions associated with ceremonial bundles and tipis. The mountains are the homes of powerful beings that continue to interact with the people.

Although the majority of activities in traditional Blackfoot life are associated with the prairie and its resources, the Blackfeet utilized the Rocky Mountains for hunting and collecting of medicinal plants and animals for the bundles. The peaks in Glacier National Park are known to contain numerous vision quest sites dating from millennia ago to current times (Reeves 2012). Thus, the Blackfeet have much to contribute to the anthropological goals of the Ice Patch Project.

PROJECT METHODOLOGY

Through a subcontract with the University of Wyoming-Laramie , the University of Arizona is assisting the Blackfeet Tribe in the preparation of an ethnographic report that includes literature review and information obtained through on-site interviews with tribal elders (as feasible). This draft report summarizes information obtained from classical ethnographic literature and contemporary Blackfeet site and resource assessments. In particular, the report entitled: "Our Mountains Are Our Pillows": An Ethnographic Overview of Glacier National Park" by B. Reeves and S. Peacock (2001) contains an extensive review of past and present relationships between the Blackfeet Tribe and Glacier National Park that was consulted for this project, in addition to other ethnographies.

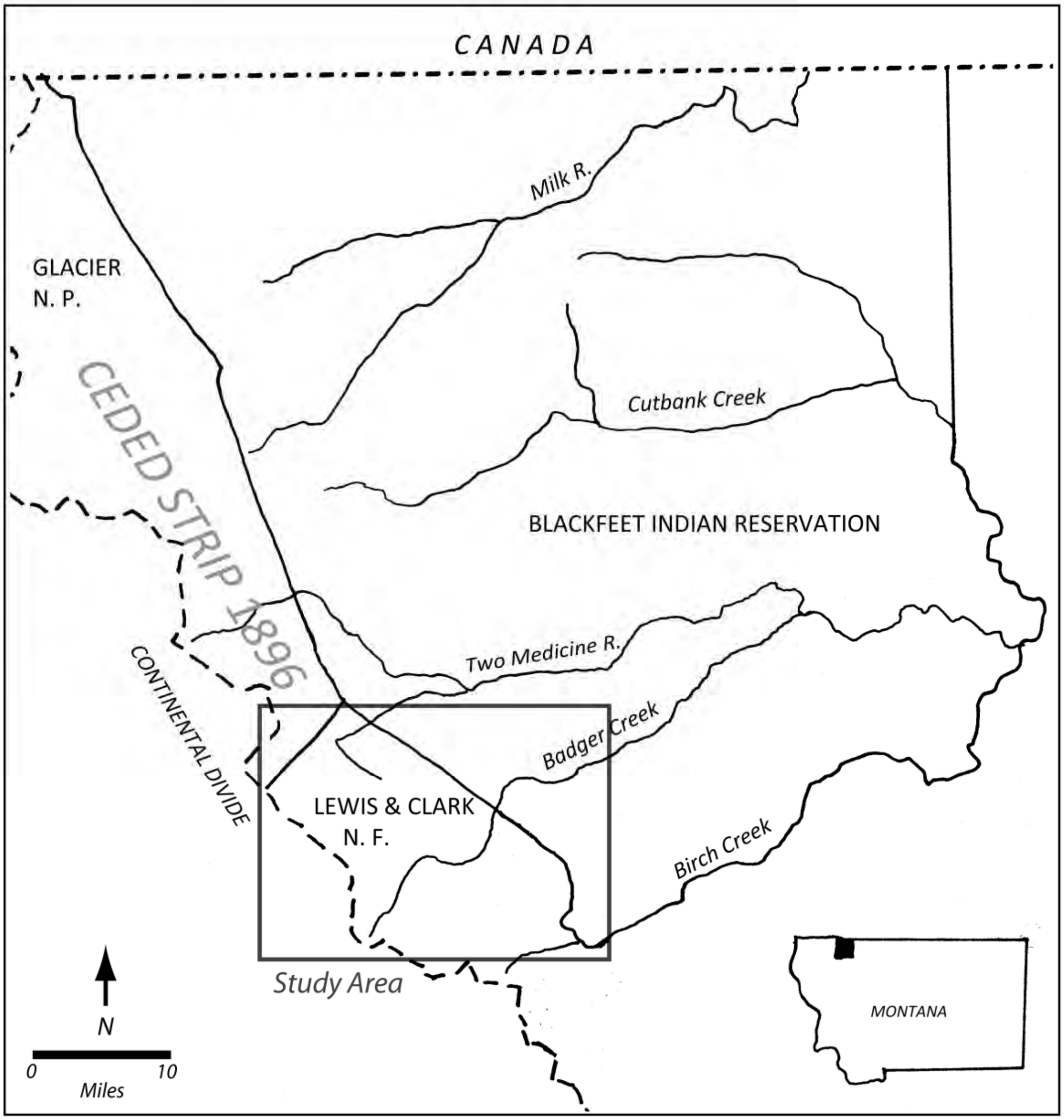

Figure 1. Boundaries of the Blackfeet Indian Reservation, Montana (Zedeño 2012:fig. 1)

The Rocky Mountains are called *Mistakis*, “Backbone-of-the-World” (McClintock 1992:13). McClintock (1992:352-353) briefly mentions three Blackfeet supernatural beings who personified natural forces: Thunder Chief, the Wind Maker, and Es-to-ne-a-pesta, Maker of Storms and Blizzards, all of which originate in the glaciers or the interglacial lakes.

NAPI

The Rocky Mountains were built by Old Man Napi, when he remade the world after it was destroyed by floods (Reeves and Peacock 2001:142). Napi traveled north until he stop at a place where, with the rock crumbs left in his pockets, made the Sweetgrass Hills (Sweet Pine Hills). Napi left this world with a promise to care for the people and return, though they would be transformed before he came back (Clark 1966:257; Reeves and Peacock 2001:143).

When standing on Two Medicine Ridge in the Lewis & Clark National Forest, one may clearly see the outline of Napi, "the Chief" lying down on the peaks of Glacier National Park, his headdress pointing north.

Figure 2. Old Man Napi, resting on the Rockies (Zedeño et al. 2006:fig. 2.1)

THUNDER, THUNDERBIRD, THUNDER CHIEF

Thunderbird or Thunder is one of the most powerful supernatural beings, one who brings rain and gave the medicine pipes to the people (Reeves and Peacock 2001:140). Almost all of the Medicine Pipes most sacred to the Blackfeet come from the Rocky Mountains, according to consultants of Reeves and Peacock (2001:159). The Blackfeet have many stories about Thunderbird. They say he once visited the camp after being overcome by a snowstorm. After visiting with the head chief and showing off his many-colored plumage, Thunderbird flew off into the storm clouds. "The Indian belief made the storm cloud the Thunder-bird's vehicle, behind which he moved through the air, making peals of thunder by flapping his wings, and shooting forth flashes by the blinking of his all-penetrating eyes" (McClintock 1992:520).

Thunderbird is also associated with the bison. A Peigan elder recently told M. N. Zedeño the following story:

> *Thunderbird stole the wife of this man and took her to his lodge. The husband went out looking for them but could not find them. That night the man had a dream, where he could see inside their lodge and his wife was with thunderbird. Then raven came to him and gave him a tail feather. He said: "go back to the mountains and you will find his lodge. Point my tail feather to the lodge and it will split open." Then you may take your wife back. So the husband did as instructed. As he was pointing raven's feather to the lodge it began to split. Thunder came and told him: "don't do that, you will destroy us all. Go ahead, take back your wife, and I will also give you my pipe and my horses." Then thunderbird brought the bison out and said, "Here, these are my horses."*

IMPORTANCE OF CHIEF MOUNTAIN

Chief Mountain, or Ninastakis, is one of the holiest places in the Blackfeet landscape. Chief Mountain was so entitled by the Blackfeet for its prominence among the other mountains (Schultz 1916:233), though there are more fanciful stories attributed, as described by Reeves and Peacock (2001:182). Chief Mountain is known as a significant the focus of many prayers. Eagle Head, an old warrior of the Small Robes band, in an account relayed to Grinnell by Schultz, prayed heartily for a return of the bountiful ancient days, when "buffalo covered the prairie, and the people were content" and they had the materials needed to make the proper offerings and medicines (Reeves and Peacock 2001:147). In this way, the strength of the land is intimately connected to the strength of the people.

Figure 3. Chief Mountain (photo by Rilley McCleland)

In addition to Chief Mountain's holiness in itself, the Rocky Mountains are the home of many of the greater and lesser supernatural beings. Chief Mountain is cited by Wissler and Duvall (1908:19) as the place where the Creator, Napi, sat with the animals to recreate the flooded world. The Thunderbird also lives throughout the Backbone, though especially at a cave near the summit of Chief Mountain (McClintock 1992:424-426, 520).

Brings-Down-the-Sun told the story of when his father, Running Wolf or A-pe-so-muckka, found the lodge of the Thunderbird (McClintock 1992:424-426):

> *"I was once camped with my grandfather and father on the Green Banks (St. Mary's River), close to the Rocky Mountains. They were digging out beavers, which were very plentiful. My father went off for a hunt to supply our camp with meat. He followed the trail of some elk up the side of a steep mountain, until he came to timber-line, where he saw a herd of mountain-sheep. He followed them towards Nin-ais-tukku (Chief Mountain). When he drew near the summit, he discovered a dense, foul-smelling smoke rising from a deep pit. He pushed a huge boulder into it to hear it fall. There came back no sound, but a cloud of smoke and gas arose so dense and suffocating, that he turned to flee, but it was only to meet a black cloud coming up the mountain side. He was frightened and tried to escape, but suddenly there came a terrible crash, and my father fell to the ground. He beheld a woman standing over him. Her face was painted black and red zig-zag streaks like lightning were below her eyes. Behind the woman, stood a man holding a large weapon. My father heard the man exclaim impatiently, 'I told you to kill him at once, but you stand there pitying him.' He heard the woman chant, 'When it rains the noise of the Thunder is my medicine.' The man also sang and fired his big weapon. The report was like a deafening crash of thunder, and my father beheld lightning coming from the big hole on the mountain top. He knew nothing more, until he found himself lying inside a great cavern. He had no power to speak, neither could he raise his head, but, when he heard a voice saying, 'This is the person who threw the stone down into your fireplace,' he realized that he was in the lodge of the Thunder Maker. He heard the beating of a drum, and after the fourth beating, was able to sit up and look around. He saw the Thunder Chief, in the form of a huge bird, with his wife and many children around him. All of the children had drums, painted with the green talons of the Thunder-bird and with Thunder-bird beaks, from which issued zig-zag streaks of yellow lightning.*
>
> *"We call the thunder Isis-a-kummi (Thunder-bird). We believe that it is a supernatural person. When he leaves his lodge to go through the heavens with*

> *the storm-clouds, he takes the form of a great bird with many colours, like the rainbow, and with long green claws. The lightning is the trail of the Thunder-bird.*
>
> *"Whenever the Thunder Maker smoked his pipe, he blew two whiffs upwards toward the sky, and then two whiffs towards the earth. After each whiff the thunder crashed. Finally the Thunder-bird spoke to my father, saying, 'I am the Thunder Maker and my name is Many Drums (expressive of the sound of rolling thunder). You have witnessed my great power and can now go in safety. When you return to your people, make a pipe just like the one you saw me smoking, and add it to your bundle. Whenever you hear the first thunder rolling in the spring-time, you will know that I have come from my cavern, and that it is time to take out my pipe. If you should ever be caught in the midst of a heavy thunder-storm and feel afraid, pray to me, saying, 'Many Drums ! pity me, for the sake of your youngest child,' and no harm will come to you. (This prayer is often used by the Blackfeet during dangerous storms.) As soon as my father returned, he added to his Medicine Bundle a Pipe similar to the one shown to him by the Thunder-bird."*

It is important to point out, however, that the Pikaani (Blackfeet) elders looked upon Divide Mountain as the most sacred of the peaks in Glacier National Park (EOP to Zedeño, 2012). Little is known about Divide Mountain ethnographically, and it should be investigated as part of this project.

