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The Nelson stone tool cache, North-Central Ohio, U.S.A.: Assessing its cultural affiliation

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ABSTRACT

The Nelson stone tool cache was discovered in 2008 in Mount Vernon, Ohio. The cache does not include any diagnostic materials, and independent age control is unavailable. Although aspects of its 164 bifaces are suggestive of a Clovis affiliation – including the occasional occurrence of unmistakable flute scars – nearly all are in the early- to mid-stages of production, there are no definitive finished Clovis fluted points that would make it possible to assign the cache to that time period. To ascertain its cultural affiliation, we undertook a detailed qualitative and quantitative comparison of the Nelson cache bifaces with ones known to be both Clovis and post-Clovis in age. We also conducted geochemical sourcing, ochre analyses, and microwear analysis to understand the context of the cache, regardless of its age and cultural affinity. By some key measures it is consistent with Clovis caches in this region and elsewhere, but the case remains unproven. Nonetheless, if the Nelson cache is from the Clovis period, it is significant that most of its bifaces appear to be made on large flakes, in keeping with Clovis technology in the Lower Great Lakes, and an economically conservative, risk-mitigating strategy that conforms to predictions of human foragers colonizing the area in late Pleistocene times.

1. Introduction

A cache is a collection of materials or tools in useful condition that appear to have been set aside for future use (Huckell and Kilby, 2014:1). This utilitarian definition distinguishes caches from other collections of items that have been buried with no intent for future retrieval, for example in certain ritual or mortuary purposes (Kornfeld et al., 1990). Based on ethnographic, ethnoarchaeological, and archaeological research, caches have been categorized in several ways depending on their observed or inferred purpose(s). Some are considered to have had

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utilitarian or ritual purposes (or both); been stashed for specific seasons, or year round access; been intended for individuals or communities; and can contain a variety of resources, such as bone, meat, and stone – the latter in different forms, from raw material to finished products (Binford, 1979, 1980; Frison and Todd, 1986; Kilby, 2014; Thomas, 1985).

Caches of all types have been found across North America, and from the Late Pleistocene to Historic periods (e.g. Kilby, 2008; McKnight, 2007; Scott et al., 1986; Singleton, 1995). When the contents of these caches yield remains that can be chronometrically dated or exhibit diagnostic artifacts, such as finished stone projectile points or particular raw materials (e.g. copper), identifying their age and cultural affiliation becomes a fairly routine procedure. However, caches may yield a collection of artifacts that cannot be directly dated, or are not culturally or temporally diagnostic, e.g. a set of unfinished stone tools. In such cases, it may never be possible to *conclusively* demonstrate a cache's cultural affinity. Nonetheless, and as we have previously argued (Eren et al., 2018a, 2021), a strong *inferential* case can be made by conducting a careful and detailed comparison of the unknown stone tool cache to caches of known age and cultural affiliation. Such a comparison should be done using multiple lines of evidence, technological and otherwise, and analytical tools such as geometric morphometrics, calculations of flake scar density, and flake type frequency (Eren et al., 2015, 2018a). The inference can be strengthened by demonstrating the occurrence of attributes (if any) that belong only to a particular culture, and whether on an individual attribute basis or at the assemblage level, and which tend to appear more frequently and significantly in one culture as opposed to another (Lycett, 2015, 2017; Lycett and Cramon-Taubadel, 2015; Maguire et al., 2018; Norris et al., 2019). We define "culture," following Mesoudi (2011), as "socially transmitted information," and thus *a* culture as a group of agents who socially transmit information to each other.

We undertook such an effort with the recently discovered Nelson biface cache (Fig. 1) recovered in north-central Ohio (Knox County). Although the cache lacks independent age control, aspects of it are suggestive of artifacts from the Clovis Paleoindian period, including the occurrence of unmistakable flute scars. Yet, nearly all the Nelson specimens are early- to mid-stage bifaces, making their affiliation more ambiguous. Also complicating their assignment to Clovis is the fact that the form and technology of Clovis bifaces in the eastern woodlands differs in a few important respects from those found in western North America, and especially in comparison with the oversized and remarkably well-fashioned bifaces from a number of the western North American Clovis caches (where virtually all Clovis caches have been found, including Anzick, East Wenatchee, Fenn, and Simon). Nelson does not look like these iconic caches. Likewise, several of its attributes that appear to be diagnostic of Clovis-age technology may not be; and, conversely, too little is known of post-Clovis technology to allow us to eliminate the possibility that such attributes date to those later times (Eren et al., 2018a, 2021; see also O'Brien et al., 2018; Groucutt, 2020). Thus, to determine the cultural affinities of the Nelson cache, whether Clovis or from a later period, requires careful assessment of a suite of evidence (Eren et al., 2018a, 2021).

To assess the possible cultural affinity of the Nelson cache, we have undertaken a detailed, multi-pronged investigation of 164 of its 165 specimens (one was unavailable for study). This study includes a qualitative and quantitative technological comparison of the Nelson cache to ten confirmed Clovis caches from western North America, as well as to six post-Clovis age caches from the Upper Midwest (Figs. 2 and 3). In addition, and to provide a deeper understanding of its broader context, the possible role and function of the Nelson cache in the technological system of the group who produced it, we report here on geochemical sourcing of the lithic raw material, the occurrence of red ochre on cache specimens, and a detailed microwear study (including an experimental component). In the Supplementary Online Materials (SOM), we have made available all of our data, as well as high-resolution images and 3D scans of every biface from the Nelson cache we analyzed.

Fig. 1. The Nelson cache (n = 164).

1.1. *Discovery and site context*

The Nelson cache was discovered in the fall and early winter of 2008 by William Nelson at the base of a small tree in a wooded section of Camp Cornish (near Mount Vernon, Ohio). The roots of the tree had been shallowly disturbed by wild turkeys, which exposed the first of the bifaces. Nelson, at times assisted by his son-in-law and grandson (co-authors Scott and Chase Centea), ultimately dug out 165 bifaces from an approximately 60 cm circular area in and around the roots of the tree. The roots, Scott Centea recalls, were like a cage protecting whatever laid beneath, and a number of the specimens were recovered by feeling for stone pieces in and around the roots, and then wriggling the specimens loose. After three trips to the site over a relatively short period of time, it was determined that all the bifaces had been recovered. The tree was marked for a later visit when the weather warmed, but there was no immediate return trip.

