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ARTICLE

Refining chronology for surface collections: A new adaptation of morphological dichotomous keys for the Plains Typology and the Greater Yellowstone Ecosystem

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This paper uses new lithic research with well-dated stratified collections from the foothills of the Absaroka Mountains and adjacent Bighorn Basin to build a dichotomous key for chronologically classifying points in the northern Greater Yellowstone Ecosystem (GYE) as Late Prehistoric (200–1,500 cal BP), Late Archaic (1,500–3,200 cal BP), Middle Archaic (3,200–5,700 cal BP), Early Archaic (5,700–8,500 cal BP) or Paleoindian (8,500–12,000 cal BP). The Plains Typology, which is currently used throughout the GYE, has never been formally based on points with affiliated absolute dates. Further, it has always been unclear how well this typology functions in the mountains of the GYE. Based on detailed attributes from over 600 points, including Mummy Cave (48PA201), a foundational chronology for the region, we build a key intended for use with fragmentary surface collections. We then use this key to consider variation in high elevation projectile points from the Beartooth and Absaroka Mountains.

KEYWORDS high elevation, lithic studies, projectile point, typology, chronology, Rocky Mountains

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In general, high elevation archaeology is often surface archaeology. Stratified sites do certainly exist in many mountain contexts, but the most frequent site type is a surface lithic scatter, with projectile points the only potential temporal marker. Indeed, due to the general lack of stratified sites and radiocarbon dates at high elevations, any diachronic research in the mountains is largely based on typological dates of projectile points. This kind of relative dating has its limits in terms of precision, but it is preferable to leaving enormous amounts of archaeological data unmoored from chronology. In this paper, we create a simple, intuitive dichotomous key for typing projectile points from the mountainous regions of the northern Greater Yellowstone Ecosystem (GYE), including portions of southwest Montana and northwest Wyoming (Figure 1). Vitally, this key is based entirely on points from stratified sites with associated radiocarbon dates (Figure 2). It sorts points into five broad categories of the Holocene: the Late Prehistoric (200–1,500 cal BP), Late Archaic (1,500–3,200 cal BP), Middle Archaic (3,200–5,700 cal BP),

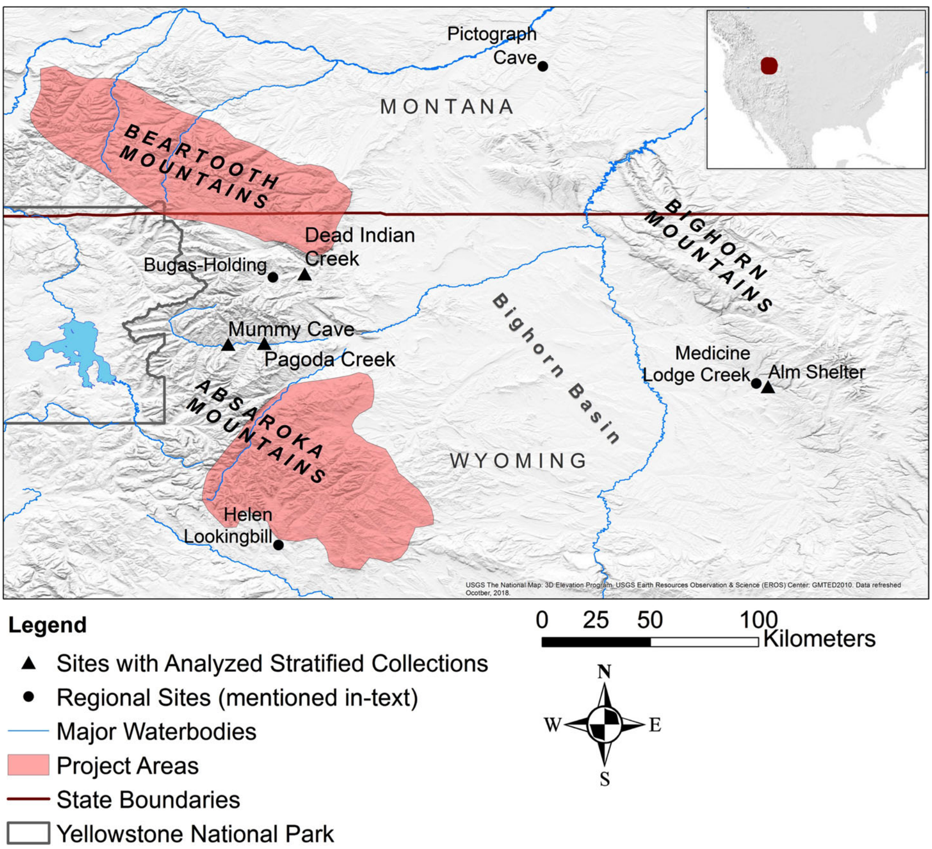


FIGURE 1 Overview map of the Greater Yellowstone Ecosystem, showing the portions of the Absaroka and Beartooth Mountains from which the Greybull River Sustainable Landscape Ecology (GRSLE) dataset and the Waples Collection arise, respectively. It also shows the stratified sites used to create the dichotomous key and other regional sites discussed in the text. The Digital Elevation Model is from the U.S. Geological Survey.

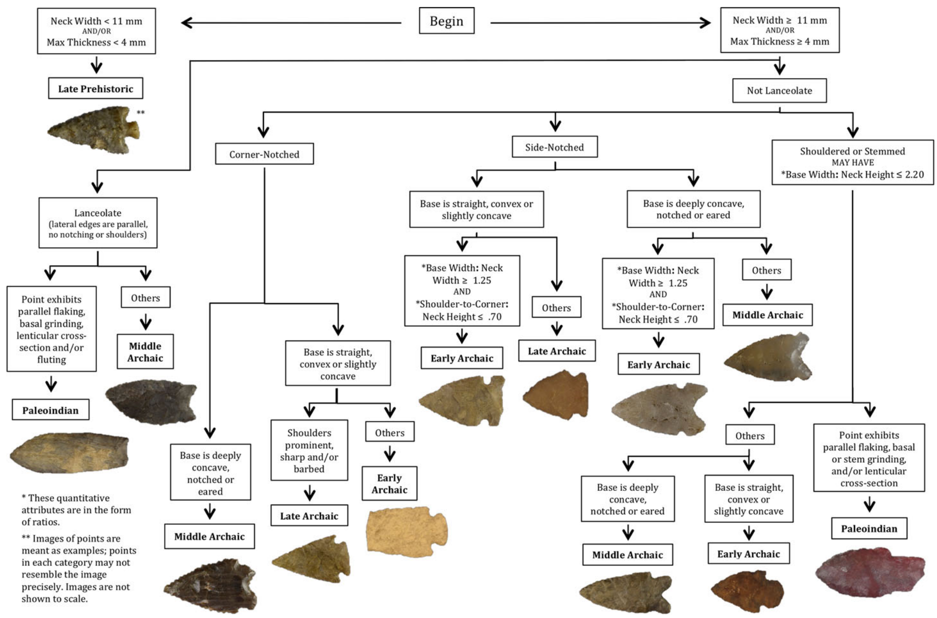


FIGURE 2 Morphological dichotomous key for chronologically typing points from the northern Greater Yellowstone Ecosystem and the Bighorn Basin.

Early Archaic (5,700–8,500 cal BP), and Paleoindian (8,500–12,000 cal BP) (Figure 3). Based partially on qualitative attributes and partially on quantitative measures and ratios, it captures most of the variation observed in stratified collections from four sites in or near the northern GYE: Mummy Cave (48PA201), Dead Indian Creek (48PA551), Pagoda Creek (48PA853) and Alm Shelter (48BH3457) (Figure 1). We then test the key against the projectile point variation contained within two datasets from the northern GYE: the Greybull River Sustainable Landscape Ecology (GRSLE) archaeology project, which includes data on more than 1,000 points from the Absaroka Mountains, and a lithic collection from high elevations in the Beartooth Mountains that contains more than 600 points.