Figure 4. Divide Mountain (photo by A. Thompson)

COLD MAKER, ES-TO-NE-A-PESTA, MAKER OF STORMS AND BLIZZARDS

Cold Maker made the mountain ice and is the bringer of cold, snow, and storms from the Far North (Reeves and Peacock 2001:140).

After taking some mountain goats in the high reaches of the Backbone, Schultz proposed climbing a nearby ice-field with his guides, No Runner and Star Woman. On his way, No Runner explained the history of the glaciers (Schultz 1930:186-188):

> *'These great ice masses are wonderful; they are Cold-Maker's medicine leavings,' he said, as we made our way up across a long slope of talus. 'He and Sun are*

> *always fighting. He comes down from the Far North, bringing with him his snowstorms and terrible cold winds, and day by day drives Sun away to the South. He does the best that he can, but always he loses strength; his storms become more and more feeble, his power for cold-making weakens, and then Sun turns and slowly but steadily drives him back whence he came, melting his snows, warming the earth, and causing the grass to grow again. But in the very first of their battling, Cold-Maker made strong medicine. Here and there along these mountains, along this Back-Bone-of-the-World, he deposited great thicknesses of ice, and when he had made them he said to Sun: "Just at this time you are stronger; you drive me back; but I leave these thick ice places along my trail as a sign that I shall come again. Unless you can turn them into water and make them disappear, you can never conquer me."'*
>
> *'"Ha! If that is all I have to do then you shall soon be no more!" Sun cried, and sent his heat down upon the ice places with all his strength. Water began to stream from them; rivers of water poured from them. Sun laughed: "This is too easy. I shall soon melt them," he said. But he failed to do it, and when he had used up all his heat, and had melted only a small part of them, back came Cold-Maker and drove him South, and made fresh ice in place of that that had been melted. And so it has gone on, this battle between the two, and so it will go on. There, almost-brother, you now know all about these ice places!'*

But the supernatural beings of the Blackfeet world work in conjunction with each other, as Star Woman was correct to remind him (Schultz 1930:188):

> *'Not all! You forgot to tell him about Wind-Maker!' Star Woman reminded him.*
>
> *'Oh, yes! Wind-Maker!' he exclaimed. 'Wind-Maker is Cold-Maker's helper,' he explained. 'He is a very large animal, something like a moose, and has enormous ears. He works his ears and thus causes the wind to blow, very softly, or very hard, just as he pleases. Well, when Cold-Maker is driven North by Sun, he leaves Wind-Maker here in these mountains, to do all that he can against Sun during the summer. He, too, is tired and weak, but now and then, even when Sun is strongest, he manages to ear-fan a terrible wind, so cold that for the time it prevents the ice melting. Thus he is of great help to Cold-Maker.'*

THE SNOW TIPI

In The Old North Trail, McClintock tells the story of Na-toia-mon, a Blackfeet hunter, and his encounter with Cold-Maker and the Snow Tipi (McClintock 1992:133-138). One year, winter was late in coming and a band of hunters was running buffalo in the warm, fine weather. The success of their hunt distracted them from an approaching storm rolling in from the north. A blizzard approached suddenly and two of the hunters, Na-toia-mon and his son, crawled into a makeshift shelter beneath the hide of a fresh buffalo carcass.

Na-toia-mon then fell asleep and dreamed that he was travelling alone on the plains. He discovered a large tipi in the distance and, as he drew nearer, saw that it was decorated. Its top was yellow like the sunlight, with clusters of the seven stars painted on both sides, representing the North, from whence the blizzards come. At the back was a red disc for the sun, to the centre of which was attached the tail of the sacred buffalo. At the bottom were the rolling ridges of the prairies, with their rounded tops, and a broad yellow band, with green discs to represent the colour of holes in ice, or frozen drifts. Beneath the yellow top and on four sides, where stood the four main lodge poles, were painted four green claws with yellow legs representing the Thunder Bird. Above the door, which was made of spotted buffalo calf-skin, was a buffalo head in red, with black horns and eyes in green,—the ice colour. Horse tails were tied at either side over the door, and bunches of crow feathers, with small bells attached, that tinkled whenever the wind blew, were fastened to the ends of both ear poles" (McClintock 1992:135).

A large, handsome man, painted with yellow, with a yellow medicine stick and a black feather in his white hair, beseeched him enter the tent. As Na-toia-mon went inside, the stranger sat himself behind a smoking altar laid with juniper branches. He wore a long white robe and otter and mink skins with bells attached and smoked a black stone pipe from a mink tobacco pouch. The stranger spoke:

> *I am Es-tonea-pesta, the maker of cold weather and this is the snow tipi or yellow paint lodge. It is I who bring the cold storms, the whirling snow, and the biting winds from the north, and I control them at my will. I have called you to my lodge because I have taken pity on you. I am going to help you for the sake of your son who was caught in the blizzard with you. I now give you the snow tipi with its decorations and medicines. With it I also give you the mink-skin tobacco pouch, the black stone pipe, and my supernatural power. You and your son will not perish in this storm. Your lives will be spared. When you return to camp make a tipi just as you see this one is made.*

Es-tonea-pesta, Cold-Maker, Maker of Storms and Blizzards, carefully explained the decorations, songs, ceremonials, and garments and their use. The mink skin was a war charm and the horse tails brought good horse luck. He woke as the storm broke and when the time came, in the spring, to make new lodges, he made the Snow Tipi (McClintock 1992:136).

Figure 5. Making the Storm Maker's Lodge (from Goble 2001)

Though the power of the Snow Tipi was great, Na-toia-mon only ever used it one time. In the following winter, the Blackfeet were camped in deep snows near Cutbank Canyon. He and a party of hunters went to hunt buffalo on the Milk River, but were again caught in a blizzard. Morning Plume asked Na-toia-mon to use the power of Cold-Maker to drive back the Ma-kai-peye, the blizzard. Reluctantly, he sent the men to break a trail for the horses and set the women and children warmly bundled on travois and prepared them to ride quickly, as his power to hold back the storm could not last long. He blew smoke to the north-east, where the storm came from. He prayed to the Maker of Storms for pity. He blew smoke to the south-east, where the sun peeked through the clouds. He called on his people and smoked to the south-west as the clouds began to break. He made his final prayer to the north-west as the last clouds drew back and hurried towards camp while he could. When they were not far from their camp, the storm returned, but they reached it in safety. "From that time the Blackfeet have always believed in Na-toia-mon's dream. But he could never again be prevailed upon to try his

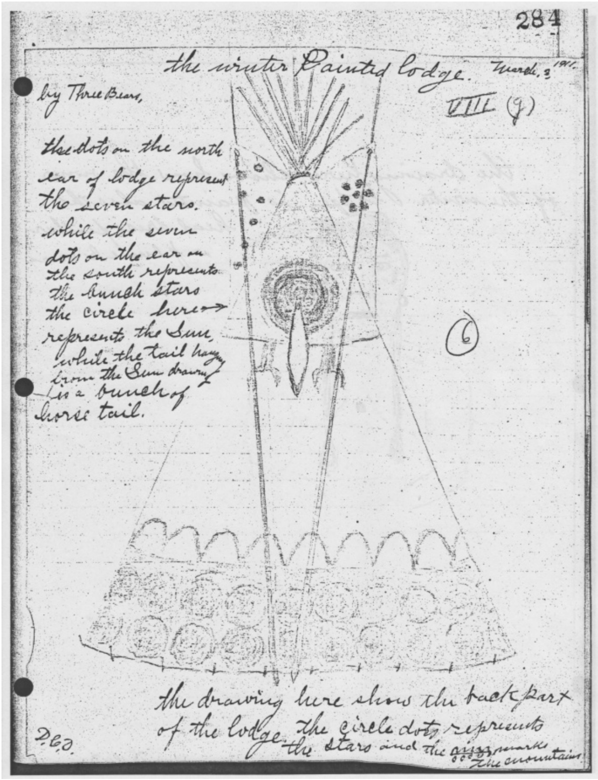

Figure 6. The Winter Painted Lodge (Duvall 1911:284)

supernatural power. He always replied, that he knew the power to control the storms would not be given to him a second time" (McClintock 1992:138).

Three Bears' description of the tipi, given to Duvall (1911:284), notes the dots on the north ear that symbolize the seven stars and those on the south ear, which depict the bunch stars. Around the bottom edge, circles and bumps stand in for stars and mountains, while a circle with a horse tail hanging from it on the back side of the lodge illustrates the Sun. The Snow Tipi has a number of titles. Duvall names it the Winter Painted Lodge. McClintock (1992) also calls it the Yellow Paint Lodge and the Bad Weather Tipi, while Goble (2001) calls it Storm Maker's Tipi.

WIND MAKER

He lives under the water at the heads of Upper St. Mary and Waterton Lakes, called the South and North Big Inside Lakes, respectively. "When Wind Maker wants to make the wind blow, he makes the waves roll, and that causes the wind to blow" (Reeves and Peacock 2001:140).

McClintock (1992:60-62) tells the story of the home of the Wind Maker that Siksikakoan told him while holed up during a ferocious three-day snowstorm. "Many years ago, when a heavy wind swept across the plains, a chief of the Blackfeet faced the storm and made a vow to find its origin. He crossed the plains and entered the mountains. His way led through dark canyons and dense forests, where the wind rushed and roared. The terrible wind and the dark and gloomy surroundings filled him with dread, but, because of his vow, he pressed forward until, at last, he saw in the distance, close to one of the highest peaks, the shining water of a lake. During a lull in the storm, he crept close to the shore and watched. Suddenly from the middle of the lake, arose the huge antlers of an enormous bull elk. His eyes were red and flames darted from his nostrils. When he waved his huge ears, a wind arose, so fierce and terrible, that the waters of the lake were whisked up into the air. When the elk sang again beneath the waves, the wind went down. The chief hurried back to his tribe to tell them of his wonderful discovery of the home of Medicine Elk, the Wind Maker." No Runner (from Schultz 1930:186-188) identifies Wind Maker as a large, moose-like animal with very large ears, which are used to control the wind, causing it to blow and moderating its strength; others identify the creature as "like a monster bull elk" (McClintock 1923:16).

