ICE BISON, FROZEN FORESTS, AND THE SEARCH FOR ARCHAEOLOGY IN COLORADO FRONT RANGE ICE PATCHES

Craig M. Lee and James B. Benedict

ABSTRACT

This paper provides a synthesis of date and distribution information on bison and paleobotanical remains found in association with Colorado Front Range ice patches. Radiocarbon dates on bison (Bison bison) remains recovered at seven ice patches range in age from 210 ± 60 B.P. to 3270 ± 15 B.P., while radiocarbon dates on spruce (Picea sp.) from four ice patches range in age from 2840 ± 20 B.P. to 3860 ± 15 B.P. Front Range surveys were largely focused on the identification of archaeologically productive ice patches as “triage” in the face of global warming; however, no ice patches yielded definitive archaeological materials.

INTRODUCTION

Surveys in the Colorado Front Range (CFR) concentrated on perennial “ice patches,” which characteristically exhibit little internal deformation or movement. These features can contain ancient ice that, unlike glaciers, is kinetically stable and preservative (Lee 2012). It should be noted that some of the small “glaciers” in the CFR, most notably Buchanan Pass Glacier (Lee et al. 2006) and Ice Fields Pass Glacier (this report) have also produced the remains of bison.

To date, the CFR surveys are the only directed ice patch surveys that have occurred in Colorado, and the majority of these are within the confines of Rocky Mountain National Park (RMNP) (Lee and Benedict 2006; Benedict et al. 2008; Lee 2010a). Based on Fountain’s (2009) review of USGS maps, there appear to be over 125 permanent snow or ice bodies in Colorado, including the CFR. Additional ice patch surveys for archaeological and paleobiological material could be undertaken in the Park, Gore, Sawatch, and Tennmile mountain ranges, as well as in the Medicine Bow and San Miguel Mountains by refining Fountain’s data set with the techniques described in Lee (2010a).

Bison remains have been recovered from eight melting ice patches and/or glaciers (Table 1), and paleobotanical specimens have been collected from four melting ice patches in the CFR (Table 2). Three of the bison-bearing locations, Buchanan Pass, Spotted Pony (formerly St. Vrain Ice Patch No. 1), and Horseshoe Creek, are described in detail in Lee et al. (2006), and two paleobotanical locations in the Mummy Range (Mummy Pass) are described in Benedict et al. (2008). Subsequent to Lee et al. (2006), we determined that “Spotted Pony” is a more geographically suitable name for St. Vrain Ice Patch No. 1. The data presented in Tables 1 and 2 are ordered by year of discovery.

BISON SPECIMENS BY LOCALITY

Mt. Audubon

A purported discovery of a bison skull on Mt. Audubon in 1917 by Ralph Hubbard and the Boy Scouts of Troop 3 is of uncertain significance. Although Benedict made a note in his journal about a brief 1992 conversation regarding the skull with Dr. David Armstrong, then curator at the University of Colorado Museum, Armstrong has no recollection of the exchange (David Armstrong, personal communication to Craig Lee, February 22, 2006). The trail to the summit passes a prominent east-facing ice patch at an elevation of approximately 3,627 m, and we speculate the skull may have been associated with this feature. Nothing specific to the errant skull was located during a search of the osteology collection by Lee in the fall of 2005; however, numerous specimens attributed to Mr. Hubbard from the period were located. A records search by Mariko Kageyama, zoology collection manager at the museum, was similarly unsuccessful. Records of the Denver Area Council of the Boy Scouts of America indicate the earliest Eagle Scout out of Troop 3 was Robert Taylor in 1922, suggesting the troop was likely in existence in 1917 (Vicki Bontrager, personal communication to Craig Lee, February 15, 2006).