To modern archaeologists, a dichotomous typological key might seem simplistic, a relic of culture historical approaches that suggests people reproduce material culture repetitively and monolithically. But that is not the intention of this key, nor the argument of this paper. Instead, classifying points in this manner can offer us a tool to highlight temporal and spatial patterns of variation. And, as Thomas (1981) points out, if archaeologists want to study diachronic change, we must have some way of tying the artifacts and sites we study to a chronology. In landscapes where surface artifacts predominate, morphologically typing lithics often represents the most abundant, straightforward method for establishing age. Therefore, tools like this key are vital steps toward further research questions about what controls the lithic variation we see, both temporally and spatially. But we cannot take those further steps until we first develop evidence-based chronological moorings for our data. Ultimately, this paper is intended both as a specific local chronology and as

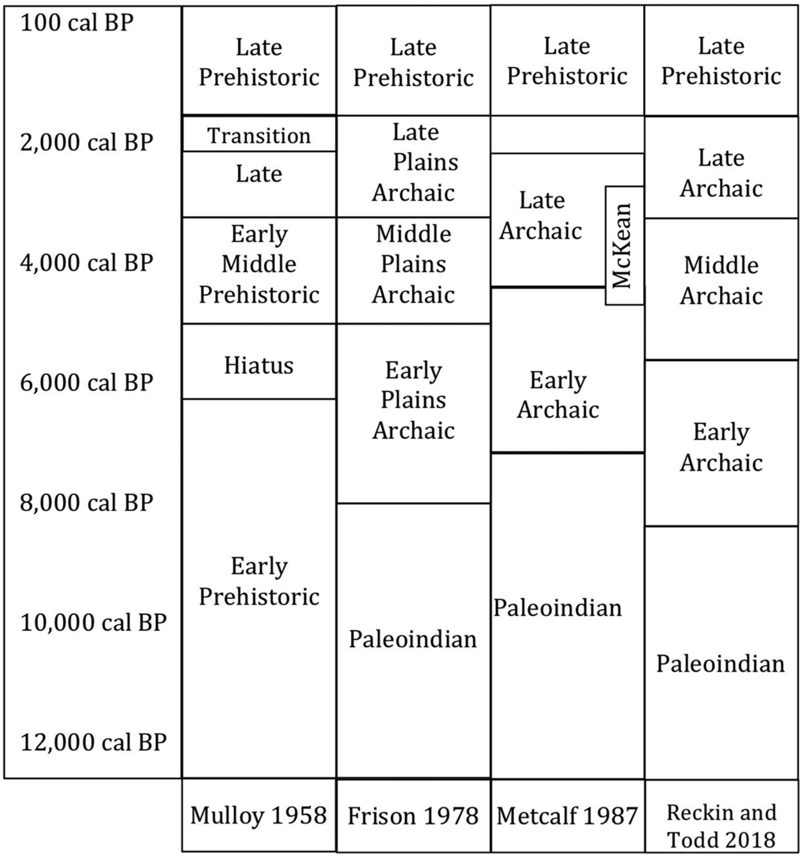


FIGURE 3 Adapted from Frison (1991). Several prominent Plains chronologies in comparison. Note that the Metcalf chronology was specifically developed for use in Southwest Wyoming. Final column is the chronology used in this analysis.

a contribution to how surface archaeologists everywhere grapple with the complexities of chronology-building without absolute dates.

Any typology must first be based on specific research questions, methods and assumptions. In this case, we intend the dichotomous key to denote chronological types at a relatively coarse scale based on morphology. Importantly, it is designed for use with fragmentary surface collections, which contain very few complete points. It is also designed to integrate extant data from the Greybull River Sustainable Landscape Ecology archaeology project in the Absaroka Mountains (Todd 2015, 2019) and collections from the Beartooth Mountains (Figure 1). Many of the projectile points in the GRSLE database remain in the wilderness locations where they were documented, and cannot be re-analyzed. Therefore the dichotomous key's foundational measurements are somewhat limited by what the GRSLE project has already collected. We also intend for it to be used in the future on uncollected artifacts in the field, meaning it must rely on simple attributes that do not require extensive equipment or time to measure. Additionally, it is designed to minimize user error by employing attributes that are the most consistently measured between different analysts (e.g. Corliss 1972; Dibble and Bernard 1980). Finally, it is designed for use in the northern GYE and the Bighorn Basin (Figure 1). This paper does not consider how far outside that specific region this key may function.

Typological classification systems for hafted bifaces are foundational in North American archaeology, where types of projectile points are frequently used to date cultural levels in buried sites as well as surface lithic scatters (Knecht 1997). Radiocarbon dating is rightly used to refine stratified chronologies, but often analysis still begins by noting that a site contains McKean or Pelican Lake style projectile points, for example. These types are not as well-defined as one might hope, however, and their chronology, morphology and geographic spread can be ambiguous (e.g. Eighmy and LaBelle 1996). The GYE provides a particularly complex lithic landscape, as it is at the confluence of a series of biogeographic zones: the Great Plains, the Pacific Northwest, and the basin and range ecozones to the south and west, which lead to the Great Basin. The typology currently in use for the GYE is a variation of the Plains Typology, which may sound incongruous from the start. This is a region filled with mountains and intermontane basins, though it abuts the plains – why use the "Plains" Typology here? Because, in the extended history of the Plains Typology, several of the most important sites upon which it is based are not in the plains, they are in the intermontane basins and valleys of Southwestern Montana and Northwestern Wyoming.

The Plains Typology is the product of more than sixty years of lithic research beginning with the work of William Mulloy (1958). He based his analysis on a deeply stratified site in Montana called Pictograph Cave (24YL1). In spite of its name, Pictograph Cave is made up of a series of rockshelters, excavated first by H. Melville Sayre of the Montana School of Mines from 1937 to 1939, and then by Mulloy in 1940 and 1941 (Corbyn 1979). Amateur archaeologists from nearby Billings had previously done some minor digging in the cave's deposits, reporting their findings to the Montana Society of Natural History in 1937, and inspiring Sayre's work (Corbyn 1979). Of all the major type sites near the GYE, Pictograph Cave is the closest to being truly on the plains, though it is still on their Rocky Mountain edge. In his analysis, Mulloy argued for essentially four periods of prehistory, which can be seen in Figure 3. This chronology has been refined several times since then, most notably in the work of seminal Wyoming archaeologist George Frison (1978, 1991). In addition to Pictograph Cave, which was almost solely the basis of Mulloy's work, Frison considered the chronologies of 25 other sites in the intermontane basins and on the northwestern plains. Some of the most major and deeply stratified of these sites are also located in the intermontane basins and valleys of the Absarokas and the Bighorn Basin (Figure 1). These include Mummy Cave (48PA201) (Husted and Edgar 2002; McCracken 1978; Wedel et al. 1968), Helen Lookingbill (48FR308) (Frison 1983), and Medicine Lodge Creek (48BH499) (Frison 1976; Frison and Wilson 1975).

Data

The present analysis is based on four different stratified sites from the foothills of the Absarokas and the Bighorn Basin, shown in Figure 1: Mummy Cave (48PA201), Dead Indian Creek (48PA551), Pagoda Creek (48PA853) and Alm Shelter (48BH3457). The research presented here relies on affiliations between artifacts and radiocarbon dates. For each site, we considered what was available in terms of excavation records, publications, and how the artifacts themselves were labeled in curation. For the most part, we followed the excavators' assignments of artifacts to particular stratigraphic or occupational layers that they also affiliated with radiocarbon samples. In the case of Pagoda Creek, we dated six additional samples from the two major occupational levels (Cannon 2017: Figure 10). For Alm Shelter, we used a time-depth model created for the site. In general, if a particular artifact had not been clearly assigned to a stratigraphic or cultural level that also had an assigned radiocarbon date, we did not include it in our sample. However, we did not insist that artifacts be point-plotted. Because the key relies on broad chronological categories (even the shortest time period, the Late Prehistoric, is 1300 years long), minor discrepancies in dating should not cause points to be placed in an incorrect category.