UNDER-WATER PEOPLE

Under-Water Persons are the givers of some of the Blackfeet most significant gifts, such as tipi designs and the Beaver Bundle. The mountain lakes of Glacier National Park are shrouded in powerful stories of Under-Water People, particularly the beaver, who take humans into their lodges and there they teach them songs, and other knowledge.

Other Under-Water people, the "Soieiitaapi," can also be evil, kidnapping women and children who dare cross certain streams of enter certain lakes. They live in the lakes and streams within Glacier, including Two Medicine, Upper St. Mary, and Waterton lakes (Reeves and Peacock 2001:141). In telling the story of Running Eagle Falls, one of the homes of the water spirits, Old Sun and Eagle Catcher explained the ancient enmity with the People. "Old Man, remember, had already made Under-Water People, and had given them the water for their country, and the life that is in it for their food. He did not make our ancestors until he had completed his world-making. Nor did he intend, I feel sure, that the Under-Water People and we should not be enemies. But enemies we are – oh, how many of us they have seized and drawn down to death in the deep water of the rivers – and so, my children, you must keep away from that river cave" (Schultz 1920:24 ff).

Though some people took vision quests at Two Medicine Lake, Clark Wissler (1912b:80) noted that, according to one Piikáni medicine man, many people who tried to vision there were scared away before they received one. In his own vision on the lake, a mysterious man invited him to his tipi, where he met his family, received a puzzle, and something slippery slid down his throat. He said, "Since that time I drink a great deal of water, because this thing which he gave me requires much water. Every day I must take a swim, as I do not feel right unless I do" (Wissler 1912b:80).

Besides its supernatural elements and sacred uses, the area around these mountain lakes was also home to a fair amount of game. Though moose, elk, and deer were hunted around the lake, others said that "there was not much hunting up at the lakes" (Reeves and Peacock 2001:205). In the story of Red Eagle's Thunder Medicine Pipe as related by Two Guns to Schultz (1916:23-42), some people with their dogs were hunting bighorn sheep from the foot of Lower Two Medicine Lake into the mountains.

BUNDLES, CEREMONIALS, AND THE VERY SPECIAL ANIMALS THAT GO IN THEM

GRIZZLY BEAR

McClintock (1992:253) tells the story of how the Grizzly Bear offered his pelt to the Blackfeet for the curative Medicine Pipe Bundle associated with the grizzly. "The Grizzly Bear afterwards appeared to the same man, and said to him, 'I give you my skin to wrap around the sacred bundle, because it is larger than the skins of other animals. Whenever you transfer the Pipe to anyone, steal quietly upon him just before daybreak, the time I am on the move, and take him by surprise, just as I do chanting my song, and making the sound of a bear charging. When you catch a man and offer him the Pipe, he will not dare to refuse, but must accept it and smoke it. It is sure death to refuse, because no man may dare to turn away from a grizzly bear" (McClintock 1992:253). See Reeves and Peacock (2001:162) for an explanation of how the pipe is never named for the bear, only the badger. Most pipe bundles have coverings of elk skin (Reeves and Peacock 2001:206).

The grizzly bear has also leant his strength to the Blackfoot through the Bear Spear. Onesta was the owner of that sacred item when McClintock encountered the Blackfeet a hundred years ago (McClintock 1992:352-367). The Bear Spear was first given to the people in the time before horses, in the fall. The head chief's dog travois was missing and his son, Sokumapi, begged permission to look for the missing canine. He followed the travois tracks into a ravine and then into a cave, where he found the bundle, but no sign of the dog. Instead a fearsome grizzly roared out of the cave's entrance.

> *"The grizzly grasped the boy in his paws and carried him back into the cave, where it was very dark. Gradually sokumapi's eyes became accustomed to the darkness and when he discovered the enormous size of the bear that held him, his spirit left his body. When he came to himself, he was lying on the floor of the cave. He was so close to the head of the grizzly, he could feel his hot breath. When he moved, the bear placed his heavy paw across his body and stretched out his great claws. After that, the boy lay still; for a long time he did not even move, but gazed straight ahead. Finally, the grizzly spoke to him saying: 'do not be alarmed, my son, for I will do you no harm. I am the head chief of all the bears and my power is very great. I know that you have wandered to my den because you are trying to help your father. It was my supernatural power that drew you here, because I want to help you. Live with me here while the snows are deep. I have provided plenty of food and no harm will come to you. Before you leave my*

> *cave in the spring I will bestow upon you some of my supernatural power, so that you will be of great help to your people.'"*

The grizzly bear showed the boy the different kinds of edible berries and showed him the dance that would transform buffalo chips into pemmican and more berries. When snow melted and the warm Chinook blew, Sokumapi prepared to leave and Medicine Grizzly granted him his supernatural power. He taught the boy how to make the Bear Spear, with pointed end, bear's teeth and nose, eagle feathers, bear skin painted with sacred red paint, and grizzly claws that rattle. Carrying the spear, wearing claws in his hair, and imitating the noise bear makes as he charges, the warrior would wield the power of the bear and his enemies would turn in fright. He also taught him to paint his face and body as the bear to avoid being struck in battle and the chants used to heal the sick. Sokumapi returned to the camp and told everyone the story of Medicine Grizzly and began work making the Bear Spear. Soon the Blackfeet met the Crow in battle and with Sokumapi wielding the supernatural's weapon and chanting the songs of the bear, the Crow fled and the Blackfeet killed many. The boy was made a war chief and the power of the Bear Spear was proven in battle, and then, in healing. McClintock (1992:360-361) also discusses protocol for handling the bear spear, as described by Onesta. "The sacred Spear is unrolled and taken out in the spring, when the first thunder is heard, just as with the Medicine Pipe, because the bear appears in the spring, and remains out all summer, like the thunder. In the late autumn, when the bear disappears for the winter, the sharp point is removed from the staff and the Spear is put away" (McClintock 1992:361).

MOUNTAIN GOAT

The mountain goat is one of the most iconic animals of the Rocky Mountains. When Schultz was traveling with No Runner and Star Woman up in the high mountains of what had yet to become Glacier National Park, they encountered some mountain goats that, largely unfamiliar with human hunters, allowed them to close quickly on them (Schultz 1930:184-185):

> *We began skinning the animals, and I asked No Runner to tell me what he knew about them.*
>
> *'You shall hear what our wise ones say about them,' he answered. 'It is believed that Cold-Maker himself made the first pair of them and turned them out somewhere in these north mountains to live and breed their kind. See, he made their coats so thick they cannot feel the cold of winter. Nor can they bear the heat of summer; so it is that they live only in the high mountains; and the colder it is, and the deeper the snow falls, the higher they go; for the snow cannot lie on the faces of the cliffs, and it is there that they get their winter food, the moss that*

> *grows upon the rocks. They are very plentiful all along this Back-Bone-of-the-World as far north as any of our people have gone, but they are never found anywhere south of the head of Point-of-Rocks River. We do not know why that is; it is thought that Cold-Maker does not allow them to go farther south.'*

OTHER ANIMAL CEREMONIALS

The park is full of spiritually powerful animals. Of those specifically mentioned by Grinnell (1892:260) as containing this power — the buffalo, bear, raven, wolf, beaver, kitfox, and goose — all could be found within Glacier, except for the bison, which has been extirpated from the park, and the kitfox, though other foxes are uncommonly spotted. Besides subsistence uses, many small mammals and birds are used in ceremonial bundles of the Blackfeet. According to the owner of the Long-Time Pipe, George Kicking Woman, the contents of that one bundle included parts of squirrels, chipmunks, otters, ravens, crows, swans, other miscellaneous mountain birds, and deerskin (Reeves and Peacock 2001:208). A Blackfeet medicine bundle described by Wissler (1912a:136) from the mountains included wrappings of bear skin, elk hide, and flannel cloth; the pipe decorated with white buffalo skin, hair, and an eagle feather; and another package containing a secondary pipestem, "an owl, two loons, two white swans, two cranes, a muskrat skin, an otterskin, a rattle, a skin of a fawn, a whistle and sometimes the skin of a prairie dog." Wissler (1912a:169) lists some of the varying ingredients of the beaver bundle, which include parts of antelope, badger, beaver, blackbird, buffalo, crow, deer, duck, elk, gopher, grouse, hawk, loon, lynx, magpie, mink, mountain goat, mountain sheep, mountain squirrel, mouse, mud hen, muskrat, night hawk, otter, packrat, prairie chicken, prairie dog, snowbird, sparrow, raven, weasel, wildcat, and woodpecker. A great number of ingredients go into each bundle and each must be replenished as they decay, provided the bundle holders have access to the appropriate plants and animals.

A consultant of McClintock's, Onesta, keeper of the Bear Spear, also owned a mink skin, which had once belonged to the spear's medicine and had been in his keeping for thirty years. He burned an incense called Pono-kan-sinni, or elk food, made by drying the tops of the narrow-leaved puccoon (McClintock 1992:360).

Ancient Raven, a supernatural favored by the Sun, appeared in the guise of a man to help Old Sun, an eagle catcher and respected Piikáni medicine man, during his vision quest in a cave on Red Mountain (Rising Wolf) in Two Medicine (Schultz 1922:46 ff). In his vision, he was attacked by a grizzly bear and something hurling rocks before rescue by a friendly wolf and his helper Ancient Raven.

WINTER, SNOW, AND WEATHER PHENOMENA

THE SNOW AND THE RAIN

"The Snow and the Rain" is a story narrated by Three Bears and recorded by David C. Duvall (1910:180-183), Clark Wissler's assistant during his fieldwork with the Blackfeet, in 1910.

> *Once upon a time, the Snow, and the rain, were people, and the Snow people, lived far in the north. And the Rain people, lived near the mountains, in the west, Now the snow people, used white earth paint while the Rain people, used the black paint. Now the Rain people, one day were all traveling East and the Snow people attacked them from the north. And a great number of people were killed on both sides, but the snow people, got much the best of the fight, for they froze a lot of the rain people, some of the Rain people got into springs of water and hid In these springs with only their mouth and noses sticking out of the water. One of the women, of the Rain people that was killed, was found by an old woman, now this old woman noticed the dead woman's bellie a moving, and she took out her knife and cut the dead woman's bellie open and took out a baby boy, for this dead woman was heavy with child. The old woman raised the child, and when the boy became a man, the young man began to think that the old woman, was not his mother, on account of her old age. Now the young man asked the old woman if she was his real mother, and the old woman said no and explained how his mother had been killed by the snow people and how she came to find him.*
>
> *Now when the young man, heard of this, it made him very angry towards the snow people and he wish to get a revenge on the snow people.*
>
> *Now the young man, went out by himself, and sleep for many day and nights in the hills, untill* [sic] *he had a dream, through which he secured some power. Now this was in the winter and while the young was going along, a very cold snow storm came on him. Now the young man took some water in his mouth and spated* [sic] *the water up in the air and it turned the snow storm into a rain storm. Now it rain very hard and thawed nearly all the snow drifts, or killed many of the snow people, thus the man gained revenge on the snow people.*
>
> *Now it is even so now days, some times in the middle of the winter it rains and that is the reason that springs do not freeze in the winter, and some times you will notice the water of these springs a steaming it is so because when the rain people were hiding in them their breaths were steaming. Now the Ravens use to*

> *be white, instead of black, and belong to the winter people. And the Thunder bird, and rain birds, belong to the summer and rain people.*

READING AND NAMING THE WEATHER

Brings-Down-the-Sun watched the sky for signs of the changing seasons. When a storm is slowing and a rainbow appears, that is Thunder lassoing the rain with his Akatsis or Lariat (McClintock 1992:487, 521). In winter, violent winds follow the sighting of the Aurora Borealis, which come from the fires of Northmen (McClintock 1992:487). "When the Sun paints both his cheeks, that is, when two Sun Dogs (Ick-ski) appear on both sides of the Sun, it is a warning that fierce storms, with violent winds and severe cold, are coming" (McClintock 1992:487). In Indian sign-language, as reported by Reverend Dorsey in McClintock's appendices (1992:522), sun dogs are represented as "Fires to warm the Sun." Brings-Down-the-Sun also knew how weather phenomena could foretell events of great significance to the Blackfeet, like the death of a chief or an upcoming famine. The black clouds over the mountains that accompany the Chinook gave the wind its Piikáni name, Black Wind (Schultz 1916).