The site was not visited again until the summer of 2016, when Scott

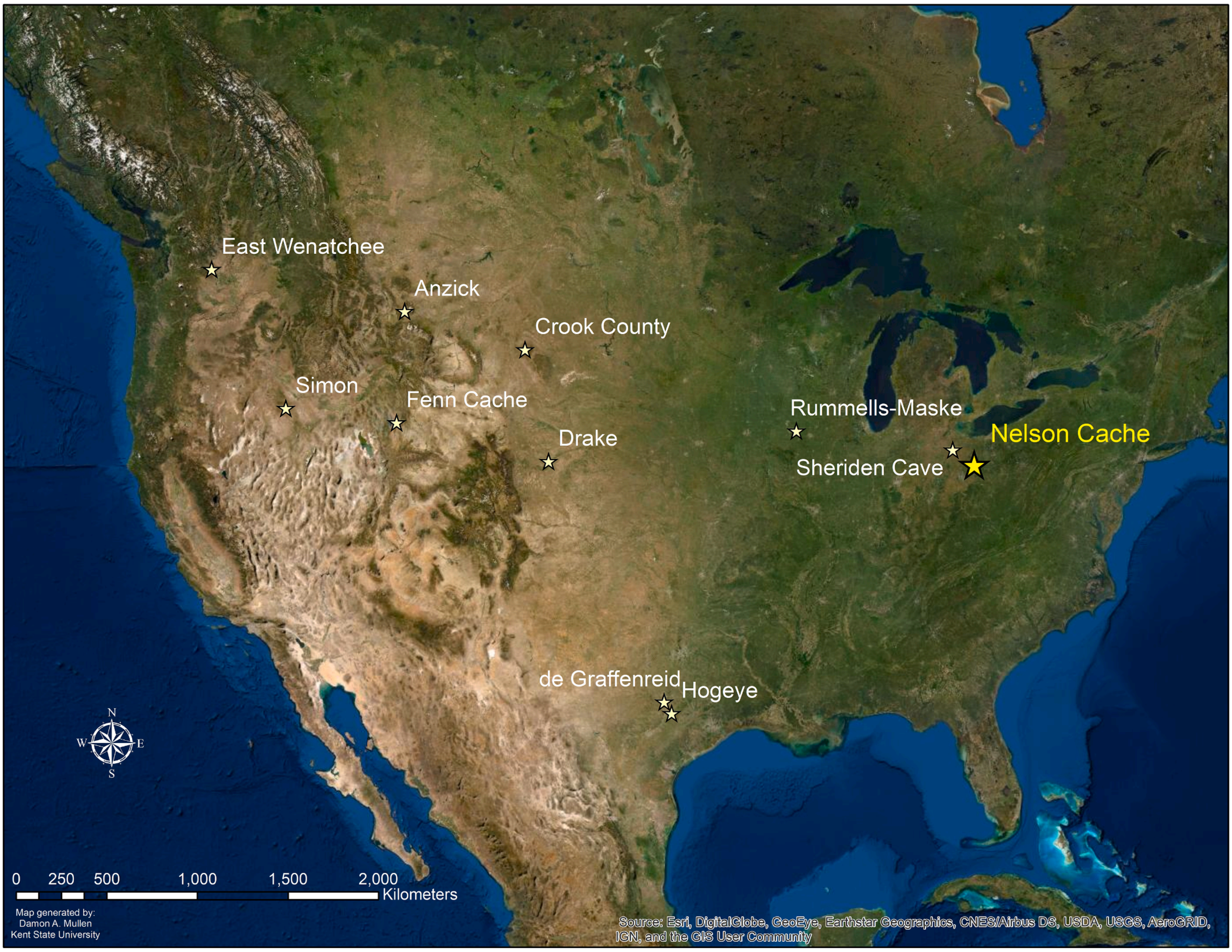

Fig. 2. Map of 10 Clovis caches and the Nelson cache. The Clovis caches are Anzick (Wilke et al., 1991), Crook County (Tankersley, 1998; Kilby, 2008), de Graffenreid (Collins et al., 2007), Drake (Stanford and Jodry, 1988), East Wenatchee (Gramly, 1993), Fenn (Frison and Bradley, 1999), Hogeye (Waters and Jennings, 2015), Rummels-Maske (Morrow and Morrow, 2002), Sheriden Cave (Redmond and Tankersley, 2005), and Simon (Butler, 1963, 1965). While Clovis caches are often thought of as a "western" phenomenon, this map, which only includes caches that possess finished Clovis fluted points in addition to the Nelson cache, suggests that Clovis caches could instead be regarded as a "northern" phenomenon.

Centea and several of the other authors went to the site. The area of the discovery was then under heavy regrowth of brush and vegetation, with many large, downed trees from a powerful windstorm four years earlier. This made it difficult to re-locate the tree under which the cache was found. Although no additional bifaces were recovered on the occasion, a few small flakes of macroscopically similar toolstone to the cache bifaces were found in the general area (see geochemical sourcing analysis below). On a later visit, Centea was successful at finding the tree under which the cache had been found (Fig. S1), and collected sediment samples. Although the area was surveyed by us, that effort yielded only a very few flakes. In the absence of any evidence of a site at this locality (many caches are isolated occurrences), and assuming that the entire cache was collected by Nelson and the Centeas, no systematic excavations were undertaken. Nonetheless, we continue to monitor the locality.

The cache find spot is in a sloping, low-lying (~300 m asl) area <25 km east of the Wisconsin terminal moraine, and within ~200 m of Schenck Creek, a tributary of the southeast flowing Kokosing River (Fig. 4). There is at present nothing topographically or ecologically distinctive about this particular spot, or that indicates why a cache of bifaces would be placed here; again, this is true for most cache finds. It is worth noting that Clovis fluted points are known from Knox County, though in far lower numbers than in adjacent Coshocton County immediately to the east (Seeman and Prufer [1982], for example, tallied 16 fluted points from Knox County, and 184 from Coshocton County).