Mummy Cave, in particular, is a regionally-important, deeply stratified site that spans from the Paleoindian to the Late Prehistoric, including the human remains that gave the rockshelter its name. It has famously good organic preservation, with 26 radiocarbon dates on 18 occupational layers including more than 500 projectile points (Hughes 2003:23–24). Mummy Cave is located on the north bank of the North Fork of the Shoshone River as it passes through the Absaroka Mountains at approximately 1,920 meters above sea level (m asl). It lies, therefore, on a major travel route between the Yellowstone Plateau, to the West, and the Bighorn Basin to the East. Excavation at Mummy Cave began in the early 1960s with Robert Edgar and Harold McCracken of the Buffalo Bill Historical Center in Cody, Wyoming (McCracken 1978; Wedel et al. 1968). In 1966, Wilfred Husted of the Smithsonian took over the excavations, completing the initial work in that same year. In addition to extensive lithics, the cave contains spectacular organic artifacts, including basketry, arrow shafts, bone tools, cordage, and leather. For the most part, Husted and Edgar found the occupational levels were separated by sterile layers (2002:19). However, Mummy Cave is not without complexities with its stratigraphy and precise artifact provenience. Artifacts were, theoretically, point-plotted at the time of excavation, but that ledger book is lost. The artifacts are labeled by level, but the transition between excavators led to several different numbering systems for the levels of the cave that can be confusing (Hughes 2003: Table 2.2). Susan Hughes revisited the site's collections in the 1980s and did extensive work sorting through the original excavation notes and ironing out the chronology (Hughes 1988, 2001, 2003). Robert Kelly of the University of Wyoming has since revisited the site for clarifying chronostratigraphic excavation and analysis (personal communication 2017). First, Kelly's work demonstrated that the oldest occupation of the site is, indeed, approximately 10,450 cal BP, which Susan Hughes (2001) also argues. In addition, the oldest sediments in the site appear to be younger than 13,000 cal BP, though they proved difficult to date (Robert Kelly, personal communication 2017). We relied on the efforts of Hughes and Kelly to assign artifacts to particular levels, and we are also working to obtain new dates to clarify the chronology further. In spite of these concerns, thanks to its extended sequence Mummy Cave has become a foundational site for the Plains Typology, refining the chronology Mulloy had originally proposed at Pictograph Cave (24YL1) in Montana (Mulloy 1958). The Mummy Cave collections are held at the Buffalo Bill Center of the West in Cody, Wyoming.

Dead Indian Creek (48PA551) is at 1,860 m asl in the Sunlight Basin of the Absarokas, to the north of Mummy Cave. Like Mummy Cave, it lies on a natural human migration route between the higher elevations of the Absarokas and the plains, as Dead Indian Creek is a tributary to the Clark's Fork of the Yellowstone. The site also sits in between the major high elevation plateaus of the Beartooths and the Absarokas, in a region about which, archaeologically, we know relatively little (Figure 3). George Frison led initial excavations of this open-air site from 1969 to 1972 (Frison and Walker 1984; Smith 1970). This work recovered 566 projectile points and three radiocarbon dates (4,430 ± 250, 4,180 ± 250, and 3,800 ± 110 BP) that solidly place the site's most extensive occupation in the Middle Archaic, with a median two sigma calibrated age of 4,725 ± 835 cal BP. In 1985, the Office of the Wyoming State Archaeologist revisited the site in relation to road works on the Clark's Fork Road (Ingbar et al. 1986). A single radiocarbon date from their Unit C dated to the Early Archaic (5,470 ± 130 BP), with a two sigma calibrated age of 6,223 ± 287 cal BP. We calibrated all dates discussed here using the IntCal13 curve (Reimer et al. 2013) and the software OxCal, version 4.3 (Bronk Ramsey 2009). There are also Late Archaic and Late Prehistoric components of this site, judging by the projectile point morphology, but we did not include those points in this paper's analysis as we do not currently have radiocarbon dates for those levels. The postcranial remains of a child and a possible pit house structure also make this site notable in local archaeology. The faunal remains suggest its Middle Archaic occupation was at least partially a winter camp (Fisher 1984; Smith 1970).

Pagoda Creek (48PA853) is a well-stratified open-air site on the south bank of the North Fork of the Shoshone River, downstream from Mummy Cave (Cannon 2017). The Office of the Wyoming State Archaeologist oversaw the initial excavations at the site in 1985 (Eakin 1989). It contains two primary occupation levels, with approximately 20 cm of separation between the two. Both levels are Late Archaic; bone re-dated in 2017 revealed the upper level dates to approximately 2,750 cal BP (2595 ± 15, 2645 ± 15, and 2600 ± 15 BP), and the lower level to approximately 2,775 cal BP (2675 ± 20, 2690 ± 15, and 2680 ± 15 BP). The faunal remains from the site are mostly bighorn sheep, and those in the lower level, in particular, indicate it was a winter occupation gently buried by overbank flooding episodes (Eakin 1989). Pagoda Creek contributed just eight points to the sample, but having eight additional solidly-dated Late Archaic points helps expand sample sizes for this period, which is otherwise predominantly represented by Mummy Cave artifacts.

Alm Shelter (48BH3457) is on the eastern edge of the Bighorn Basin at 1,570 m asl, near the mouth of Paint Rock Canyon. The site is a stratified rockshelter, and excavations there under Robert Kelly have uncovered two to three meters of deposits covering the past 13,000 years (Craib and Kelly 2019; Ostahowski and Kelly 2014). The excavations began in 2005 and have continued intermittently through 2018 (Robert Kelly, personal communication 2019). Twenty-five radiocarbon dates provide clear chronology for the site, and it includes 34 projectile points from the Paleoindian through the Late Prehistoric used in this analysis. For the dates affiliated with these artifacts, we used a time-depth model developed for Alm Shelter by Spencer Pelton.

The total number of points included in our sample from these stratified sites, which are all affiliated with radiocarbon dates, is 659. For additional data on the chronological periods to which these points belong, see Table 1. Middle Archaic points are overrepresented because of the large quantity of projectile points from Dead Indian Creek, an abundance that is not matched at any of the other sites. We have measurements for a total of 704 points, but 36 of those did not have proveniences clearly associated with radiocarbon dates, so we did not include them in this analysis.

We compare the data from the stratified sites discussed above with data on high elevation points from the Beartooth Mountains, much of which comes from the Vernon Waples Collection, which is currently held at the Billings Curation Center in Billings, Montana. Waples spent over thirty years, from the 1950s through the 1970s, serving in the Absaroka-Beartooth Wilderness as a game warden for the state of Montana. During his service and before, he systematically collected more than 2,000 artifacts from Southwestern Montana, many of them from above 2,500 m asl in the Beartooths. The collection also includes artifacts collected by other local families that Waples bought or otherwise acquired over the years. Wilfred Husted worked extensively with Waples while he was alive to record proveniences for the points as accurately as possible, a painstaking and time-consuming project (Husted 1990, 1991, 1992a, 1992b). Husted was also responsible for brokering the return of the artifact collection to federal curation alongside Custer-Gallatin National Forest archaeologists Halcyon LaPoint and Mike Bergstrom. During the summer of 2015, Reckin spent several weeks measuring and photographing all projectile points from this collection. In total, there are 437 points from the Beartooths to which Reckin assigned chronological periods using the key, including points from the Waples Collection and those recorded with additional fieldwork.