Brings-Down-the-Sun taught McClintock (1992:486-487) his father's names for the changing of the moons, the different seasons that are signaled by the natural environment. Autumn is titled "Time of the first frost." Early winter, November, is known as "After the first snowfall," while late December and early January are called the "Time of the first Chinook." Midwinter in January has three names: "When the buffalo calves are black," "When the heavy snows come," and "The time, when the jackrabbit whistles at night." Because of snow blindness, March is reputed as "The time for sore eyes," while April marks relief as the month "When the ice breaks up in the rivers." Other months are noted by the colors of the plants and the migrations of various animals, but snow and ice characterize Blackfeet winter naming.

The Blackfeet mark their history through "winter counts" recording the main events on buffalo hides. When Brings-Down-the-Sun told McClintock (1992:422) about the events recorded on his father's counts, many of them related the stories of the weather, "the summers of droughts and the hard winters, when game was scarce and snows lay deep." He had noted the severe winter of 1876 that spelled the death of many of the camp's horses, the winter of a coughing illness, the winter when they ate dog to ward off starvation, the winter when the buffalo were scarce, and the winter when they caught the antelope in deep snow (McClintock 1992:422-423). The stories of winter mark the passage of time. Winter counts were the purview of Beaver Bundle owners, and their winter sticks are still in some bundles.

CONTEMPORARY USES OF THE PARK

SPIRITUAL RENEWAL AND VISION QUESTING

Many Blackfeet men and some women have sought vision quests on the peaks and ridges of Glacier National Park over the years. Vision questing generally consists of a sweat in preparation, then reaching the site with offerings, then four days and nights of fasting and prayer, followed by another sweat. On the fourth night of a successful vision quest, the seeker may receive a vision from an animal or supernatural being and be given personal medicine. Reeves and Peacock (2001:147-158) mention around twenty locations within the park where consultants or historical accounts have reported receiving visions. They've historically been located on peaks and ridges, near mountain lakes and waterfalls, on islands, in caves and rockshelters, and other sacred places far removed from settlements and other people (Reeves and Peacock 2001:147-148). Within Waterton-Glacier, there are over a hundred vision questing- or fasting-related structures recorded (Reeves 2000a).

The mountains are sacred and clean. Several of the informants in Reeves and Peacock's ethnographic survey reported visiting the area for religious activity, like ceremonies. It was intergenerational; "a lot of them old people" visited the park in the day and more were bringing their children. "There's a lot of things in Glacier National Park. What we'd like to keep for ourselves, for religious… Buster, he goes up there quite often. I go up there, my kids. We exercise something that rightfully belongs to the Indian people and often that we have told the Forestry that we are really doing ceremonies… And I understand that they have made an agreement to protect all of this, to utilize at some later date. We began to show, like sometimes I take my kids up here in the mountains. I show them different leaves. Long time ago, what we used for everything. See we have all sorts of roots, medicines" (EW-1 in Reeves and Peacock 2001:144).

PLANT RESOURCES

The only existing Blackfoot ethnobotany specific to Glacier National Park is Brian O.K. Reeves and Sandra Peacock's 2001 *"Our Mountains Are Our Pillows"* (209-245; see also general Blackfeet ethnobotanies by Zedeño et al. 2006, 2007, 2008). The information is summarized in Appendix A.

ANIMAL RESOURCES

A number of big game animals were taken by the Blackfeet around Glacier. Bighorn sheep and mountain goats were particularly sought in the mountains (McClintock 1992:46; Schultz 1916). Elk and deer were also hunted throughout the mountain valleys, particularly the eastern slopes and into the reservation area. These animals did not require as much coordination as was necessary to drive the elusive mountain goats (Reeves and Peacock 2001:204). Blackfeet hunted game extensively throughout Glacier according to various sources compiled by Reeves and Peacock (2001:204-206), including: Belly River (elk, especially in summer), Chief Mountain (sheep, goats, deer, elk, bighorn, especially in winter), Kennedy Creek (sheep, deer, elk, grizzlies), Many Glacier (sheep), East Flattop and Boulder Creek (sheep, deer, elk), Divide Creek Basin (sheep), Red Eagle (elk), Cut Bank Creek (elk, deer, sheep, goat, grizzlies), Two Medicine (moose, elk, deer), Midvale Creek, Marias Pass (elk, especially north side just west of the summit). Now many of these hunting locales are truly on the foothills rather than higher elevations. See Appendix B for a list of culturally significant animals.

Before the creation of the park, Blackfeet would trap a number of animals, especially the martins, lynx, and wolverines that were more common within that area. Trapping locales included the Belly River (including the North Fork), Slide Lake, Many Glacier, Boulder valley, and Cut Bank valley (Reeves and Peacock 2001:206). After its establishment, most activities associated with subalpine and alpine environments, particularly hunting, and plant and animal collecting, moved to the Lewis & Clark National Forest (Zedeño 2012).

MINERAL RESOURCES

The Blackfeet may look for deposits of clays, minerals, or rocks in the glaciers. "Glacial deposits in the Park, aside from those associated with recent (Little Ice Age) advances of the early 1700s, are primarily of the Pleistocene age. The latter include a variety of glacial tills, mass wasting, and lacustrine and alluvial deposits. Most, because of the source rock types involved, are enriched with clay and iron oxide. Subsequent in situ weathering has further enriched certain glacial deposits and secondary post-glacial deposits resulting from their erosion" (Reeves and Peacock 2001:198). Glaciers may provide raw materials for crafting pipes, making paints, holding sweats, or creating other kinds of sacred objects. The Blackfeet gather sweat rocks from particular sources both within the park and in adjacent spaces, such as the reservation. Consultants of Reeves and Peacock (2001:202) report that glacial and post-glacial gravel deposits along the Front contain spiritual power, while those found on the western plains in gravels from the Canadian Shield aren't useful for sweats. For sweats, the Blackfeet particularly favor "black 'lava' rocks (Purcell Basalts and Belt Series Diorites) and white and red quartzites (primarily derived from the Apekunny and Grinnell formations)."

EARLY HISTORICAL ACTIVITY OF GLACIER

Up until the first half of the nineteenth century, McClintock (1992:3) reports that the Blackfeet utilized both the mountains and the plains for subsistence, using animal products from the beaver, wapiti, moose, mountain sheep, and grizzly bear of the mountains, as well as the antelope and buffalo of the plains. With the colonization of white settlers, subsequent plague, and annihilation of the buffalo, the Blackfeet were decimated. “Greatly reduced in numbers and crippled in resources, the Blackfeet slowly retreated before the advancing tide of white settlers. Yielding to the pressure from the whites and their own dire necessities, they sold by treaty vast tracts of land to the United States, so that they now occupy only a narrow strip of country bordering upon the eastern slopes of the northern Rockies. The climate, being subject to severe storms in summer and blizzards in winter, has so far seemed unfavourable for agriculture. Their chief occupation of raising cattle and horses is handicapped by the hazards of extreme heat and cold” (McClintock 1992:4).

Running north and south through the foothills is the Old North Trail. Once a well-traveled Blackfeet path for horses and travois, by the time (McClintock 1992:18) happened upon it in the 1890s, it had already passed out of use, interrupted by white settlements and fence lines. Other paths cross the width of the Rockies, along the rivers; these trails were once used by the Blackfeet to make war against neighboring tribes (McClintock 1992:39).

The ridges made a good location for trapping eagles to obtain feathers for use in ceremonies, regalia, and bundles (Reeves and Peacock 2001:206). Old Sun, in his quest to gain the eagle catching authority and power as described in Schultz’s 1922 book *Seizer of Eagles*, found an old eagle trap on Rising Wolf Mountain (Red Mountain) above Two Medicine Lake (Schultz 1922:58-60). The Blackfeet no longer trap eagles, though eagle feathers still hold a significant role in Blackfeet religious ceremony.

Sacred activities associated with Glacier National Park (Reeves and Peacock 2001:145, table 6) include vision questing, digging paint, collecting plants, cultivating sacred tobacco, trapping eagles, burying people, holding ceremonies and sweats, and building medicine lodges. Again, all these activities were transposed to the Lewis & Clark National Forest in the early twentieth century (Zedeño 2012).

USE OF GLACIERS IN THE ARCHAEOLOGICAL RECORD

The spine is largely interconnected and “almost continuously traversible” throughout Waterton-Glacier (Reeves 2003a:269). The alpine grasslands have been very productive seasonally for mountain bison, mule deer, and bighorn sheep. And with easy access to the valley floors, the area has proved rich in archaeological artifacts, with 97 alpine archaeological sites in Waterton-Glacier (see Reeves 2003b:table 9, figure 40).

BOULDER GLACIER, BOULDER PASS, HOLE-IN-THE-WALL, AND BROWN PASS

The Boulder Glacier once filled Boulder Pass, during the Little Ice Age. The Boulder Pass area, including Hole-in-the-Wall and Brown Pass, still contains glaciated pockets, including the smaller Boulder Glacier, as well as a number of rich archaeological finds (Reeves 2003a:279-285). Brown Pass, per Reeves (2003a:281; following Holterman 1985:24-25 and Schultz 1926:188), was known to the Blackfeet as the pass used by Kootenay Brown to travel between Waterton and the Flathead.