With consent from the Nelson and Centea families, Scott Centea donated 164 of the 165 bifaces to Kent State University in 2016 for description and analysis (keeping one of them for his family). At the close of our study the 164 bifaces will be given to the Cleveland Museum of Natural History for permanent curation and access to other researchers.

2. Inferring cultural affiliation

Although we are obviously interested in the possibility that the Nelson cache might be a rare instance of a Clovis cache in eastern North America, it is important that we consider other possibilities. In order to assess its cultural affiliation, we compared the Nelson cache qualitatively and quantitatively to ten Clovis and six post-Clovis caches. Although 25 Clovis caches have been reported (Huckell and Kilby, 2014: Table 1.1; Kilby and Huckell, 2013), only 10 have diagnostic Clovis projectile points and/or radiocarbon ages securely placing them in

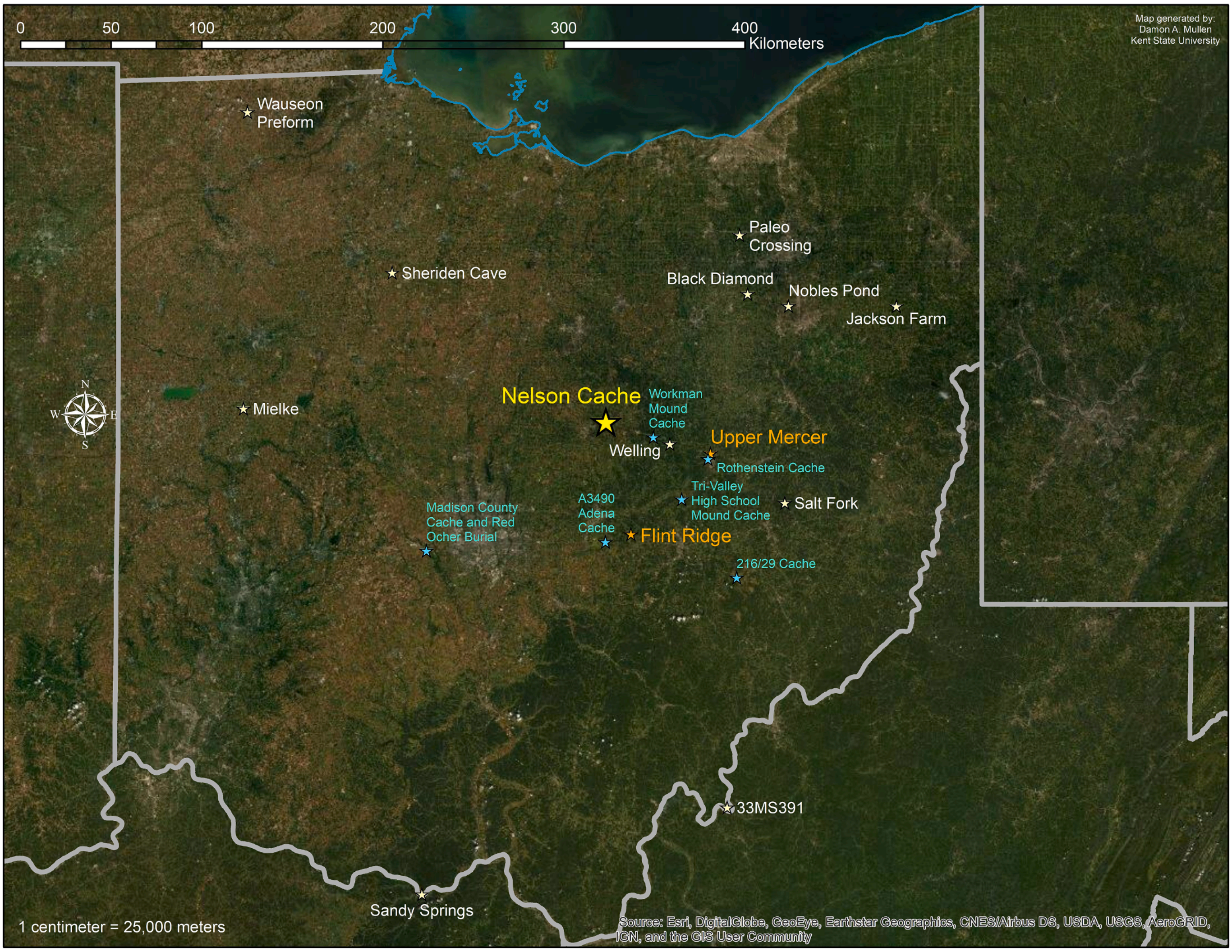

Fig. 3. Locations of the Nelson cache, the Upper Mercer and Flint Ridge outcrops, Ohio post-Clovis caches, and Ohio Clovis sites. The Ohio post-Clovis caches include the Late Woodland Red Ochre Burial cache (Nolan et al., 2015), the Tri-Valley High School Mound Terminal Middle Woodland cache (Carskadden and Morton, 1983); the Adena Rothenstein cache; the Adena A3490 cache; the Workman Mound Hopewell 48/110 cache; and the Archaic 216/29 cache. The Ohio Clovis sites include Paleo Crossing (Eren et al., 2018b), Black Diamond (Eren et al., 2019), Nobles Pond (Gramly and Summers, 1986), Jackson Farm (Bebber et al., 2017), Salt Fork State Part (Werner et al., 2017), 33MS91 (Lothrop and Cremeens, 2010), Sandy Springs (Purtill, 2017), Mielke (Converse, 2002), Sheriden Cave (Redmond and Tankersley, 2005), Welling (Miller et al., 2018), and the Wauseon Preform (Eren et al., 2016).