TABLE 1

SAMPLE SIZES OF PROJECTILE POINTS USED IN THIS ANALYSIS AFFILIATED WITH THE FIVE MAJOR PERIODS OF ROCKY MOUNTAINS/PLAINS PREHISTORY

	Stratified Sites	Absarokas	Beartooths
Late Prehistoric	86	468	136
Late Archaic	36	271	109
Middle Archaic	464	74	105
Early Archaic	45	64	74
Paleoindian	28	27	13
Totals	659	904	437

For a comparative sample of high elevation projectile points from the Absaroka Mountains, we rely on data from the Greybull River Sustainable Landscape Ecology project. From 2002 to 2017, Lawrence Todd, alongside students and other project archaeologists, has gathered archaeological data in the Absarokas (Todd 2015, 2019). The project relies on an off-site landscape archaeological approach (Dunnell 1992; Foley 1981), meaning that we record every artifact individually wherever possible rather than relying on site-based recording techniques. The vast majority of what the GRSLE project records are lithic artifacts, from tiny retouch flakes to formal tools. Currently, the database contains over 170,000 artifacts, 4,957 of which are formal tools. We use a total of 904 points from the GRSLE record for comparative purposes here. Quantities of these comparative points for both the Beartooths and the Absarokas are included in Table 1.

Methods

Unsurprisingly, not all archaeologists agree, even informally, on the precise dates of specific artifact types in the Plains Typology (Eighmy and LaBelle 1996). There is general agreement among modern Plains archaeologists, though, about the broader time periods that have now become known as the Late Prehistoric, Late Archaic, Middle Archaic, Early Archaic, and Paleoindian (Figure 3). Even in Figure 3 when Metcalf (1987) appears to disagree with Frison and Mulloy by only showing the Early and Late Archaic, what he is demarcating as the McKean style includes what other archaeologists have come to label the Middle Archaic. For our analysis, therefore, we began by dividing the Holocene into five time periods (Figure 3), based on a conglomerate of different typologies including those mentioned above as well as Eighmy and LaBelle (1996), Foor (1985), Kornfeld et al. (2010), and Reeves (1969).

Ultimately, however, we refine the temporal divisions shown in Figure 3 further using the radiocarbon dates affiliated with shifts in projectile point style within the stratified collections analyzed here. Binning data whose variation is continuous into finite categories, like time periods, must always be undertaken carefully because it has the potential to distort meaningful patterning. In this case, each division into a different time period is marked by a distinct shift in projectile point style (Figure 2). From the Paleoindian to the Early Archaic, points shift from lanceolate and stemmed to large side or corner-notched. From the Early Archaic to the Middle Archaic, points shift again to smaller lanceolate and stemmed points, and occasionally side- and corner-notched points, most with deeply concave bases. During the Late Archaic, points are mostly corner-notched and occasionally side-notched, with sharp shoulders and a straight base. The Late Prehistoric denotes the most significant shift, as the introduction of the bow and arrow into the region means points became much smaller and thinner overall.

We choose to execute this particular typology as a dichotomous key because it is visual, and follows the essential thought process lithic analysts intuitively undergo as we type a point. It must be said that this key is not strictly dichotomous, but polytomous, because it occasionally has more than two leads. Dichotomous keys arise predominantly from biology, allowing botanists to determine the species of a plant, or ornithologists to classify a bird. Using such keys to determine chronological types is relatively uncommon in lithic analysis. David Hurst Thomas's Monitor Valley typology (1981), based on the highly-stratified Gatecliff Shelter (26NY301) and intended for use in the Great Basin, is a notable exception. This rarity is likely because dichotomous keys can seem simplistic, and we know that lithic variation is anything but simple. Studies using 3-D scanning and geometric morphometrics to document morphological variation are becoming more and more popular (e.g. Bretzke and Conard 2012; Cardillo 2010; Grosman et al. 2008; Shott and Trail 2010), but do not fulfill the requirements of this study thanks to their reliance on relatively complex equipment. As 3-D scanners become simpler, smaller, and more easily used in the field, they may become more appropriate for use in remote field archaeology. Yet there is also something to be said for straightforward analysis that requires no more complex or expensive equipment than a set of calipers and a scale.

Limitations and potential biases of typological dating

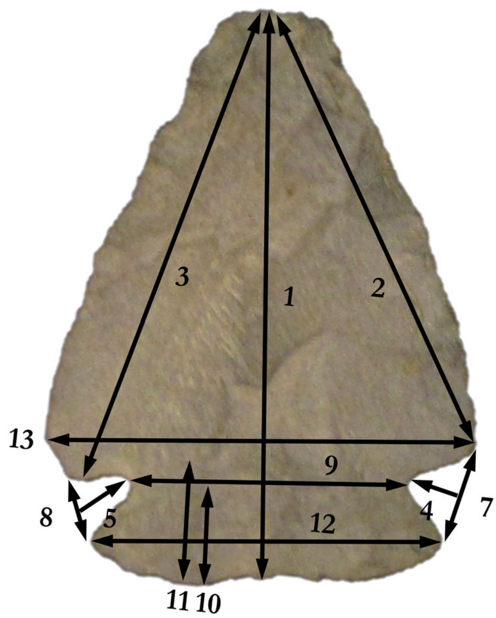
Dating an artifact using morphology alone is certainly not without pitfalls. Studies have shown that different lithic analysts and pottery specialists type and describe the same artifacts differently when empirically tested (Beck and Jones 1989; Fish 1978; Gnaden and Holdaway 2000; Whittaker et al. 1998). We were concerned about such individual researcher bias in our analysis; Todd typed many of the points from the Absarokas in the GRSLE database and Reckin typed all of the points from the Beartooths. If we were not typing points consistently and accurately, it could cause significant skewing in our data. Therefore we measured and typed the points from the stratified collections together, testing ourselves against the radiocarbon dates. We could not determine a type for 28.2% ($n = 186$ of 659) of the points we initially measured, most of which were distal portions or tips of points. Of the remaining 473 that we did type, we were correct when checked against the radiocarbon dates 97.3% of the time ($n = 460$ of 473). We were also able to confirm informally that between the two of us, we were typing the points consistently.

Issues like resharpening, hafting, and impact fracture can cause points to fall into several different supposed typological categories through their uselife alone, a phenomenon commonly referred to as the Frison Effect (Flenniken and Raymond 1986; Frison 1968). Using only artifacts with affiliated absolute dates counteracts this problem. None of the points used to create this key were typologically dated. For example, even if a resharpened Early Archaic point in the collections resembled a Late Archaic point morphologically, we still could confirm that it was Early Archaic because of its affiliated radiocarbon date. In addition, the key focuses on measurements and attributes of the base of the point, its hafted portion. Logically, these portions of the point will change less with resharpening and rehafting, while the blade of the point is more likely to break and dull (Binford 1963; Close 1978; Meltzer 1981; Sackett 1986). Studies have also found that haft elements are more consistently diagnostic than blades (Bacon 1977; Corliss 1972). In addition, raw materials can cause points to differ significantly in size and shape – the knapper may not have been able to achieve an ideal shape and size thanks to difficult raw material (Andrefsky 1994; Goodyear 1979; Proffitt and de la Torre 2014). Skill may also play a role in final execution (Bamforth and Finlay 2008). The best way to avoid significant skew in the data from these factors is in robust sample sizes and observation of especially problematic raw materials. In this particular region, quartzites, volcanics, and petrified woods of varying qualities are most likely to complicate a flintknapper's execution of his or her vision. Yet among the stratified collections, we typed the quartzite points correctly, according to the radiocarbon dates, just as frequently as the others.