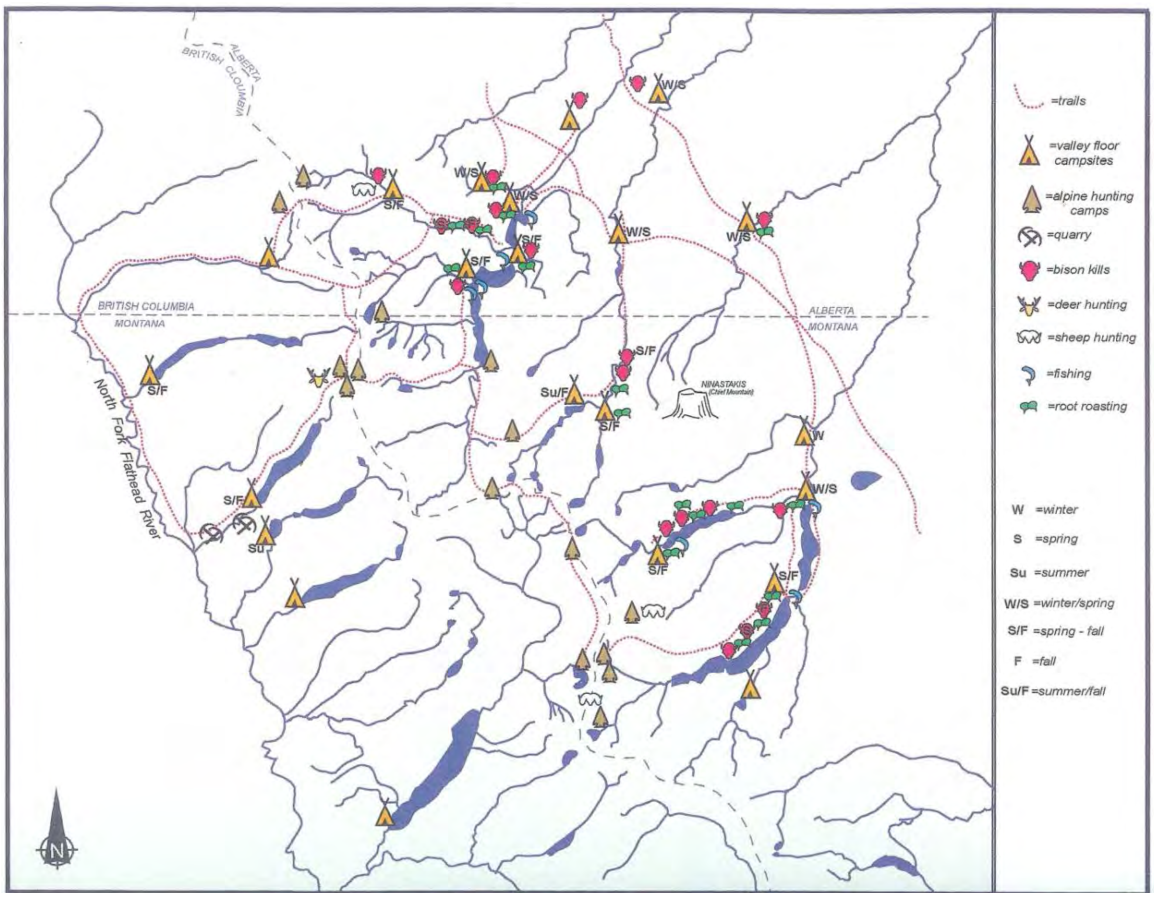

Figure 7. Seasonal Resource Use/Occupancy 3000-1600YA includes alpine hunting camps at glaciers (Reeves 2003b:908, fig 32)

This area was identified as an area of potential interest before Reeves's 1993 field inventory uncovered a number of isolated flakes and alpine campsites, including five sites recommended as eligible for the National Register of Historic Places. This high alpine locale, dotted with shrinking glaciers, was a significant Precontact alpine resource harvesting and occupancy area associated primarily with the Blue Slate Canyon Subphase. Significant finds include three campsites in Boulder Pass and two in Brown Hole-Hole-in-the-Wall. Their location is indicative of "the major development of the Bowman Creek quarries during this phase and the movement of this material in summer/early fall through the Brown Pass route, directly to the Waterton and Belly River Valleys (Reeves 2003a:282).

The major sites in this section of the park are well situated for intercepting or observing game, though some sites have already been disturbed by glacial movement (in addition to other factors like recent camping activity). For example, Site 24FH536 is a small site located 100 m below the Boulder Glacier Neoglacial moraine in a high mountain fir grove on a glacial bench at the west end of Boulder Pass. The krummholz grove concealed an artifact scatter consisting largely of Bowman Chert flakes, but also a number of local and non-local flakes, a small chert utilized flake and a broken Metamorphosed Green Argillite biface. The position of the lithics suggests that the site was used to capture bighorn sheep moving across the west end of the pass, though the Neoglacial advance of Boulder Glacier has removed evidence of any rock alignments built in the pass above (Reeves 2003a:283). Site 24FH537 still contains four cairn-like features extending 10 m across an open meadow and on glaciated bedrock; these were probably part of a fence or trap in the valley.

The Hole-in-the-Wall site, 24FH543, found on the west side of the cirque basin, dotted with small streams, is described by Reeves (2003a:283) as "a repeated series of small encampments characterized by localized concentrations of lithic artifacts surrounded by diffuse scatters of lithics , bone, and fire-cracked rock."

Site 24FH44 was a site used more frequently, well-situated on the trail from Bowman to Waterton at the west end of Brown Pass, a high alpine pass clear of permanent ice patches these days. Found at the site were two Pelican Lake Corner Notched points, one Bowman Chert and one a red/brown dendritic chert, heat-treated; three Bowman Chert biface fragments; a Bowman Chert core and 114 flakes; and various other lithic types, including obsidian flakes, Knife River Flint, quartzite, cherts, and chalcedonies (Reeves 2003a:284). The high occupancy of the site is explained by its prime trailside location and proximity to game hunting on neighboring alpine and subalpine meadows. Game would also be intercepted moving through the pass, from creek to creek or slope to slope.

Reeves (2003a:285) interprets the record:

> *Hand-up-in-the-Mountain resource harvesting and occupancy appears, based on the archaeological evidence, to have been most intensive during the Blue Slate Canyon times, although early use of the area, 8000 years ago is evidenced by the Alberta point find on the west buttress peak of Mount Custer. The temporal focus of its occupancy appears to be associated with the use of Bowman Chert and the resulting intensification of occupancy of as well as movement through the area*

> *during Blue Slate Canyon times in summer to and from the Bowman Creek quarries and the Waterton and Belly River Valleys (Figure 32).*
>
> *Earlier hints of occupancy do occur in the artifactual record. The isolated biface of Bowman Chert found at site 24FH541 is heavily weathered, in contrast to other Bowman Chert surface artifacts such as the secondary flakes found at site 24FH540. The biface is an oval form that has not been found to date at any other sites within the Crown. The Metamorphosed Green Argillite biface from the Boulder Pass site (24FH536) also might be an earlier type, as might the snapped flake graver from Brown Pass.*

These are highlights of the archaeological evidence for precontact occupation of alpine Glacier National Park around Boulder Glacier, Boulder Pass, Hole-in-the-Wall, and Brown Pass; see Reeves (2003a:279-285 and accompanying charts and figures) for more details. Also, Reeves (2012) presents his most recent summary of vision quest sites, ancient and modern.

THE CARTER GLACIERS, JEFFERSON PASS, AND REDHORN PASS

After the wealth of the Boulder Pass area, other alpine passes in northern Glacier have much less evidence of regular occupation and use. Jefferson Pass is a sub-par alternative to the northern passes for crossing the divide, as it is inaccessible by horses in summer because of a large willow swamp and is longer overall (Reeves 2003a:286). Only one large retouched flake of Knife River Flint (24GL691) was found within the pass.

Redhorn Pass is not connected to any regional trail system, but provides access to the slopes southeast of the Carter glaciers east of the Divide. The summit contained three sites (Reeves 2003a:287). Site 24FH535 contains a possible cairn of bedrock boulders, a large retouched Bear Gulch Obsidian flake, and a piece of Bowman Chert shatter. An isolated Metamorphosed Green Argillite lancelate-shaped biface associated only with Early Period regional phases, over 5750 years old, is the single find at 24GL689. East of the Carter glacier, surveyors found Site 24GL690, containing only a Bowman Chert flake and a white chert Salmon River Side Notched point.

SUMMARY

To summarize this brief overview, it is likely that ancestors of the Blackfoot-speaking people entered the Glacier National Park region at the end of the Pleistocene, through deglaciated or unglaciated passes. The oral tradition points to a creation time that includes drastic changes in the landscape, not the least of which are extensive floods and ecological renewal. Uses of the subalpine and alpine environments were unique to the Blackfoot speakers in the sense that their lifeways and belief systems centered on the prairie habitats, however, a continuum from mountain to prairie, as reflected in all realms of life, prevailed throughout their occupancy of the region until the early 20th century, when much of the traditional uses of Glacier National Park were moved south to the Lewis & Clark National Forest.

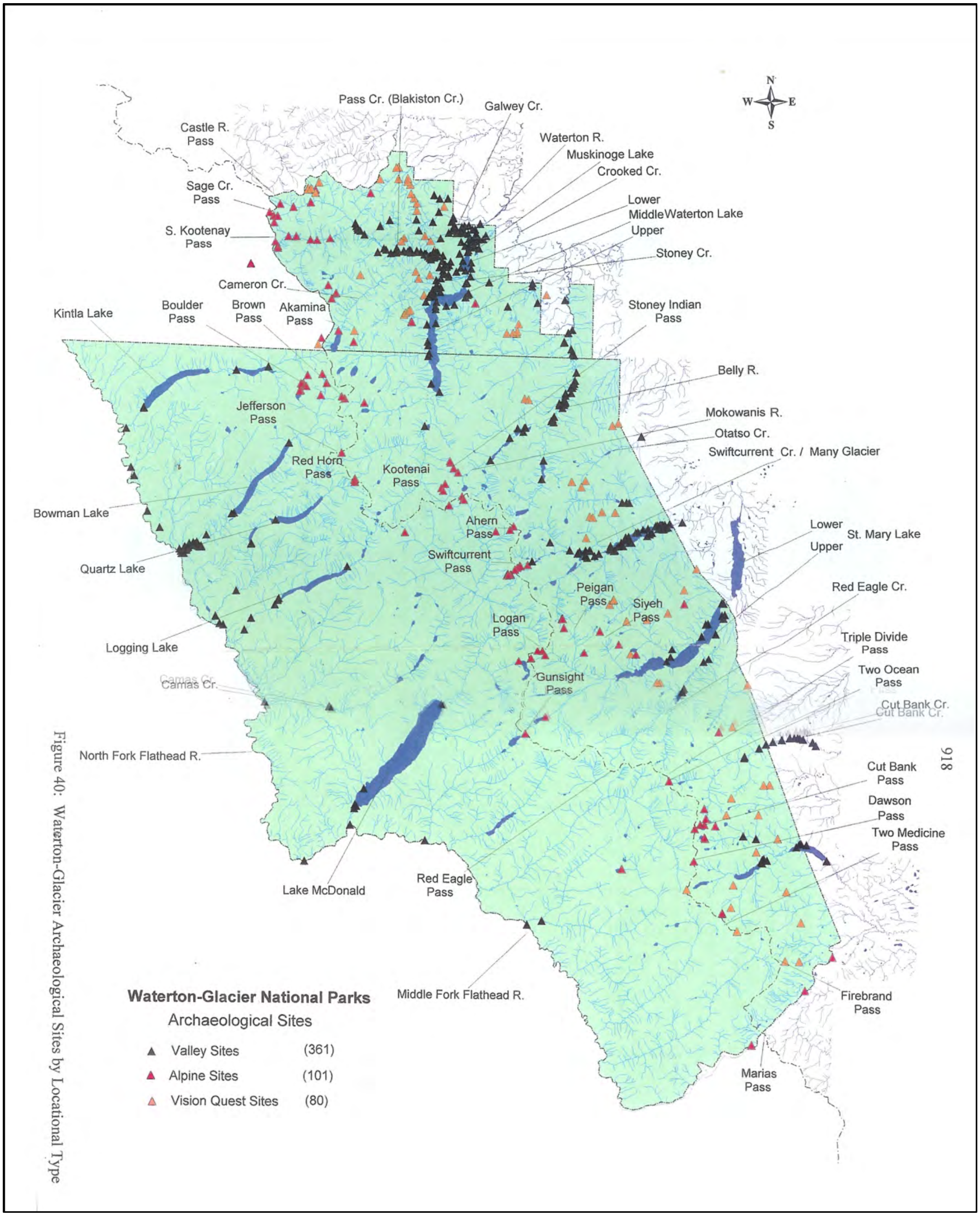

Figure 8. Waterton-Glacier archaeological sites by locational type, note alpine locales in red (Reeves 2003b:fig. 40)