Clovis times[2]. These are Anzick (Wilke et al., 1991), Crook County (Tankersley, 1998; Kilby, 2008), de Graffenreid (Collins et al., 2007), Drake (Stanford and Jodry, 1988), East Wenatchee (Gramly, 1993), Fenn (Frison and Bradley, 1999), Hogeye (Waters and Jennings, 2015), Rummels-Maske (Morrow and Morrow, 2002), Sheriden Cave (Redmond and Tankersley, 2005) and Simon (Butler, 1963, 1965) (Fig. 2)

The six post-Clovis caches used in our study include the Late Woodland Red Ochre Burial cache (Nolan et al., 2015), the Tri-Valley High School Mound Terminal Middle Woodland cache (Carskadden and Morton, 1983); the Adena Rothenstein cache (*Ohio Archaeologist*, 1964); the Adena A3490 cache; the Workman Mound Hopewell 48/110 cache (Moorehead, 1897); and the Archaic 216/29 cache (Fig. 3). We do not know of any good published references for the Adena A340 or the Archaic 216–29 post-Clovis caches, but can state that they are curated at the Ohio History Connection (OHC). The cultural affiliations of the A3490, 48/110, and 216/29 caches were provided by William Pickard (OHC, personal communication). We chose to geographically limit our six post-Clovis caches to ones found in Ohio, since if the Nelson cache is not Clovis in age, those are the caches it should most resemble. (We did so out of analytical caution: were we to compare the Nelson cache to post-Clovis caches on the High Plains, for example, which might have

[2] The age of the other 15 caches said to be Clovis in age and affiliation is less secure (Eren et al., 2018a; Eren et al., 2021). Those caches lack temporally diagnostic finished Clovis projectile points or radiocarbon ages securely placing them in Clovis times (the latter is often the case since caches rarely occur in a site context – which may in part be telling of their purpose [Collins, 1999; Kilby, 2008; Meltzer, 2002] – or were recovered in situ in a controlled excavation). In the absence of such evidence, the attribution of these caches to the Clovis period is based on technological attributes, such as the presence of 'overshot' flakes on bifaces and preforms (e.g. Hill et al., 2014; Huckell, 2014), or on "Upper Paleolithic-style" blades (Collins, 1999; Montgomery and Dickenson, 1992). Although such attributes are present in Clovis technology, they are also present in post-Clovis age technologies (Bamforth, 2014; Eren et al., 2018a; Eren et al., 2021; Jennings and Smallwood, 2018; Muñiz, 2014; Sellet, 2015), and hence are not reliable indicators of cultural affiliation. The Green cache is an exception: comprised of 17 blades, it lacks fluted points and was not found in situ, but was well argued to have come from Clovis age deposits at Blackwater Locality 1 (Green, 1963). The Green blades are not, however, typical of Clovis blades from other localities (Bradley et al., 2010; Collins, 1999; Waters et al., 2011).

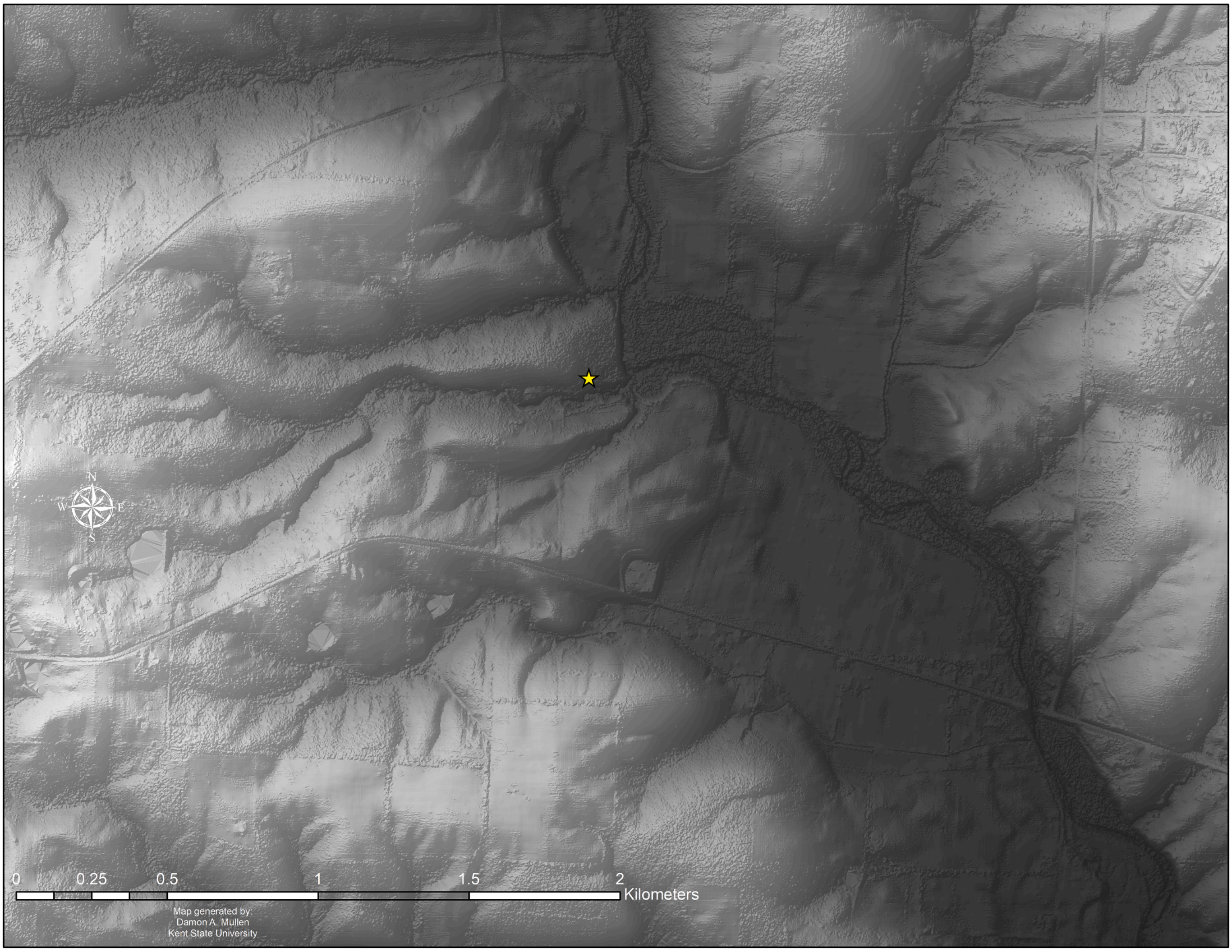

Fig. 4. The Nelson cache find spot is in a sloping, low-lying (~300 m asl) area <25 km east of the Wisconsin terminal moraine, and within ~200 m of Schenck Creek, a tributary of the southeast flowing Kokosing River.

very different morphological and technological forms than the post-Clovis caches of Ohio, it could make the Nelson cache appear closer to the Clovis than post-Clovis caches).