Selecting attributes for analysis

In selecting the attributes we used to create the key, we were once again considering its specific intended use. In general, much of current research in the GYE falls under an ethos of wilderness archaeology, meaning we leave as many artifacts in situ as possible. This is partially thanks to consultation with the United States Forest Service, National Park Service, and local tribes, and partly from a desire to leave as much of the archaeological landscape intact as possible. We only collect artifacts that are in particular danger of illegal collection or loss, or those we plan to subject to obsidian sourcing or other specific testing. Todd has collected geographic and attribute data on more than 1,000 projectile points through the GRSLE archaeology project in the Absarokas since 2002, many of which are still in the field. To be able to use this key to consider that trove of data, we had to ensure that the measurements and observations upon which the key is based were compatible with the GRSLE database. We also relied on personal experience with the practicalities of gathering surface measurements in the field, including considerations of consistency and equipment. To this end, we combined Todd's original measurement process for the Absarokas points (e.g. Burnett 2005) with attributes primarily from Andrefsky (1998) and Thomas (1970, 1981) (Figure 4).

Generally speaking, haft elements are not just more reliably diagnostic, they are also more consistently available on broken points. Among the surface collections for which we are designing this key, few of the points are complete. This means that measurements based on total length or blade length are often impossible (Titmus and Woods 1986). Even within the Waples Collection, a set of artifacts that were likely curated partially for their completeness, just 61.9% of the projectile points (*n* = 376 of 607) are complete. Yet many of Thomas's (1981) defining attributes for his Great Basin dichotomous key either require that the point is complete, or are difficult for less skilled fieldworkers to measure. For example, angle measurements – of notches, in particular – are notoriously difficult to replicate (Benfer and Benfer 1981; Dibble and Bernard 1980; Gunn 1981). Neck widths, on the other hand, are consistently preserved, and relatively easy to measure (Corliss 1972; Fawcett 1998; Fawcett and Kornfeld 1980; Thomas 1978). Thanks to issues of incompleteness, the key also does not rely on weight, which is least susceptible to measurement error but uninformative on fragmentary points. Measurements like neck width, base width, and neck height are much more consistent. Every point has a measurement for maximum thickness, maximum length, and maximum width, though the maximum length and maximum width measurements are



1 Axial Length
2 Blade Length 1
3 Blade Length 2
4 Notch Depth 1
5 Notch Depth 2
6 Notch Depth 3 (basal)
7 Shoulder to Corner 1
8 Shoulder to Corner 2
9 Neck Width
10 Neck Height
11 Haft Height
12 Base Width
13 Blade Width (often also Max Width)

FIGURE 4 Graphic demonstrating attributes measured on each point, not including qualitative categories like side-notched, corner-notched or stemmed. Please note that Neck Height and Haft Height are measured from the furthest extent of the point's base, not necessarily from its center point.

unhelpful diagnostically for points that are incomplete. Sample sizes for particular categories of points also decrease because we could not always obtain all of the relevant metrics on each point. If the base was broken, for example, we would be unable to obtain neck widths or base widths. Therefore, sample sizes in the Results section often reference the total number of points from which the relevant metric could be gathered, not the total number in that category overall. Ultimately, Figure 4 shows the measurements we collected.

In terms of qualitative, descriptive attributes, we rely on initial designations of the points as lanceolate, side-notched, corner-notched, or stemmed (Figure 2). Yet these categories clearly grade into one another, and there are points that exist right on the cusp of two or more categories. The difference between side-notched and corner-notched points in this key involves the angle of the shoulder (or the top of the notch). If it is 90 degrees or greater, as considered against a straight line running down the axis of the point, then it is side-notched. If it is less than 90, it is corner-notched (Figure 5). This is a general guideline and not a specific measurement because of the uncertainties of angle measurements discussed above. Thanks to the muddiness of attributes like this one, we tried to ensure that analysts would still end up ultimately placing a point in the correct category even if one person called it side-notched and another called it corner-notched. Building this kind of fail-safe into the key is most challenging with the more qualitative descriptions of certain attributes, such as the concavity of the point's base (Figure 6) or the prominence of its shoulders (Figure 7). To identify Paleoindian points, the key requires that analysts

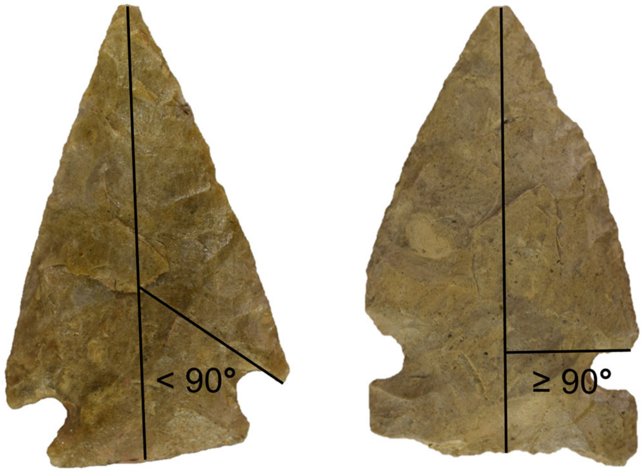


FIGURE 5 Graphic demonstrating the method used to distinguish between corner and side-notched points. Photos by Reckin.

FIGURE 6 A sample of points from the stratified collections to illustrate the way this key considers degrees and types of basal concavity. The top row includes, from left to right, a point with a notched base, an eared base, and a deeply concave base. The bottom row includes three points with slightly concave bases.

FIGURE 7 A sample of Late Archaic points from the stratified collections with sharp, prominent and/or barbed shoulders.

identify attributes like basal grinding, parallel flaking, lenticular cross-section and fluting. Definitions for these attributes can be found in Andrefsky (1998). We should note, as well, that many of the Middle Archaic points are lanceolate with no notching or shouldering, making it difficult to gather metrics on their bases.

Results

We systematically compared groups of points from the five established Holocene time periods to one another, focusing first on the difference between Late Prehistoric points, which are arrow points, and all other time periods, which likely represent atlatl dart or spear points. Figure 8 contains box plots of neck width and maximum thickness, demonstrating the variation in each time period. We determined first that 84.1% ($n = 69$ of 82) of Late Prehistoric points have neck widths ≤ 11 mm and maximum thicknesses ≤ 4 mm. In the meantime, just 1.7% ($n = 5$ of 298) of points with measurable neck widths from all other periods fall into that category (Figure 9). Therefore this combination of measurements consistently differentiates the Late Prehistoric from all other periods. Interestingly, all five points that do overlap with the Late Prehistoric on these attributes are Middle Archaic. Indeed, Middle Archaic points have by far the greatest range in size (Figure 9).