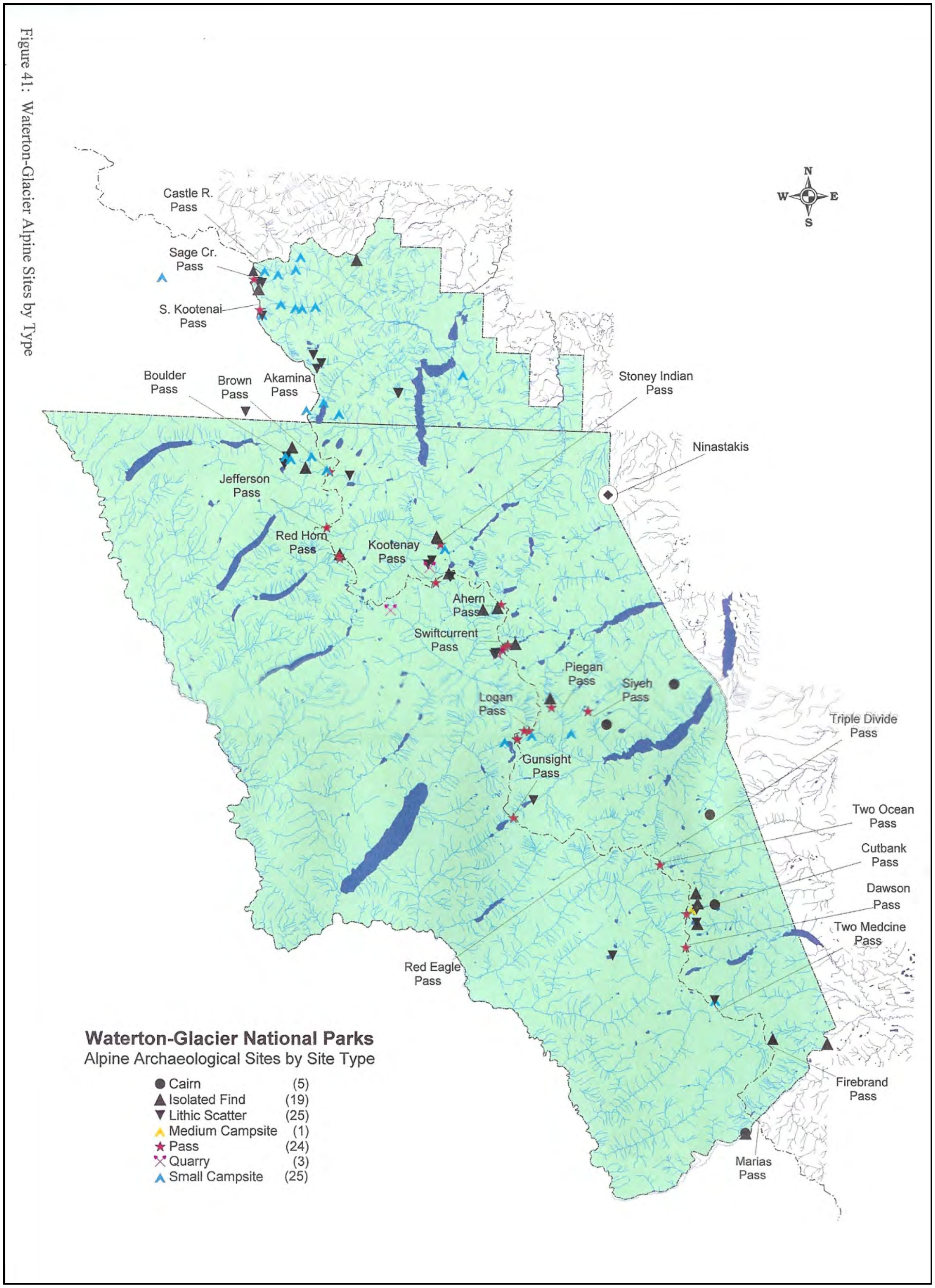

Figure 9. Waterton-Glacier alpine archaeological sites by site type (Reeves 2003b:fig. 41)

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Cover image: Glenns Lake, taken by National Park Service staff. Available here:
http://www.nps.gov/glac/photosmultimedia/Glacier-Scenics.htm

APPENDIX A. BLACKFEET PLANTS

Plant	Scientific Name	Food	Medicine	Ceremonial	Domestic
Aspen	*Populus tremuloides*			X	
Bear grass	*Xerophyllum tenax*	X			
Bearroot (Alpine sweetvetch)	*Hedysarum alpinum*		X		
Birch	*Larix laricina*		X		
Blueberry	*Vaccinium sp.*				
Bottlecap					
Buffalo sage			X	X	
Bullberry	*Shepherdia argentea*	X		X	
Cactus			X		
Cattails	*Typha latifolia*	X		X	
Cedar	*Thuja sp.*			X	
Cherry	*Prunus sp.*	X			
Chokecherry	*Prunus virginiana*	X	X		
Cold's foot	*Galax urceolata*		X		
Conifer					
Cottonwood	*Populus sp.*			X	X
Creeping cedar	*Juniperus horizontalis*		X	X	
Dog berry	*Ribes cynosbati*				
Douglas-fir	*Pseudotsuga menziesii*				X

Plant	Scientific Name	Food	Medicine	Ceremonial	Domestic
Flannel mullein	*Verbascum thapsus*				X
Gooseberry	*Ribes sp.*				
Gumweed	*Grindelia squarrosa*		X		
Horse mint	*Monarda punctata*		X		
Hound's tongue	*Cynoglossum sp.*		X		
Huckleberry	*Vaccinium sp.*	X	X		
Jack pine	*Pinus banksiana*				X
Juneberry/Saskatoon/ Service berry	*Amelanchier alnifolia*	X		X	
Juniper	*Juniperus sp.*		X	X	
Kinnickinnick/Bearberry	*Arctostaphylos uva-ursi*			X	
Larch	*Larix laricina or L. occidentalis*				
Lily	*Lilium sp.*		X		
Lodge pole pine	*Pinus contorta*			X	X
"Manicopi"/white top	*Lepidium draba*			X	
Milkweed	*Asclepias viridiflora*		X		
Paintbrush	*Castilleja sp.*				
Peppermint	*Mentha piperita*		X	X	X
Pine	*Pinus sp.*	X			X
Quaking aspen/quaking ash	*Populus tremuloides*	X		X	X

Plant	Scientific Name	Food	Medicine	Ceremonial	Domestic
Raspberry	*Rubus idaeus*	X			
Rose hip	*Rosa sp.*		X		
Rutabaga	*Brassica napobrassica*	X			
Sage	*Artemisia sp.*		X	X	X
Sheep sorrel	*Rumex acetosella*		X		
Sneeze root	*Veratrum speciosum*		X		
Spruce	*Picea sp.*				X
Sweet pine (Subalpine fir)	*Abies lasiocarpa*			X	
Sweetgrass	*Hierchloe odorata*			X	
Thimbleberry	*Rubus parviflorus*	X		X	
Thistle	*Cirsium sp.*		X		
Wild carrot	*Daucus carota*	X			
Wild iris	*Iris sp.*		X		
Wild licorice	*Glycyrrhiza lepidota*		X		
Wild onion	*Allium sp.*				
Wild strawberry	*Fragaria virginiana*		X		
Willow	*Salix sp.*		X		
Yarrow	*Achillea millefolium*		X	X	

APPENDIX B. BLACKFEET ANIMALS

Animal	Scientific Name	Family	Consultants
American badger	Taxidea taxus	Mustelidae	BF, HV, DRS, RCM
American bison	Bison bison	Bovidae	RN, BJ, GG, GTG
American black bear	Ursus americanus	Ursidae	RWM, GTG, BRD, DRM, WS
American crow	Corvus brachyrhynchos	Corvidae	GG, CW, WS
American mink	Mustela vison	Mustelidae	GG, CW, WD, SEJR
American robin	Turdus migratorius	Turdidae	CM
Bear	Ursus sp.	Ursidae	CT, RN, CM, SEJR, CW, WD, DRS
Bighorn sheep	Ovis canadensis	Bovidae	HI, GG, RJ, DRS, CM
Black-billed magpie	Pica hudsonia	Corvidae	GTG, BF, BRD, WS
Blackbird	Xanthocephalus & Euphagus sp.	Icteridae	RJ
Black-tailed deer	Odocoileus hemionus columbianus	Cervidae	RWM
Blue grouse	Dendragapus obscurus	Phasianidae	RJ
Blue jay	Cyanocitta cristata	Corvidae	BF, DRM
Bobcat	Felis rufus	Felidae	GG, HV, WD, CM
Butterfly			DRS
Gray jay (Camp robber)	Perisoreus canadensis	Corvidae	DRM
Chickadee	Poecile sp.	Paridae	CW, RCM
Chipmunk	Tamias sp.	Sciuridae	CM, DRS

Animal	Scientific Name	Family	Consultants
Common raven	Corvus corax	Corvidae	CT, GG, CW, RCM
Cottontail rabbit	Sylvilagus sp.	Leporidae	HV
Coyote	Canis latrans	Canidae	BJ, GG, SEJR, BRD, HV, RJ, DRS, BF
Crane			CW
Deer	Odocoileus sp.	Cervidae	RN, HI, GG, CM, GTG, BF, SEJR, BRD, HV, CW, WD, WS, RJ
Duck		Anatidae	RWM, CW, DRS
Eagle		Accipitridae	CT, RN, HI, GG, CM, BF, CW, DRS, RCM, WS
Elk	Cervus elaphus	Cervidae	CT, RWM, RN, HI, GG, CM, GTG, BF, SEJR, BRD, HV, CW, WD, RJ, DRS, DRM, RCM, WS
Fox			SEJR, DRS, WS
Goose		Anatidae	CW
Gopher		Geomyidae	GG, HV
Great blue heron	Ardea herodias	Ardeidae	CW
Grey wolf	Canis lupus	Canidae	CT, BJ, GG, SEJR, WD
Grizzly bear	Ursus arctos horribilis	Ursidae	RN, GG, GTG, BRD, DRM, RCM
Ground squirrel	Spermophilus richardsonii	Sciuridae	CW
Grouse	Dendragapus & Bonasa sp.	Tetraonidae	RWM, HI, BF, RJ, DRM
Hawk	Buteo sp.	Accipitridae	CM, BF, CW, WS
Long-tailed weasel	Mustela frenata	Mustelidae	CW, SEJR