Lake Louise Ice Patch

The RMNP Museum contains two partial bison skulls (Bison bison) collected by David R. Stevens (former park naturalist) on September 2, 1981. One skull (ROMO-6655) is largely complete (Figure 1); the other (ROMO-6656) is fragmentary but includes two detached horns with horn sheaths. Museum files indicate the skulls were found “on [the] south side of [the] snowfield on
TABLE 1. Radiocarbon dates on Colorado Front Range ice patch bison. All dates are AMS ¹⁴C except for the Buchanan Pass specimen (GX-30359), which is a conventional date. Dates are calibrated with the online executable version of CALIB 6.0.

<table>
<thead>
<tr>
<th>Locality Number</th>
<th>Locality Name, Resource Area¹ and Altitude (m a.s.l.)</th>
<th>Geographic Coordinates (UTMs, WGS 84)</th>
<th>Discoverer(s) and Year</th>
<th>Material Dated</th>
<th>Lab Number</th>
<th>Age (¹⁴C yr BP)</th>
<th>±(‰) (2σ)</th>
<th>Mean of Calibrated Age Range</th>
<th>Relative Area Under Probability Distribution at 2σ</th>
<th>Relative Probabilities for Age Range(s)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mt. Audubon Ice Patch, IPWA (3662)</td>
<td>13, 44882E, 445302N</td>
<td>Roy Scoular, Troup III and Ralph Hubbard (1917)</td>
<td>Bison skull (not dated)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>This Report</td>
</tr>
<tr>
<td>2</td>
<td>Lake Louise Ice Patch, RMNP (3530)</td>
<td>13, 44566E, 448420N</td>
<td>Dave Stevens (1981)</td>
<td>Bison bone horn sherd (keratin)</td>
<td>CURL-8126</td>
<td>680 ± 15</td>
<td>-16.5</td>
<td>AD 1278-1392</td>
<td>0.78 AD 1290</td>
<td>This Report</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Lake Louise Ice Patch, RMNP (3530)</td>
<td>13, 44566E, 448420N</td>
<td>Dave Stevens (1981)</td>
<td>Bison bone horn sherd (keratin)</td>
<td>CURL-8133</td>
<td>1095 ± 15</td>
<td>-18.6</td>
<td>AD 895-927</td>
<td>0.35 AD 911</td>
<td>This Report</td>
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</tr>
<tr>
<td>4</td>
<td>Rowe Mountain Ice Patch, RMNP (3626)</td>
<td>13, 44404E, 448302N</td>
<td>Paul Yoder (1996)</td>
<td>Bison bone radius (ion exchange amino acids)</td>
<td>CURL-9356</td>
<td>2255 ± 15</td>
<td>-18.0</td>
<td>BC 350-353</td>
<td>0.49 BC 372</td>
<td>This Report</td>
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</tr>
<tr>
<td>6</td>
<td>Buchanan Pass Glacier, IPWA (3539)</td>
<td>13, 44647E, 442138M</td>
<td>Jim Benedict, Bob Benedict (2002)</td>
<td>Bison bone humerus (collagen) conventional date</td>
<td>GX-30359</td>
<td>210 ± 60</td>
<td>-17.8</td>
<td>AD 1522-1574</td>
<td>0.07 AD 1548</td>
<td>Lee et al. 2006</td>
<td></td>
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<tr>
<td>7</td>
<td>Horsethew Creek Ice Patch, IPWA (3265)</td>
<td>13, 44938E, 442442N</td>
<td>Bill Axer, Lee Tillotson, Janet Roberts (2002)</td>
<td>Bison bone horn core (amino acids)</td>
<td>CURL-7135</td>
<td>2090 ± 45</td>
<td>-13.7</td>
<td>BC 206-AD 5</td>
<td>0.97 BC 73</td>
<td>Lee et al. 2006</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Spotted Pony Ice Patch, IPWA (3615)</td>
<td>13, 44597E, 443203N</td>
<td>Scott George (2002)</td>
<td>Bison bone horn sherd (keratin)</td>
<td>CURL-7080</td>
<td>2280 ± 30</td>
<td>-19.6</td>
<td>BC 396-228</td>
<td>0.39 BC 262</td>
<td>Lee et al. 2006</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Staysfield Pass Glacier, RMNP (3860)</td>
<td>13, 44625E, 449202N</td>
<td>Jim Benedict, Bob Benedict, Dennis Staley (2005)</td>
<td>Bison bone molars (ion exchange amino acids)</td>
<td>CURL-9413</td>
<td>3270 ± 15</td>
<td>-10.9</td>
<td>BC 1563-1500</td>
<td>0.62 BC 1532</td>
<td>This Report</td>
<td></td>
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</table>