No single measurement consistently differentiated among the periods of the Archaic, or between those periods and the Paleoindian. For that reason, this portion of the key becomes more qualitative, relying first on broad differentiations of point outline, including lanceolate, side-notched, corner-notched, and shouldered or stemmed. Early Archaic and Middle Archaic points had the most variance in

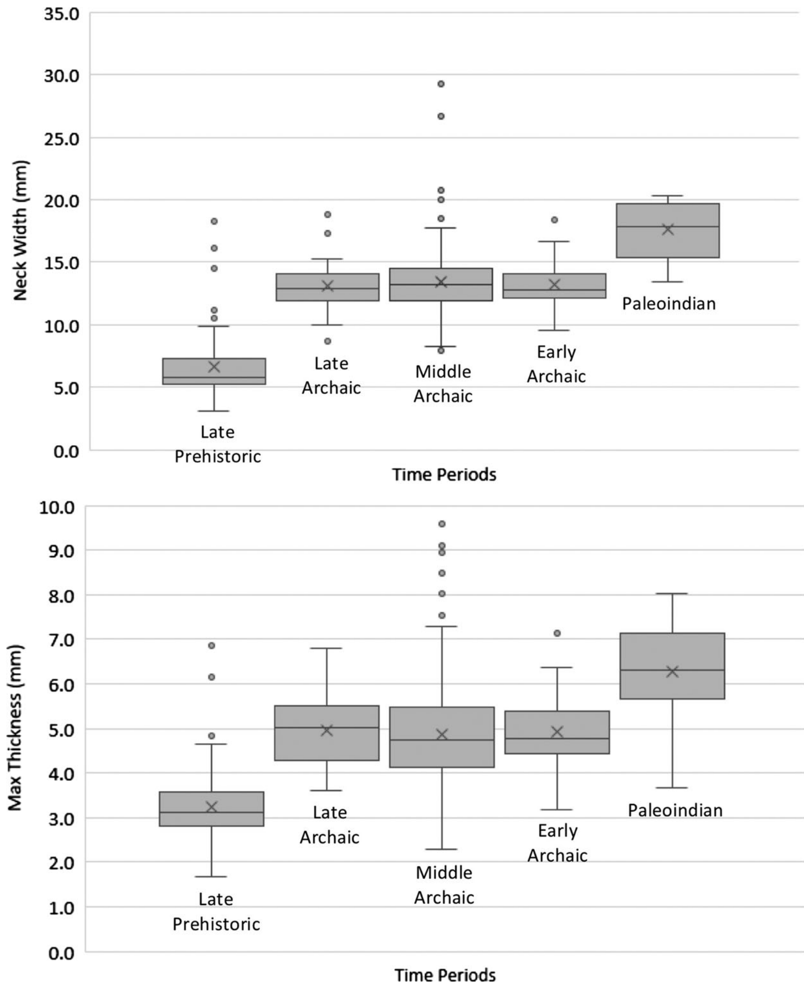


FIGURE 8 Box plots demonstrating variation in neck width and max thickness among the projectile points from the stratified collections by periods of prehistory. Figure 8 brings these two attributes together to demonstrate further how the Late Prehistoric differs from all other periods.

shape, including side-notched, corner-notched and stemmed. We categorized all of the Late Archaic points as corner-notched, but side-notched Late Archaic points are known in the region more broadly, and so are included in the key (e.g. Davis and Zeier 1978; Hughes 1981). We also wanted to ensure, again, that different readings of the qualitative attributes, like corner versus side notching, could still key out correctly. If, in this instance, all Late Archaic corner-notched points were described as side-notched, for example, 94.2% ($n = 33$ of 35) of those with measurable attributes would still key out as Late Archaic.

We were able to describe points that we categorized as stemmed quantitatively as those with a ratio of base width to neck height ≤ 2.20. Eighty-six percent ($n = 37$ of 43) shared this characteristic, whether they dated to the Middle Archaic, Early

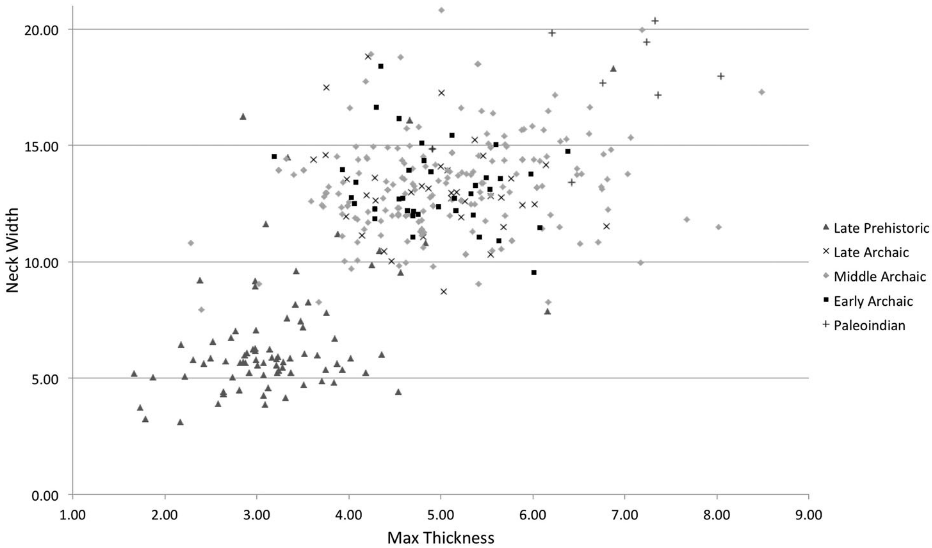


FIGURE 9 All points whose neck width could be measured from the stratified collections, plotted with max thickness. Late Prehistoric points generally cluster in the lower left of the chart.

Archaic or Paleoindian. However, 48.2% ($n = 98$ of 203) of measurable points we categorized as side-notched and corner-notched also shared this characteristic, so stemmed points are still qualitatively categorized (Figure 10). These data suggest that the most effective quantitative way to categorize stemmed points would be with ratio of axial length to neck height, but this measurement requires consistently complete points.

The only other category of point that was numerically distinct from its fellows was side-notched Early Archaic points (Figure 11). Among these, 73.9% ($n = 17$ of 23)

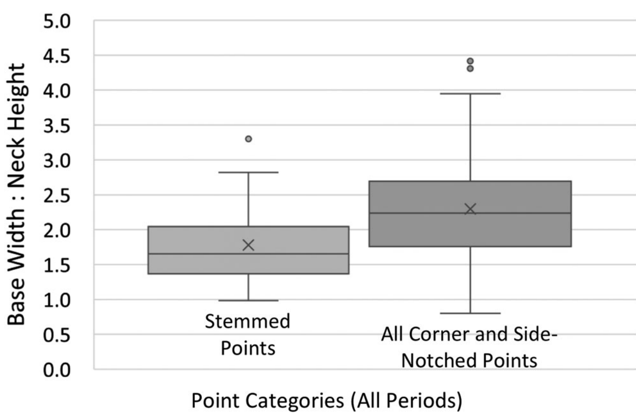


FIGURE 10 Box plot showing the variation of the ratio of base width to neck height in stemmed points versus all other corner and side-notched points among the stratified collections. The overlap between these qualitative categories is clear.

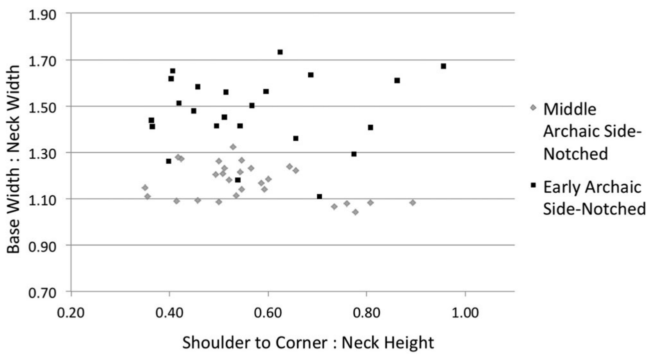


FIGURE 11 Chart of Archaic side-notched points, including ratios of shoulder to corner to neck height and base width to neck width.

have a ratio of base width to neck width ≥ 1.25 and a ratio of shoulder-to-corner to neck height of ≤ 0.70. In the current sample, 17.8% ($n = 5$ of 28) of side-notched Middle Archaic points shared these characteristics. These sample sizes are not as robust and the patterns not as clear as we would prefer, and further analysis is needed to refine our differentiation of Early Archaic side-notched points from other Archaic side-notched varieties.