We compare the Nelson cache to these Clovis and post-Clovis caches in three ways: production technology, biface plan-view morphometrics, and flake scar density. We discuss these after summarizing the morphology and technology of Nelson cache bifaces. Detailed measurements and individual descriptions of each Nelson cache biface are available in the SOM.

2.1. Summary descriptions

Relative to bifaces found in other caches, the bifaces in the Nelson cache are not large: they average 68.5 mm in length, 38.6 mm in width, and 10.22 mm in thickness. The mean width-to-thickness ratio (W:T) is 3.82; length-to-width ratio (L:W) is 1.78; and length-to-thickness ratio (L:T) is 6.75 mm (Table 1). The average mass of each biface is 33.6 g; the 164 bifaces of the Nelson cache on aggregate weigh 5511.3 g (12.15 lbs), which is not a substantial amount of material to carry (Speth et al., 2013; for comparison, the 52 preforms that comprise the Hogeye cache weigh an aggregate of 3954.2 gms, but each biface in that cache is more than twice the weight and length of the Nelson cache bifaces [data from Waters and Jennings, 2015: Table 11]).

As noted, none of the bifaces in the Nelson cache are finished Clovis fluted points: they lack lateral edge grinding (though small edge-ground areas are present as a byproduct of platform preparation), and few have the plan and profile symmetry, fine-edge trimming, and relatively uniform thickness typical of finished forms. In these respects, the Nelson bifaces are like early stage bifacial preforms or ‘blanks’ seen in Clovis caches (e.g. Wilke et al., 1991).

A majority of the bifaces in the Nelson cache (n = 140) display some form of basal (proximal) end-thinning or ‘fluting’ (82 specimens exhibit that attribute on one face; 58 specimens exhibit that attribute on both faces, while 24 lack any evidence of end-thinning). That end-thinning is present on only one face or altogether absent in the majority of the specimens (n = 106) does not preclude a Clovis affinity: the distinctive fluting seen on finished Clovis points often is done toward the end of the production process. It can occur in the early stages of bifacial point production (Callahan, 1979), but not all early stage bifaces are fluted, nor is there always a clear line in Clovis points, especially but not only unfinished ones, separating culturally-diagnostic ‘fluting’ from a knapper’s in-process end-thinning of a biface – they can grade into one another (Bradley et al., 2010; Callahan, 1979). Obviously, in other fluted forms, mostly notably Folsom, Barnes, and Cumberland points, there is little ambiguity in the matter of whether the point is fluted.

Where present, the length of the first, or only, flute scar (n = 82) averages 23.02 mm in length, marking on average one-third (33.6%) of the total biface length. The average length of the second flute scar when

Table 1
Summary statistics of Nelson cache bifaces. Mass is in gram (g); length, width, thickness, and flutes are in millimeters (mm).

Statistic	Mass	Length	Width	Thickness	W:T	L:W	L:T	Flute #1	Flute #2
Sample size	164	164	164	164	164	164	164	140	58
Mean	33.6	68.4	38.6	10.2	3.8	1.7	6.7	23.0	15.8
Standard Deviation	12.3	10.7	5.4	1.2	0.6	0.2	1.1	7.8	4.0
Minimum	13.9	44.2	27.0	7.3	2.4	1.2	4.2	10.3	7.5
Quartile 1	25.8	61.6	34.9	9.4	3.4	1.6	5.9	16.9	12.5
Median	30.7	66.7	37.9	10.1	3.7	1.7	6.6	21.0	15.3
Quartile 3	37.9	73.5	41.3	11.0	4.0	1.9	7.3	27.3	18.6
Maximum	83.2	112.6	59.5	13.4	6.2	2.5	13.4	47.9	25.8
Range	69.3	68.3	32.4	6.1	3.8	1.3	9.1	37.5	18.3
Inter-quartile range	12.0	11.8	6.4	1.6	0.6	0.2	1.4	10.3	6.0

present (n = 58) is 15.88 mm, or 23.1% of total biface length. Given that forms of fluting and end-thinning during biface production are present in later time periods (Eren et al., 2018a, 2021; Nolan et al., 2015; Norris et al., 2019), the occurrence of this attribute alone cannot be used to designate the Nelson cache as Clovis.

Nelson cache bifaces range from 'minimally flaked' (in author Eren's experience, minimal flaking requires an investment of roughly a minute or two of shaping), to specimens that are fully flaked and nearly finished (Fig. 5). Most of the Nelson bifaces, however, would likely be considered to be in the "early or middle phase" of biface production (Bradley et al., 2010). As noted, the evidence of edge grinding on many of the Nelson cache bifaces, is consistent with platform preparation for flake removal.

Most of the bifaces exhibit large, well-spaced 'overface' flake scars (Smallwood, 2010, 2012), which extend well past the biface's plan-view midline axis; in addition, 13 of the Nelson bifaces (7.9% of the cache) exhibit overshot flake scars (Fig. 6) (Eren et al., 2013, 2014a). At least fifteen of the bifaces (9.1% of the cache) exhibited flaking so unorganized they readily fit into their own category, and suggest a highly expedient production. We note that these statements about overshot/overface scars are not support for a Clovis designation, merely a description. Overshot flake scars can occur in high frequencies in post-Clovis assemblages (e.g. Muniz, 2014, also Eren et al., 2018a).