²IPWA - Indian Peaks Wilderness Area; RMNP - Rocky Mountain National Park
³Geographic Coordinates and elevation are based on the southern margin of the ice patch east of Ice Fields Pass and west of Lake Louise

TABLE 2. Radiocarbon dates on Colorado Front Range ice patch paleobotanical materials. All dates are AMS ¹⁴C. Dates are calibrated using CALIB 6.0.

<table>
<thead>
<tr>
<th>Locality Number</th>
<th>Locality Name, Resource Area¹ and Altitude (m a.s.l.)</th>
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<th>±(‰) (2σ)</th>
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<th>Relative Probabilities for Age Range(s)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>May Creek Ice Patch, Log 1, (3420)</td>
<td>13, 437450E, 4427863N</td>
<td>Jim Benedict, Craig Lee, Patrick Cappa (2007)</td>
<td>Wood macrofossil, Picea sp. (spruce)</td>
<td>CURL-9552</td>
<td>2840 ± 20</td>
<td>-20.6</td>
<td>BC 1054-920</td>
<td>1.00 BC 987</td>
<td>This Report</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Ice Patch N of Mt. Ida (ROMCO 3), RMNP, (3487)</td>
<td>13, 43341E, 4472855N</td>
<td>Craig Lee, Patrick Cappa (2010)</td>
<td>Wood macrofossil, Picea sp. (spruce)</td>
<td>CURL-12602</td>
<td>3855 ± 15</td>
<td>-24.8</td>
<td>BC 2458-2418</td>
<td>0.10 BC 2439</td>
<td>This Report</td>
<td></td>
</tr>
</tbody>
</table>

¹IPWA - Indian Peaks Wilderness Area; RMNP - Rocky Mountain National Park
[the] east side of Ice Field Pass,” at the head of the North Fork of the Big Thompson River. With the exception of the questionable Mt. Audubon bison skull, these two specimens represent the first bison recovered in association with an ice patch in the CFR. It is unknown if any postcranal remains were present with the Lake Louise skulls. The ca. 400-year-age difference between the skulls indicates at least two periods of entrainment.

**Rowe Mountain Ice Patch**

In late August 1996, Paul Yoder found a fused radius and ulna “melted out of a snowfield at an elevation of 13,000 ft” that eventually made its way to Rocky Mountain National Park archaeologist Bill Butler (personal communication to Craig Lee, April 13, 2006). Yoder recalls the radius-ulna coming from an ice patch up-drainage from the Icefield Pass Glacier, and north of Rowe Peak; however, he took no photos and did not mark the location on a map (Paul Yoder, personal communication to James Benedict, October 26, 2007). Benedict believes he identified and revisited the location in 2007 and observed an additional large limb bone with a possible spiral fracture. Although Yoder’s bone was weathered and checked on the surface, it was very dense and fresh on the inside and still contained a sizeable portion of marrow. The bones are now curated at the RMNP Museum (Tim Burchett, personal communication to Craig Lee, December 6, 2010).

**Jones Pass Ice Patch**

The Jones Pass discovery was made by amateur archaeologist Ed Knapp in August 2001 (Graham 2003). In addition to the skull Knapp collected, he and Russell Graham, then curator of paleontology at the Denver Museum of Nature & Science (DMNS), collected postcranal elements at the site in September 2001 and August 2002 (Graham 2003). The bones are not heavily weathered, suggesting they were predominantly frozen or snow covered for the last 400 years (Graham 2003). They are curated at the DMNS, and Graham is preparing a report on the details of the skeleton (Graham, personal communication to Craig Lee, October 28, 2011).