Overall, this key accounts for the variability in 96.4% ($n = 635$ of 659) of the points we measured from stratified collections. Even presuming catastrophic misreading of some of the qualitative attributes, the key is markedly successful. If, for example, the Middle Archaic stemmed points are categorized as corner-notched, they would still key out as Middle Archaic. As it stands, the most significant weaknesses involve the Early Archaic. Currently, this key would misattribute 20% ($n = 9$ of 45) of the Early Archaic points as Middle Archaic (Figure 11). We also simply do not have enough data to differentiate more fully between Early Archaic and Late Archaic corner-notched points at this juncture, leaving the qualitative attribute of prominent, sharp, and/or barbed shoulders vulnerable to misattribution. Figure 12 shows five corner-notched Early Archaic points currently in the dataset, demonstrating the morphological variation they display. Projectile point 48PA201-2156, in particular, lies outside this key entirely. Finally, the quantitative measures used to differentiate Early Archaic side-notched points from Middle and Late Archaic are based on relatively small sample sizes, meaning those results should be treated with caution.

Typing the Waples collection

Using this key, Reckin assigned all typable points in the Waples Collection and some additional points measured during fieldwork in the Beartooths to one of the five broad temporal categories of the Holocene. There were occasional moments where the key's parameters felt unsatisfactory while considering a particular point, but the key successfully accounted for the vast majority of the variation in the collection. Because the Waples Collection is without absolute dates, it is impossible to determine whether the key is typing every point chronologically correctly. But

FIGURE 12 Corner-notched Early Archaic points, all from Mummy Cave (48PA201). From left to right, they are 1851, 1452, 1449, 1812 and 2156. Some of these points could also be categorized as stemmed; either way, all but 1812 fall outside the key. Photos by Todd.

we could test the key's results against those of other long-serving local archaeologists, including Wilfred Husted and Forest Service Archaeologists Halcyon LaPoint and Mike Bergstrom. They had typed 107 Waples points for a museum display in the early 2000s. Reckin typed those same points using the key without referencing their notes, and checked the results against theirs after completing the analysis. Reckin agreed with Husted, LaPoint and Bergstrom on 93% of the point types ($n = 100$ of 107).

Having these collections also offers the opportunity to compare the stratified material to the variation from the Beartooths, in the Waples Collection, and the Absarokas, in the GRSLE database. We are, however, limited in our ability to compare morphological groups from the Absarokas, like side-notched, corner-notched, or stemmed, because the pre-2017 GRSLE database does not include these attributes. Generally, an examination of the Beartooths, in particular, demonstrates much broader variation than we see in the stratified collections. Specifically, there are point types represented that suggest cultural connections with the Northern Plains and the Pacific Northwest. It is important to note, however, that the sample of material from the stratified collections is purposefully limited to just four sites, so perhaps it is unsurprising that those four sites have relatively limited variation. The Beartooths sample, in the meantime, covers an area of approximately 4,000 km^2 and dozens of individual sites.

When considering the Late Prehistoric, for example, we can see that the two defining characteristics that differentiate the Late Prehistoric from all other periods – neck width and maximum thickness – actually differ between the three collections (Figure 13). All of the points typed as Late Prehistoric from the Beartooths fall within the boundaries of the key. None, that is, had neck widths $\geq$11 mm *and* maximum thickness $\geq$ 4 mm. However, 26.4% ($n = 34$ of 129) had maximum thicknesses $\geq$ 4 mm. Three even had maximum thicknesses $\geq$ 5 mm (Figure 13). Their general morphology and narrow neck widths argue convincingly that they are Late Prehistoric, but as Figure 13 shows, Late Prehistoric points in the Beartooths are generally more robust in terms of both neck widths and thicknesses. Raw material is likely playing a role; among the Late Prehistoric points made of quartzite, basalt/dacite or petrified wood ($n = 14$) mean maximum thickness is

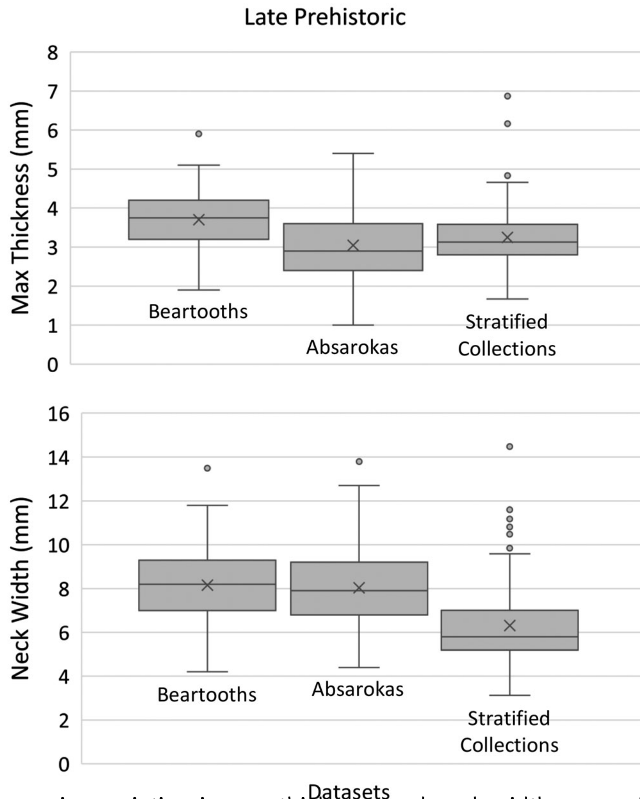


FIGURE 13 Comparing variation in max thickness and neck width among Late Prehistoric points from the Beartooths, Absarokas and the stratified collections.

4.2 mm ($\sigma = 0.4$). Meanwhile, among those made of chert, chalcedony, porcellanite, or obsidian ($n = 114$), mean maximum thickness is 3.6 mm ($\sigma = 0.7$). These mean maximum thickness values differ significantly (unpaired t test: $t = -3.14$, df = 126, $p = 0.002$). Mean neck width between the two samples is virtually identical; it is 8.2 mm ($\sigma = 1.8$) among the quartzite, basalt, and petrified wood sample, and 8.2 mm ($\sigma = 1.7$) among the chert, chalcedony, porcellanite, and obsidian. Raw material seems, therefore, to impact thickness of Late Prehistoric projectile points in the Beartooths collection more than neck width.

The much lower mean and median neck widths among the stratified collections are due to the extremely narrow necks of the corner-notched points in Level 3 of Mummy Cave (48PA201) in particular (Figure 14). In Wilfred Husted's published stratigraphic labeling system for Mummy Cave, these levels were numbered with the uppermost as Level 38 and the deepest as Level 1 (Husted and Edgar 2002). Harold McCracken, on the other hand, originally labeled the layers from the top down (McCracken 1978). We use the McCracken labels here as they have been used in the most recent publications on the site (Hughes 1998, 2003). McCracken Level 3 (Husted Level 36) dates to early in the Late Prehistoric, at approximately 1,100 cal BP, and 62 of the 86 Late Prehistoric points measured overall come from Level 3 of Mummy Cave. Their mean neck width is 5.4 mm ($\sigma = 0.9$).

FIGURE 14 Examples of Late Prehistoric corner-notched points from Level 3 at Mummy Cave (48PA201), demonstrating their particularly narrow neck widths. Many are also markedly serrated. Photos by Todd.

Many of these points are complete, or nearly complete, and are extremely well-made, some with serrated edges (Figure 14). Among the side-notched points, mostly from Levels 1 and 2 (Husted Levels 38 and 37 respectively) of Mummy Cave ($n = 19$), mean neck width is much higher, at 8.7 mm ($\sigma = 1.7$). The difference in neck width between these corner-notched Level 3 points and the side-notched points from Levels 1 and 2 is statistically significant (unpaired t test: $t = 11.11$, df $= 79$, $p < 0.0001$). This comparison excludes small triangular points with no measurable neck width, commonly called Cottonwood points. Levels 1 and 2 date to approximately 410 cal BP and 770 cal BP respectively.