Animal	Scientific Name	Family	Consultants
Lynx	Lynx sp.	Felidae	GG, RJ, CM
Marmot	Marmota sp.	Sciuridae	RCM
Moose	Alces alces	Cervidae	RWM, HI, GG, SEJR, BRD, CW, RJ, DRS, DRM, WS, CT
Mountain goat	Oreamnos americanus	Bovidae	HI, GG, BRD, CW, RJ, DRS, WD, RWT
Mountain lion	Felis concolor	Felidae	SEJR, WD, CM, GG
Mule deer	Odocoileus hemionus	Cervidae	RWM, RJ, DRM, RCM, DRS
Muskrat	Ondatra zibethicus	Cricetidae	GG, CM, BRD, SEJR
North American beaver	Castor canadensis	Castoridae	CT, RN, GG, CM, GTG, BRD, HV, CW, WD, RJ, DRS, DRM, RCM, BF, SEJR
North American porcupine	Erethizon dorsatum	Erethizontidae	HI
Northern river otter	Lutra canadensis	Mustelidae	BF, BRD, CW, DRS
Owl		Strigidae	RN, GG, CW
Pheasant		Phasianidae	HV
Pigeon	Columba livia	Columbidae	CW
Prairie chicken	Tympanuchus cupido	Tetraonidae	CW
Pronghorn antelope	Antilocapra americana	Antilocapridae	GG, HV
Red-tailed hawk	Buteo jamaicensis	Accipitridae	GG
Ruffed grouse	Bonasa umbellus	Tetraonidae	RJ
Squirrel		Sciuridae	DRS
Trout	Oncorhynchus sp.	Salmonidae	WD, CM

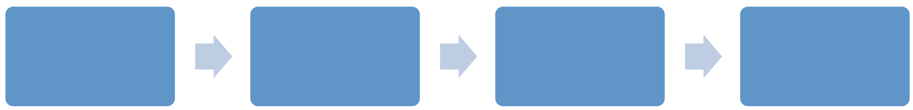
Animal	Scientific Name	Family	Consultants
White-tailed deer	Odocoileus virginianus	Cervidae	RWM, RJ, DRS, DRM, BF
Wolverine	Gulo gulo	Mustiledae	GG, GTG, BF, WS
Woodpecker	Picoides sp.	Picidae	DRS

APPENDIX D: BISON GENETICS REPORT

(BETH SHAPIRO)

Report — Glacier National Park Bison Sample

Sample processing and mitochondrial genome assembly



We received a bison femur sample from Glacier National Park. We processed the sample (Sample ID AE036) at the UCSC Ancient DNA Laboratory.

We ground a bone piece and performed DNA extraction using our protocol for ancient DNA extraction. We prepared an Illumina DNA sequencing library and then used a custom RNA biotinylated probe (MYbaits V.2) designed to capture *Bison sp*. mitochondrial genome sequences. This is a protocol designed to enable targeted sequencing, which allow us to enrich a sample and capture a particular target. Ancient samples contain many contaminants, bacterial DNA or even DNA from the person that excavated the sample, but using targeted sequencing we are able to recover DNA mainly from our species of interest.

Following this step, we sequenced this enriched library using an Illumina MiSeq, generating 1,949,936 paired-end reads. We processed these data on our computer servers, removing low quality data, for example, and preparing the data to be used in the assembly the mitochondrial genome. We mapped the resulting 1,101,030 DNA fragments against the mitochondrial genome of *Bison bison* (NC_0123-46). 56% of the DNA fragments successfully mapped to it, and we used this alignment to construct a consensus sequence of the mitochondrial genome of AE036.

We managed to assemble a complete mitochondrial genome with an average coverage of 2358×, with a minimum coverage of 343× at each site. It means that every base-pair of the mitochondrial genome was covered by at least 343 unique DNA fragments. A large coverage provides a higher the reliability of each base being correctly identified. Samples with an average coverage of 30× are considered “high coverage”, so these are remarkable results.

Sample genealogical analysis

Figure 1: AE036 genealogical analysis, simplified.

We conducted a coalescent-based genealogical analysis in order to place the AE036 within the phylogenetic context of other North American bison. We performed this analysis using the mitochondrial genome generated in the previous step. What this analysis does is compare multiple individuals’ mitochondrial genomes to infer their ancestry relationships. Figure 1 is a simplified view of these relationships.

These results show that, unsurprisingly, AE036 shares ancestry with other samples obtained from the same region, all of which share the same ancient common ancestor. This group forms a separate unit from other bison from the Klondike and Yukon regions, better seen in Figure 2. Also highlighted, other samples sent by Craig M. Lee.

Sex determination

The mitochondria are inherited from the mother, so it does not carry any information regarding the sex of the individual. We did not recover enough nuclear DNA fragments to confidently identify the sex of the specimen.

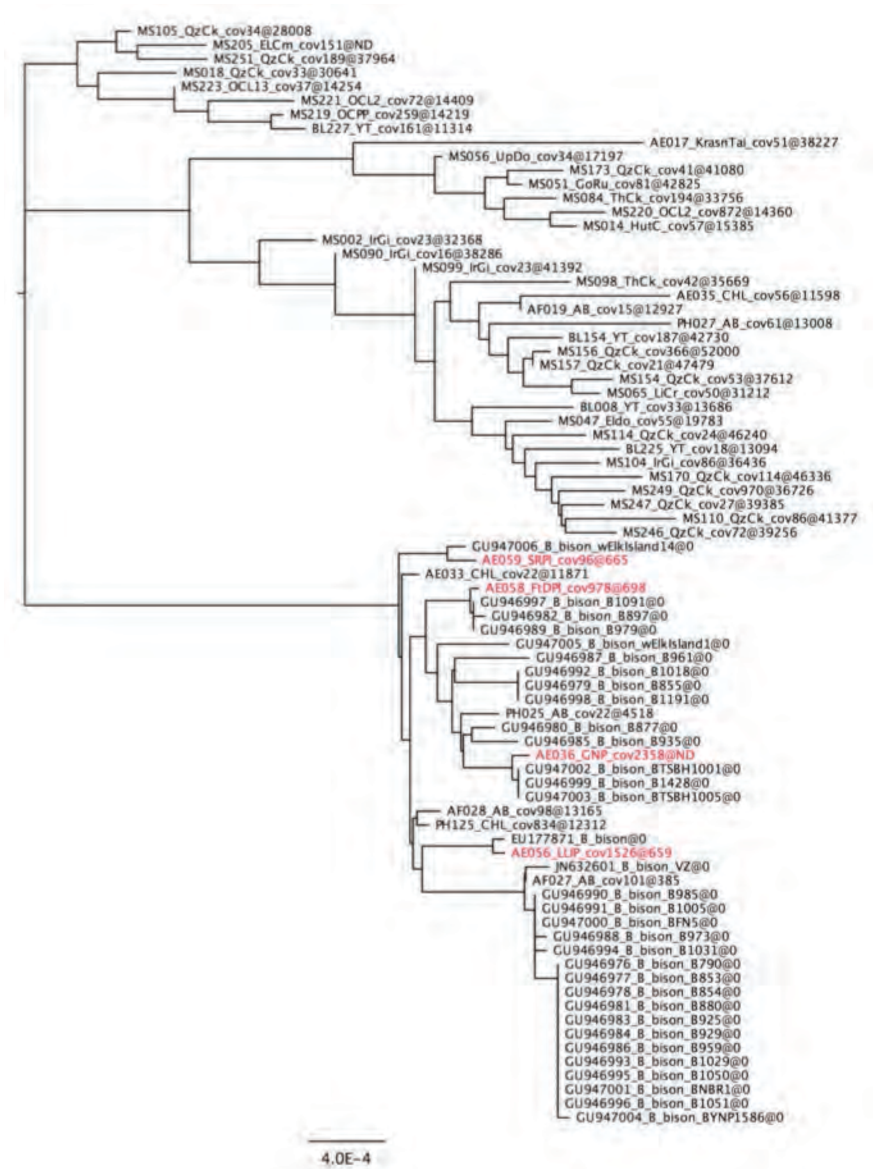


Figure 2: Complete AE036 genealogical analysis. It shows that this sample, and others from the same region, share the same common ancestor and are part of the same group.

APPENDIX E: CONTACT SHEETS, KESTREL AERIAL SERVICES OBLIQUE ICE PATCH PHOTOS

GLAC_1_5157.jpg

GLAC_1_5159.jpg

GLAC_1_MK3_4778.jpg

GLAC_13_5133.jpg

GLAC_13_5135.jpg

GLAC_13_MK3_4758.jpg

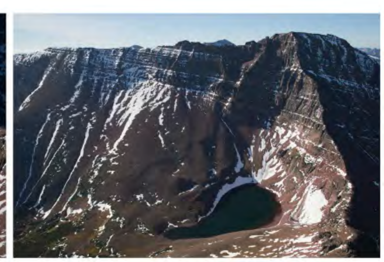
GLAC_13_MK3_4764.jpg

GLAC_16_5167.jpg

GLAC_16_5169.jpg

GLAC_17_5169.jpg

GLAC_18_5173.jpg



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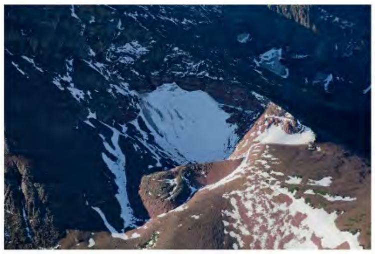

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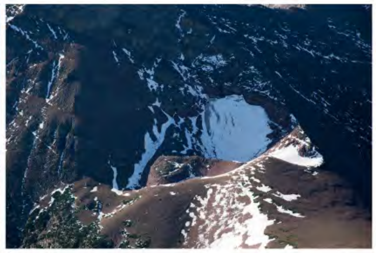

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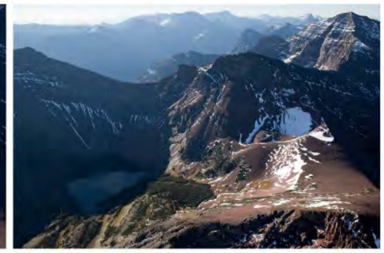

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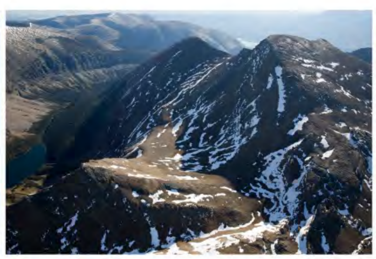
GLAC_30_5195.jpg