**Buchanan Pass Glacier**

In September 2002 a bison humerus was recovered on the melting toe of the Buchanan Pass Glacier by Jim and Bob Benedict (Lee et al. 2006). The remains of other large mammals, some still with flesh and hair, were also exposed at the time. The glacier has a distinctive crevasse, or “bergschrund” at its head indicating that ice is continuing to flow away from the cirque headwall. The bison must have become entrained in the glacier above the equilibrium line altitude (ELA), which during many years is essentially at the bergschrund. The ELA divides the glacier into two parts, with one being the ablating area or melting surface and the other being the accumulating area where snow is accreting. The conventional radiocarbon age obtained on the bison serves as a proxy for the mean time it takes snow to become glacial ice and exit the system at the toe (ca. 250 years).

**Horseshoe Creek Ice Patch**

In late September 2002, Bill Ikler, Lee Tillotson, and Janet Roberts discovered several significantly weathered bison specimens, including two horn cores, associated skull fragments, a vertebra, and a portion of a scapula scattered on the ground along the lateral periphery of this ice patch (Lee et al. 2006). The specimens were originally taken to the DMNS for identification before being given to Benedict. They have subsequently been turned over to Paul Alford, South Zone archaeologist for the Arapaho and Roosevelt National Forests at the Boulder Ranger District (Paul Alford, personal communication to Craig Lee, August 25, 2010).
Spotted Pony (St. Vrain Ice Patch No. 1)

Faunal material, including a bison horn sheath, was observed melting out of this ice patch in September 2002 by Scott George. The Spotted Pony Ice Patch was identified in Lee et al. (2006) as St. Vrain Ice Patch (Glacier) No. 1; however, we believe “Spotted Pony” is a more apt name for this location given its proximity to Spotted Pony Mountain. In addition to the bison horn sheath, George noted the presence of other bone, including a full curl big horn sheep skull he collected, as well as abundant “freeze dried” plant material (Scott George, personal communication to Craig Lee, October 7, 2003). The skull may be of particular interest to biologists, because it likely relates to the pre-contact sheep population(s) present in the CFR.

Icefield Pass Glacier

Three large, conjoined bison molars were recovered by Jim and Bob Benedict and Dennis Staley in September 2006 (Figure 2). The Icefield Pass “Glacier” is the largest ice body in RMNP (Fountain 2009). It lies on the leeward side of a ridgeline extending north from Rowe Mountain. Despite its size, the ice mass does not appear to be actively flowing. The molars were on the surface of humus-rich, “snowbed loess” about 10 m downslope of the severely diminished ice margin. The teeth are moderately well preserved and surprisingly old (Table 1); they are the oldest bison remains recovered from a glacier or ice patch in the CFR.

ICE BISON DISCUSSION

One of our rationales for this paper was to update the known occurrences of bison remains in association with CFR ice patches, and to explore the following questions: Why are bison remains associated with ice patches, and why are they primarily restricted to isolated skeletal elements? Could some of the remains be associated with hunting and/or meat-caching, or possibly spiritual offerings? Unfortunately, there is as yet no clear answer to the latter question. With regard to the former question, the predominance of skull and horn parts may relate more to their easy identification (and subsequent collection) as bison by outdoor enthusiasts when in fact there may be other elements present at these locations as well.