Corner-notched Late Prehistoric points from the Beartooths also have smaller neck widths than the average overall, but those neck widths are not as small as among the stratified collections, and the corner-notched points do not make up as high a proportion of the points. The mean neck width just among corner-notched points in the Beartooths ($n = 52$) is 7.5 mm ($\sigma = 1.7$). When compared with the corner-notched Late Prehistoric points from the stratified collections, the difference is significant (unpaired t test: $t = 8.43$, df $= 112$, $p < 0.0001$). Once again, Beartooths Late Prehistoric points prove more robust than like items from the stratified collections.

The most significant source of variation in the Late Archaic between the Beartooths and the stratified collections is in the proportion of corner-notched and side-notched points. There are no side-notched Late Archaic points in the stratified collections. However, Late Archaic side-notched points are well-documented in Montana and Wyoming more broadly, and Besant points specifically are considered a Northern Plains type, stretching north into Alberta (e.g. Davis and Zeier 1978; Hughes 1981; Larson 2001). In the Beartooths collection, 29.5% ($n = 31$ of 105) of the Late Archaic points are side-notched (Figure 15).

In the Middle Archaic sample, the Beartooths contain substantially more stemmed points than the stratified collections. Most of the Middle Archaic points from the stratified sample come from Dead Indian Creek (48PA551), and this site alone

FIGURE 15 Examples of Beartooths Late Archaic side-notched points. Photos by Reckin.

contains a great deal of variation, from truly lanceolate points, with parallel sides, to side-notched points with deeply-indented bases and fully stemmed points. Overall, just 16.4% ($n = 76$ of 464) of Middle Archaic points in the stratified collections are stemmed. In the Beartooths, stemmed points with deeply-indented expanding bases are common (Figure 16); indeed, stemmed points in general make up 60%

FIGURE 16 Examples of Hanna/Duncan-style Middle Archaic stemmed points from the Beartooths. The two photos on the right were taken by Halcyon LaPoint and Mike Bergstrom. Photo on the left by Reckin.

of the Middle Archaic sample ($n = 61$ of 102). Such points are commonly referred to as Hanna or Duncan points, though these types are not particularly well-defined. They occur well north into British Columbia, and are considered part of both Plains and Pacific Northwestern chronologies (Frison 1998; Magne and Matson 2008; Rousseau 2004; Wheeler 1954).

In typing the Beartooths projectile points, the only points that caused deviation from the recommendation of the key are likely Early Archaic. In nine cases, Reckin typed side-notched points as Early Archaic that the key, if strictly followed, would have typed as Late Archaic. The key calls for the ratio of base width to neck width among Early Archaic points to be ≥ 1.25. Among 23 measurable side-notched Early Archaic points from the Beartooths, the mean base width to neck width ratio is 1.32 ($\sigma = 0.1$), and nine of the points fall beneath 1.25. Given that the ratio of base width to neck width is essentially measuring the depth of the notches relative to the base, these points simply have shallower notches than those in the stratified collections ($n = 27$), where the mean ratio is 1.47 ($\sigma = 0.2$). The difference between these mean base width to neck width ratios for the Beartooths and the stratified collections is significant (unpaired t test: $t = 3.26$, df = 48, $p = 0.002$). However, their general size and morphology, including straight bases and rounded corners, suggest strongly that

FIGURE 17 Early Archaic points from the Beartooths. All of the points pictured technically lie outside the key; the top four have ratios of base width to neck width that do not match the key, and the bottom point is morphologically similar to Cascade points. Halcyon LaPoint and Mike Bergstrom took the three photos on the top right. Remaining photos are by Reckin.

the Beartooths points are Early Archaic (Greiser 1984) (Figure 17). We hesitate to modify the key based on these points because they are not absolutely dated, however these discrepancies further suggest that the key will require ongoing updates, and may not always account for idiosyncratic variation in particular areas or even specific sites. The example of these Beartooths points emphasizes the way we expect archaeologists to use the key: following its steps to type a point or points, but also relying on regional knowledge and expertise to acknowledge when the key may not account for variation. This example also clearly demonstrates the ability of the key to highlight similarities and differences between a particular assemblage – in this case, the Beartooths – and the wider region.

The Beartooths sample also includes a single large, leaf-shaped point that tapers on each end, which most closely resembles a Cascade point (Figure 17). Cascade points are traditionally affiliated with Oregon, Washington, and Idaho, stretching north into British Columbia, and are generally dated to the Early Archaic (e.g. Ames et al. 1998; Browman and Munsell 1969; Smith et al. 2012). This point falls well outside the dichotomous key, but we included it in the Early Archaic sample because of its morphological consistency with Cascade points, which are known farther north and west in Montana, and have been reported occasionally in Yellowstone National Park itself (Hale 2003; Taylor et al. 1964).

Conclusions and future directions

We do not consider this key a static, "finished" document – it is a work in progress which we hope to further refine with additional collections research into sites local to the Absarokas, Beartooths, and the Bighorn Basin. Medicine Lodge Creek (48BH499), a very large, stratified site in the foothills of the Bighorns, would provide another extended sequence to the sample (Frison 1976; Frison and Wilson 1975). Bugas-Holding (48PA563), in the Sunlight Basin relatively near Dead Indian Creek, would be another important site to increase our sample of Late Prehistoric material (Rapson 1990; Todd and Rapson 1988). The Helen Lookingbill site (48FR308), with its important Paleoindian component, would provide important context to the southern Absarokas as well (Kornfeld et al. 2001). We also hope to test the key in terms of its consistency between practitioners. If we give individual archaeologists the same set of artifacts, can those archaeologists use the key to consistently type those artifacts? In addition, the key should be tested on sites with increasing distance from its current core. How well does it function on sites further north in Montana, south into Wyoming or west into Idaho? A larger database of projectile points with affiliated absolute dates may also allow the key to become more chronologically specific. We simply do not have the data, currently, to say that we can differentiate consistently between sub-types. More data may allow the key to become more quantitative in general, though the extraordinary variety among Archaic points in the current database suggests this will continue to be difficult.

Having a model like this against which to test collections further afield may also provide a metric for stone tool variation in the region at large. Spatial variations in material technology can give us a sense of prehistoric cultural interactions. If the key is successful at predicting artifact morphology in sites 400 km to the north, for example, but only 200 km to the south, that may give us some sense of the spread of prehistoric variation. It may also give a sense of diachronic cultural shifts. If the key does well describing the variation in Late Archaic points from a site in central Idaho, for example, but at the same site the Middle Archaic points differ substantively from what is accounted for in the key, perhaps that suggests there were closer ties between the GYE and central Idaho during the Late Archaic than during the Middle Archaic.

Broadly, this key provides an update of Thomas's (1981) morphological classification method, designed to take chronological typologies for surface archaeology forward. So long as typologies like this one are designed and used for specific research questions and geographic areas, they can serve as a unifying mechanism for typing artifacts chronologically. Rather than relying on the assumption that regional archaeologists all approach projectile points in the same way, in this case according to some version of the Plains Typology, we can utilize an evidence-based model to categorize artifacts. The other great strength of this method is its ability to highlight areas of uncertainty in our typological knowledge, and to demonstrate the varieties of points that are currently outliers. In this case, the Early Archaic is clearly a period of immense, fascinating variation. Future research can now focus on those fuzzy areas, and continue to refine our understanding of regional chronological variation. Surface archaeologists around the world are preoccupied with typological dating because it is the best, and often the only, available option. Methods like this one provide a concrete way forward, working to standardize typology rather than relying on a presumed consensus among practitioners.

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