Over half (n = 90) of the Nelson cache bifaces retain a portion of the original surface of the stone upon which they were knapped (as evidenced by areas on the biface displaying distinctive luster). Of these, 27 were knapped on large bifacial thinning flakes, as evidenced by their profile curvature, the presence of the flake's original ventral surface, and/or the platform and bulb of that flake. This count is a conservative estimate; we suspect most of the Nelson cache bifaces were knapped on large bifacial thinning flakes, but only report here the ones that display unequivocal evidence.

Fig. 5. The Nelson cache bifaces exhibit a variety of production stages ranging from specimens that are barely knapped (top left, biface #122; top right, biface #117) to middle and late stage specimens (bottom left, biface #1; bottom right, biface #7).

If that is the case, it appears that the Nelson cache knappers took advantage of bifacial thinning flake morphology, which constricts to a point-shape at the platform, by knapping the proximal end of the flake into the distal tip of the resulting biface. Indeed, several bifaces have retained the original flake platform at their tip (Fig. 7). On a few occasions the original flake platform is at the basal corner of the biface. Once the biface tip has been established on these large thinning flakes, the goal appears to have been to eliminate the thin, weak flake edges and feather terminations. In other words, the proximal and lateral edges of the resulting Nelson cache biface was originally the distal and lateral edges of the thinning flake upon which the biface was knapped.

There is evidence, however, that not all Nelson cache bifaces were knapped on large bifacial thinning flakes. Six of the bifaces exhibited original stone surfaces on both faces that were weathered. This observation suggests these bifaces were knapped on thin tabular slabs of chert.

2.2. Production technology comparisons

The presence of fluting or end-thinning in the Nelson cache, while consistent with Clovis caches, is also not unequivocal evidence of a Clovis affinity, since the Late Woodland Red Ochre Burial Cache also exhibits this trait on 34 of its 35 bifaces (Nolan et al., 2015; see also Eren et al., 2018a, 2021; Norris et al., 2019). Likewise, the presence of well-spaced, large overface scars are also common on both Clovis and post-Clovis Ohio caches, and thus cannot be used as diagnostic criteria (e.g. Muñiz, 2014).

It is the case that, like the Nelson cache bifaces, specimens in Clovis caches are known to have been made on large flakes. Bradley et al. (2010:79) note that Clovis caches include bifaces made on flakes from the Crook County and East Wenatchee caches, and a large flake that is part of the Sheriden Cave Clovis assemblage possesses flake scars on both its dorsal and ventral surfaces that are identical morphologically to several specimens from the Nelson cache (Fig. 8).

However, we must offer the caveat that our sample of post-Clovis cache bifaces from Ohio contains only finished specimens. By this we mean that biface types and shapes are standardized; there is symmetry in both plan- and profile-view; each face is fully flaked; there is a well-established biface plane with mass equally distributed on each face; and lateral edges are straight and sharp. As a result, they yield little morphological or technological evidence of the original stone upon which they were knapped. We cannot say that post-Clovis caches are *not* knapped on flakes as well.

But it is perhaps telling that the predominant technological

Fig. 6. Overface and overshot scars are common on the Nelson cache bifaces (from left to right, bifaces #4, 76, 144, 155).

Fig. 7. Many Nelson cache bifaces exhibit the platform of flake upon which they were knapped (top left, biface #28; top right, biface #44; bottom left, biface #145; bottom right, biface #156).

difference between Clovis and the post-Clovis caches are the biface production stages evident in the cache. Clovis caches routinely contain a variety of biface stages, ranging from early phase preforms to finished points (which is what makes it possible to spot specimens that were made on flakes). In contrast, and as just noted, the post-Clovis Ohio caches almost exclusively contain "finished" bifaces. By this measure, the Nelson cache, with bifaces ranging from minimally flaked to nearly finished, more closely resembles the range of production forms seen in Clovis age caches, than post-Clovis caches.

2.3. Plan-view morphometrics of cache bifaces

We used geometric morphometric techniques to statistically compare the Nelson cache bifaces with those from caches with known temporal and cultural affiliations. Our sample includes a total of 479 bifaces from five different time periods: Clovis (n = 164), Archaic (n = 8), Early Woodland (n = 60), Terminal Middle Woodland (n = 46), and Late Woodland (n = 35), along with the 'affiliation unknown' Nelson cache (n = 156). The Nelson cache and the Archaic, Early Woodland, Terminal Middle Woodland, and Late Woodland caches are from Ohio. The Clovis cache bifaces are from nine different Clovis assemblages recovered from the western and midwestern United States and one from Ohio (Anzick, n = 45; Crook County, n = 7; de Graffenried, n = 5; East Wenatchee, n = 8; Fenn, n = 34; Simon, n = 22; Hogeye, n = 31; Rummells-Maske, n = 10; Sheriden Cave, n = 2).

Geometric morphometrics (GM) is a suite of techniques that focuses on the visualization and statistical analysis of sets of landmarks that are used to define the form of objects or organisms, or forms within objects or organisms (Adams et al., 2004, 2013; Bookstein, 1991; Dryden and Mardia, 2016; Marcus et al., 1996; Slice, 2005, 2007; Rohlf and Marcus, 1993; Zelditch et al., 2012). A common goal of GM studies is to extract shape variables from landmark coordinate data and analyze differences in the shape of objects or organisms. To do this with sets of landmark coordinates, landmarks associated with different objects are translated, rotated, and scaled via the superimposition method (Slice, 2007). To ensure correct placement of landmarks on different objects, GM relies on the use of homology. However, for GM studies of stone tools homologous landmarks are rare, and can be difficult to identify (Lycett et al., 2006). In response to this problem investigators have relied on the use of secondary and sliding landmarks to delineate the form of stone tools (e.g., Archer and Braun, 2010; Buchanan et al., 2015, 2018, 2020; Cardillo, 2010; Charlin and González-José, 2012, 2018; Costa, 2010; Lycett and Cramon-Taubadel, 2013; Lycett et al., 2010; Selden et al., 2018; Serwatka and Riede, 2016; Suárez and Cardillo, 2019; Wang et al., 2012).