In Lee et al. (2006) we explored the δ13C values returned by the AMS 14C labs as a way to evaluate the individual dietary histories of the bison we analyzed, where the δ13C value presumably reflects the dominate forage the animal consumed. In brief, C4 photosynthetic plants tend to occupy lower elevations (e.g., Great Plains) while C3 photosynthetic plants dominate higher elevations (e.g., mountains) (Lee et al. 2006). Compared with data compiled by Cannon (2004:Table 4), the Spotted Pony and Buchanan Pass specimens overlap at one standard deviation with specimens recovered at high elevations in Idaho (–19.6 ± 1‰) and Utah (–18.8 ± 1‰). In contrast, the Horseshoe Creek and Icefield Pass specimens are comparable to the isotopic signatures obtained on specimens from Kansas (–13.8‰) and Nebraska (–15.9‰). The specimens from Lake Louise bear some similarity, respectively, to the δ13C values of both comparative populations. With regard to the paleogeography of bison, these results might indicate the presence of a resident mountain bison population eating predominantly C3 grasses, as well as a migrant bison population with affinity for the Plains. A note of caution, however, is warranted with regard to the use of the AMS 14C lab measured δ13C values; the δ13C values measured in the AMS machine are primarily obtained for age calculation, and their use in dietary reconstructions must be considered a
very coarse approach. Lee and others will continue to work on this question by submitting samples for δ13C and δ15N analysis to more directly assess diet.

As noted above, the remains of other animal species are also present in ice patches, including bighorn sheep, elk, and mule deer (Lee et al. 2006). Because these animals are extant in the ecosystem today, their presence cannot be viewed as clear evidence of the antiquity of ice patch deposits. Anecdotal observation suggests they too are represented by random skeletal elements. Collectively, it seems likely that ice patches held some attraction for a range of animals in the CFR and at the least, their association with the CFR ice patches indicates this is a relatively long-term pattern. Whether or not (and why or why not) humans took advantage of this seemingly predictable behavior as they did in other areas of the Rockies (Lee 2010b, 2012) will be explored in a later paper.

PALEOBOTANICAL SPECIMENS BY LOCALITY

Paleobotanical remains had been recovered from four melting ice patches in the CFR (Table 2). Two of the locations in the Mummy Pass area of RMNP are described in Benedict et al. (2008). As with the bison bones, the paleobotanical portion of the table is ordered by year of discovery.

Mummy Pass

In September 2006, the remains of timber-sized spruce trees (Picea engelmannii) were recovered on the floors of melting ice patches in the Mummy Range in RMNP by Jim and Bob Benedict and Dennis Staley (Benedict et al. 2008). The ice patches lie downwind from the tundra uplands of Mummy Pass to the west. Benedict et al. (2008) hypothesized decreased forest cover in response to neoglacial cooling allowed snow drifts to form in the recesses and to preserve remnants of the once higher treeline in a subnival-deepfreeze for millennia.

May Creek

In September 2007, Jim Benedict, Craig Lee, and Patrick Cappa recorded portions of several enormous tree trunks in a severely melted ice patch at the head of May Creek just north of RMNP in the Mummy Range. The trunks are located on the lateral margins of the ice patch, and are strikingly dissimilar in size from the proximate trees, exceeding 1 m in diameter. AMS 14C ages on the outer growth rings of the two trunks produced concordant ages.

Continental Divide North of Mt. Ida

This ice patch was identified as “ROMO 3” in Lee (2010a). It lies east of the Continental Divide between Fall Pass and Mt. Ida in an area that was selected for survey based on a model of archeological potential. The collected specimen was from a larger chunk of possibly rooted wood. Although it was not clearly part of a large timber tree, it appeared as if it could have come from a tree that grew in the nivation hollow during a less snowy time in the past. The specimen was identified as spruce (Picea sp.) by Jeffrey Lukas (NOAA) and the identification was corroborated by Kathy Puseman and Chad Yost (PaleoResearch Institute). A few small fragments of wood were noted in adjacent ice patches as well.

PALEOBOTANICAL DISCUSSION

As with the bison-bearing ice patches, the ice patches containing the paleobotanical materials tend to occupy northeast-facing recesses and all are located downwind of tundra upland. The May Creek Ice Patch trees lie about 45 m lower than the Mummy Pass trees, whereas the wood from the Continental Divide Ice Patch north of Mt. Ida is about 15 m higher. The May Creek trees are nearly 1,200 years younger in age than the Mummy Pass specimens and are significantly larger. Given their position on the lateral margins of the ice patch, it is plausible these two large, old trees tenaciously resisted the snow infilling their recess. Given their size, they may have been among the longest-lived spruce trees in Colorado (see Brown et al. 1995). The May Creek trunks show decay similar to the trees in the Mummy Pass ice patches. In contrast to these younger trees, the wood recovered at the Continental Divide ice patch north of Mount Ida seems to have died and been preserved at essentially the same time as the Mummy Pass ice patch trees.