GLAC_30_5197.jpg

GLAC_31_5203.jpg

GLAC_31_5206.jpg



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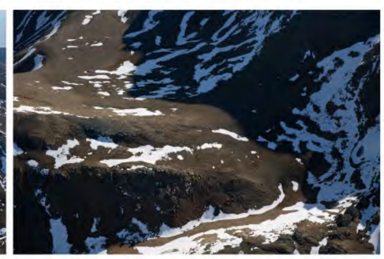

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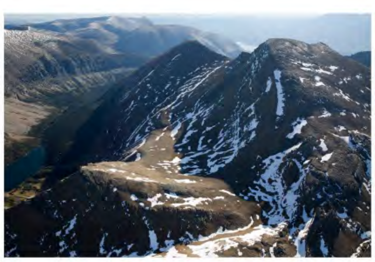

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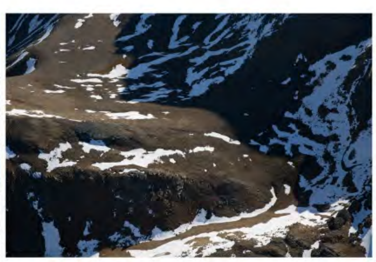

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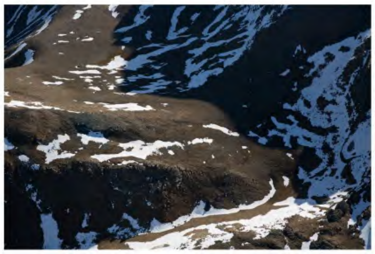
GLAC_36_5216.jpg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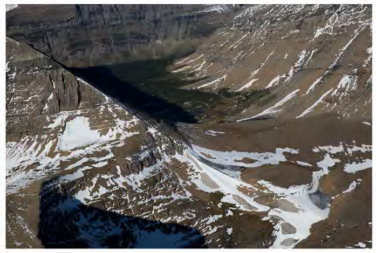
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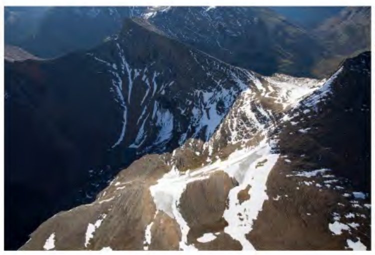
GLAC_38_5225.jpg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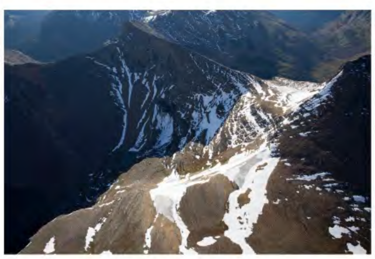
GLAC_39_5222.jpg


GLAC_39_5225.jpg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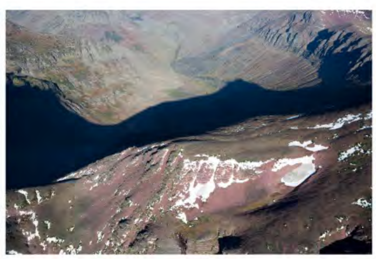
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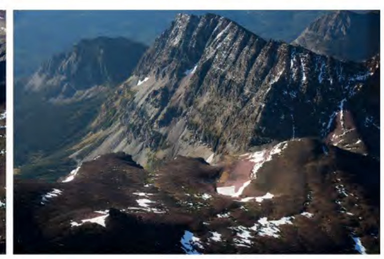

GLAC_4_5146.jpg


GLAC_4_5148.jpg


GLAC_4_MK3_4771.jpg


GLAC_40_5229.jpg

GLAC_43_5256.jpg GLAC_43_5260.jpg GLAC_43_5262.jpg

APPENDIX F: ADVICE FOR INADVERTENT DISCOVERIES

In keeping with the protocol established by the Glacier Cultural Resource Management Group (CRMG), knowledgeable persons consisting of tribal members and trained archaeologists should be present during the identification and collection of archaeological and/or paleobiological materials (see Appendix A, CRMG); however, it is possible to envision a variety of scenarios in which other backcountry personnel or Park visitors might encounter something unexpectedly. General advice for non-specialist Park staff regarding inadvertent ice patch discoveries includes the following:

> 1) Keep an eye out for ice covered with organic material, or for ice with an extensive concentration of organic material below it. If you encounter this situation, examine the organic rich area and vicinity for wooden tools, e.g., dart and arrow shafts, chipped stone projectile points, or paleontological/ paleobiological materials;
>
> 2) Regardless of whether anything is found, document the location with a GPS waypoint and photos and give this information to a Park archaeologist as soon as possible;
>
> 3) If an artifact or paleobiological sample is identified, do not disturb it, but take detailed notes of the artifact/sample location and look around for more material in the area – take numerous photos of the artifact/sample(s) in situ and call it in via radio or satellite phone if possible;
>
> 4) If an artifact is in danger of theft or destruction notify the Park archaeologist of the discovery immediately and take a qualified person to the location as soon as possible.

Because discoveries can occur unexpectedly, any materials inadvertently collected by persons other than qualified Park staff and tribal members should be delivered to the Park museum as soon as possible (the same day they are collected, or at maximum the next working day) so that the material can be stabilized and the appropriate groups notified. <u>For planned assessments of ice patches, field personnel should be in contact with the Tribes, Park Archaeologist, and the Museum Curator in advance of the work (see Appendix A, CRMG).</u>

Appendix G: Ice Patch Photos, 2010, 2012, 2013.

Glacier National Park, Ice Patch Record Photos, 2010, 2012, 2013.

***GLAC 1, Mt. Ellsworth**, 2013.*


GLAC 9, thin patch in center of photo, 2012.


GLAC-13, 2012.

GLAC-15, 2010.


GLAC-16, 2012.

GLAC-17 (foreground); GLAC-16 (upper right), 2012.

GLAC-19, 2010.

GLAC-20, 2010.

GLAC-21, 2010.

GLAC-20A, 2010.


GLAC-30, 2012.

*GLAC **32, Gunsight Pass**, 2013.*


GLAC-33, 2012.


GLAC-34 (left) and 35 (right), 2012.

GLAC 34 ***(left***) *and 35; excavators standing near bison skull, 2012.*

GLAC 35, Kelly (left) and Reckin recovering bison remains, 2012.

GLAC-36, 2012.

GLAC-38 (left) and 39, 2010.

GLAC-38A, 2010.

GLAC-39, 2010.

GLAC-40, 2010.

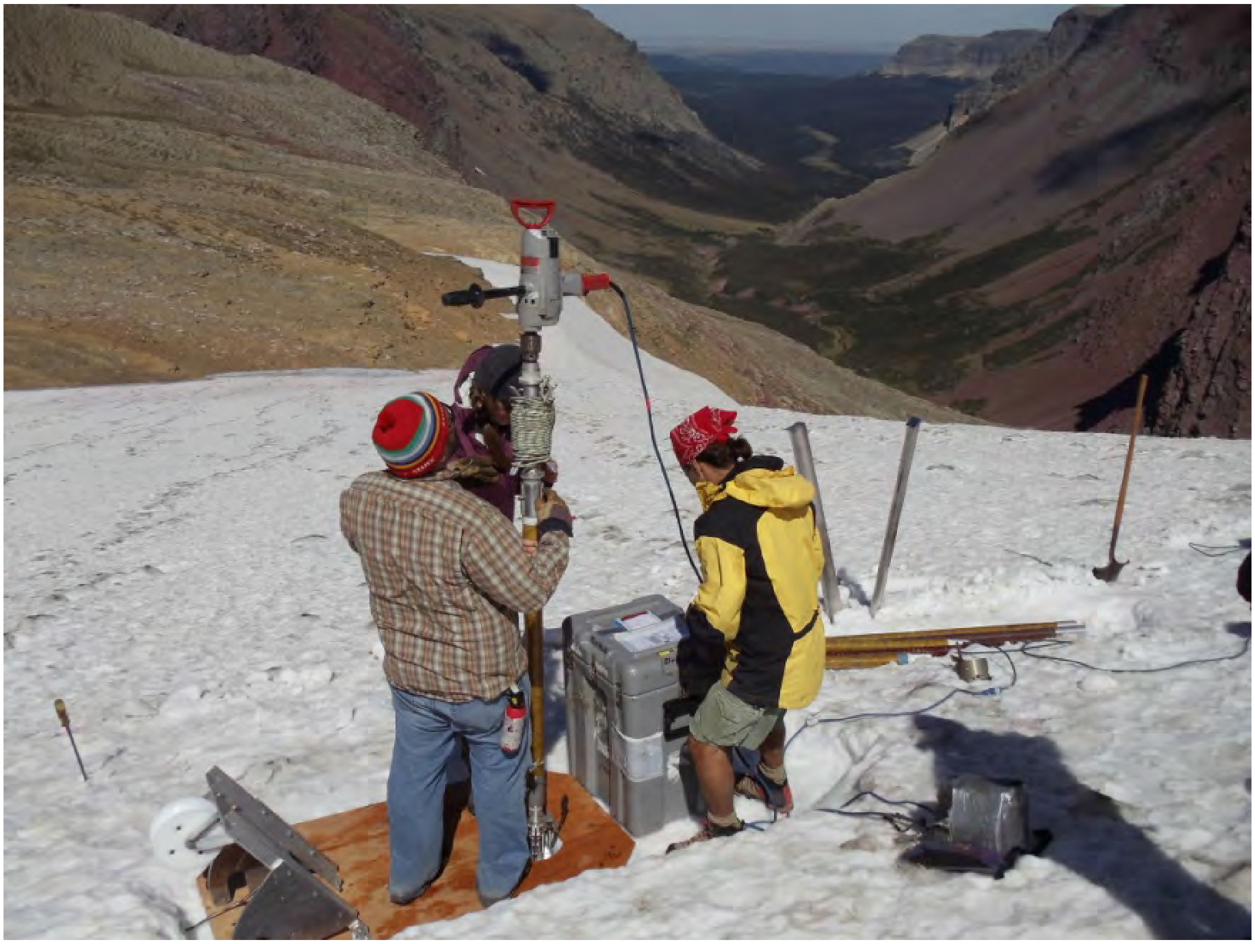

GLAC 40, Piegan Pass, manual coring in 2012; this proved unsuccessful.

GLAC-41, Piegan Pass, 2010.

.

GLAC 43, Iceberg Peak, view to south, 2013.

*Comparison of GLAC 38 (left side of photos) and 39 (right side) in 2010 (top) and 2013 (bottom). In 2013***,** *the patches were still enlarged by extensive 2010-2011 winter snow (view to north).*



GLAC 38, Core 1 in process at Siyeh Pass, 2013.

GLAC-38, 2013, core 1; Jay Kyne on box, with Rachel Reckin and Craig Lee.

GLAC-38, core 2, portion of ice core with organic lag deposit visible at left end of core.


GLAC-38, base of core 2 at 6.41m, the ground surface beneath ice patch.

GLAC-38, core 2, showing the difficulty of putting enough pressure on the drill.