For our comparative analysis of cache biface shapes we used a single primary landmark and 59 semi-landmarks to delineate the outline form of the bifaces. Generally, the shape of the bifaces in our sample ranges from elliptical to lanceolate. We oriented the bifaces in all of the digital

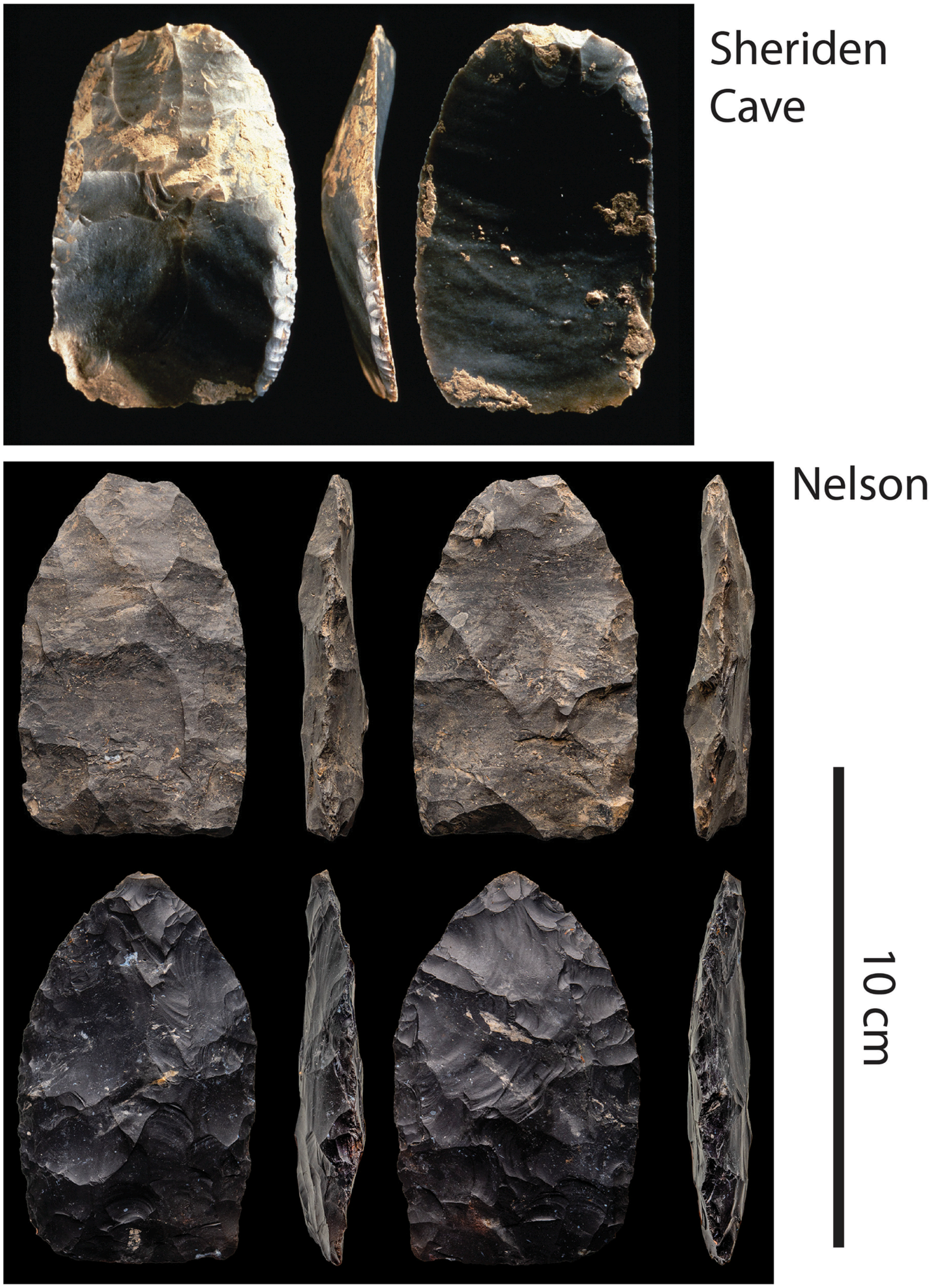

Fig. 8. The Sheriden Cave flake (top) versus examples of Nelson cache bifaces made on flakes (middle, biface #156; bottom, biface #14). The Sheriden Cave flake is at an earlier stage of reduction than the Nelson examples, but morphologically they are still similar.

images with the narrow or pointed end facing to the right (for bifaces that are more elliptical in shape and thus do not have a clear narrow or pointed end, we arbitrarily chose one end of the ellipse to face right). We defined the single primary landmark as the pointed right end where the edges converge, or the apex of more rounded bifaces. From this landmark, we used the line tool in the MakeFan7 program (Sheets, 2019) to place the secondary landmark at the opposite end of the biface. Using the line segment drawn between the primary and secondary landmarks, we used the MakeFan program again to project 60 equally-spaced radiating lines on each of the digital biface images. We then used the 'Circle 1-2′ fan function in the MakeFan program to project the lines. This program creates the desired number of radiating lines from the center of the line segment drawn between two landmarks. After projecting the radiating equally-spaced lines on all of the biface images in our sample we used tpsDIG2 software (Rohlf, 2017) to place 60 landmarks at the intersections of the radiating lines and the perimeter of the biface in each image. We saved the 479 sets of 60 landmarks and used these in our superimposition procedure and for the subsequent extraction of shape variables (the weight matrix) using the tpsRel program (Rohlf, 2016). The weight matrix includes the partial warp scores (eigenvectors of the bending-energy matrix that describe local deformation along a coordinate axis) and the uniform component (variation along the X and Y axes) that together represent all of the information about the plan-view outline shape of the bifaces (Rohlf et al., 1996; Slice, 2005).