The hypothesis that the ice patch tree stands resulted from a neoglacial cooling trend is supported by Benedict (2011), in which he demonstrated the presence of large-bodied sclerotia of Cenococcum geophilum, a common ectomycorrhizal fungus, consistent with spruce-fir forest and/or tree-island vegetation in the now treeless tundra uplands above the Mummy Pass ice patches. Benedict argues the presence of the sclerotia indicates tree limit stood ca. 100 to 150 m higher than it does today about 1,000 years before the ice patch trees became entombed. This suggestion is strengthened by Carrara’s (2011:1) work at Lake Emma in the northern San Juan Mountains of Colorado, which indicates treeline was at least 80 meters higher than present 5,400 radiocarbon years ago (about 6,200 calendar years ago). Carrara (2011: Appendix A) provides radiocarbon dates on approximately 20 other locations throughout western North America with records of higher treeline during the early to middle Holocene.

CONCLUDING THOUGHTS

The exposure of ice bison and frozen forests by the retreat of moisture-starved and heat-ravaged ice patches in the CFR is perhaps the most tangible indication of global warming in the Rocky Mountain West. Although the articulation of our ecological work with the archeological record of Native Americans is beyond the scope of the present paper, it is worth noting that the ice patches of the Greater Yellowstone Ecosystem (GYE) and else-
where illustrate repeated use of these features by humans over millennia, suggesting they were an important element of the sociocultural and geographic landscape for Native Americans (Lee 2010b, 2012). The absence of an obvious ice patch adaptation in the CFR may relate to preservation bias and the use of extensive game drive systems—features not seen in the alpine region of the GYE—following the onset of neoglacialation. The effects of climate change are tangible in northern and mid-latitude ice patches, and without the continued pursuit of these studies, we risk losing an amazing opportunity to know the past while simultaneously capturing public interest to think about the future.

**ACKNOWLEDGMENTS**

It is with a heavy heart and a sense of real accomplishment that I submit this manuscript for inclusion in this special edition of *Colorado Archaeology*. The abstract was prepared with Jim prior to his passing and the data presented is representative of our long-term collaboration on this topic. While it is absolutely correct that Jim be listed as co-author, any shortcomings in the description and analysis rest with the lead author. The number of individuals and organizations who supported our research over the last 10+ years is truly huge, and it is not possible to be exhaustive in this context. To all of the primary researchers noted in the text and tables, thank you!

We are also indebted to Russel Graham (Pennsylvania State University) for generously sharing data; Scott Lehman, Jocelyn Turnbull, Chad Wolak, and Patrick Cappa (INSTAAR AMS Radiocarbon Laboratory, University of Colorado) for providing radiocarbon analyses; Jeff Lukas (NOAA), Kathy Puseman, and Chad Yost (PaleoResearch) for identifying wood samples; and Judy Visty, Bill Butler, Adrienne Anderson, Tim Burchett, Christy Baker, Karen Waddell, Jeff Connor, and many others at the National Park Service for encouraging our research and facilitating the permits required for fieldwork in Rocky Mountain National Park. Research was conducted under the provisions of ARPA Permit 06- ROMO-01 and Scientific Research and Collection Permit ROMO-2010-SCI-0037. We thank our families, including Audrey DeLella Benedict and Jennie and Ella Lee, for their unending interest and support.

Jim Benedict passed away on March 8, 2011. A pre-eminent geoarchaeologist and ecologist of the Colorado alpine, his legacy lives on through his and his loving wife Audrey’s contribution to the Jim and Audrey Benedict Endowment for Mountain Archaeology and the Center for Mountain and Plains Archaeology at Colorado State University, as well as through more than 70 published books and articles. He is sorely missed by his family, friends, and colleagues.

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