With the weight matrix we carried out canonical variates analysis

(CVA) to compare the outline shapes of bifaces from caches from different time periods with the Nelson cache bifaces. In the CVA we used time period (unknown for the Nelson cache sample) as the grouping variable. This procedure calculates the Mahalanobis distance from the pooled within-group covariance matrix and uses this as a linear discriminant classifier. We used a leave-one-out (jackknifing) procedure to cross-validate group assignments (Kovarovic et al., 2011). Following the CVA we used a non-parametric MANOVA to test for statistical differences among the groups. We used a non-parametric MANOVA opposed to the parametric MANOVA because our weight matrix data were not multivariate normal (Mardia tests: skewness statistic < 0.000, $p < 0.000$; kurtosis statistic < 0.000, $p < 0.000$). The non-parametric MANOVA assesses significance by permutation of group membership using 9999 replicates. The statistical analyses were carried out in PAST 3.25 (Hammer et al., 2001).

A plot of the first two linear discriminant functions from the CVA representing a little more than 68% of the overall variation in the dataset, shows that the Nelson cache bifaces overlap partially with Late Woodland and Clovis cache bifaces, and slightly with Adena cache bifaces along the first and primary axis of variation (Fig. 9). However, on Axes 2–4 the Nelson bifaces overlap with most of the other assemblages (Figure S2-S3). The CVA returned an overall correct classification rate of 69.3%. The jackknifed confusion matrix showing the classification of the bifaces by time period indicates that the Nelson cache had the highest rate of correct classification (i.e., 134/156 [85.9%] of the bifaces from the Nelson cache were correctly classified as belonging to that cache), whereas the Archaic cache bifaces had the lowest correct classification rate (Table 2). In effect, the Nelson cache was different from most of the other caches.

The Nelson cache bifaces that were otherwise misclassified ($n = 22$) were statistically similar to either Late Woodland (9/156 [5.8%]), Clovis (8/156 [5.1%]), Adena (3/156 [1.9%]), and Archaic (2/156 [1.3%]). None were misclassified as Terminal Middle Woodland.

The results of the non-parametric MANOVA indicate that the cache bifaces differ significantly by time period (9,999 permutations, $F = 40.48$, $p = 0.0001$). Bonferroni-corrected pairwise comparisons indicate that only the Clovis cache bifaces and the Archaic cache bifaces are similar in shape ($p = 0.284$), and the Late Woodland and Terminal Middle Woodland cache bifaces are similar in shape ($p = 0.945$). All other comparisons are significantly different including all of the pairwise comparison between Nelson and the other caches.

2.4. Geometric morphometric assessment of Nelson biface #2

These, of course, are assemblage-level patterns in shape, whereas the Nelson cache Biface #2 (Fig. 10) illustrates the challenge of assigning individual specimens in the cache to a particular technology and period. More so than most of the specimens in the Nelson cache, Biface #2 has a lanceolate form, a slight basal concavity, evidence of fluting on both faces, and isolated and prepared platforms reminiscent of bifaces from Clovis assemblages.

We used geometric morphometric shape analysis to compare Nelson Biface #2 to a sample of 254 Clovis points from seven different regions across North America. To digitize these points we followed the protocol defined by Buchanan et al. (2014). We used 23 landmarks (3 primary landmarks defined at the tip and basal edges of each point) to outline each of the Clovis points in our sample. These analyses were also conducted using the TPS suite of software available through the Stony Brook Morphometrics web site (http://life.bio.sunysb.edu/morph/). For the comparative analyses we used the weight data matrix which includes all the information about the shape of the 255 landmark configurations, comparing the Clovis point dataset to the Nelson point.

The results of the Canonical Variate Analysis (CVA) shows that the Nelson point is closest in shape to other Clovis points from the Southeast region of the United States (Fig. 11). The Nelson point is most different from all other points along the CVA axis 2, but is close to the center of the distribution on axes 1, 3, and 4. The Nelson point is closet to a point from the Shoop assemblage in Pennsylvania, and a point from the Gault site in Texas. Table 3 presents the cross-validated confusion matrix showing that the Nelson point is misclassified as a Clovis point from the southeast.

However, as can be seen in Fig. 9, the affinities of Nelson #2 to Clovis bifaces are not altogether straightforward. That is, when the shape of all cache bifaces are examined the Nelson #2 biface overlaps with Clovis on the second axis and not the first, while Nelson #2 also overlaps with the Late Woodland Red Ochre Burial Cache morphospace along the first axis. As Nolan et al. (2015) observe, many of the Late Woodland Red Ochre Burial Cache bifaces are fluted as well.

2.5. Flake scar density analysis

Following Eren et al. (2015),[3] we calculated the flake scar densities per face for the Nelson cache bifaces, as well as for a large sample of Clovis and post-Clovis cache bifaces. We assessed flake scar density as a consequence of Bradley et al. (2010:177, 106), who state, “Clovis flaked stone technology exhibits a bold, confident, almost flamboyant strategy” that “focuses on the removal of large well-formed flakes.” Yet, how exactly Clovis versus post-Clovis cache biface flake scar densities compare – and whether Nelson is more similar to one group over the other – is currently unknown.

Flake scar density was determined by dividing the number of flake scars present on a single face by the plan-view area of the specimen. The plan-view areas of all bifaces were recorded in Adobe Illustrator. With respect to the Clovis cache bifaces, we also counted the number of flake scars in Adobe Illustrator using available and appropriate published illustrations.

With respect to the Nelson cache and post-Clovis cache bifaces, appropriate illustrations were not available. Thus, we developed a method for counting flake scars that involved making plaster copies of each biface (following Tankersley, 1989). To make the plaster copies, each biface was pressed into potters’ clay (Standard #103). Clay was chosen as the mold media because it is plastic enough to capture the fine flake details of each biface, but firm enough to function as a mold for the wet plaster.

The blocks of clay were initially cut into slabs roughly 2.5 cm thick. The slabs were then placed into a plastic tray and smoothed to create a flat surface. To make the mold, each stone biface was pressed into the clay, just past its lateral edge. This was done in a single fluid motion beginning with the base and ending with the tip. Once the biface was removed and the clay molds were complete, wet plaster (USG No. 1 Pottery plaster) was poured into each and allowed to cure. After the plaster had cured, each plaster point cast was used for flake scar counting. This method is useful for accurate counting, as the flake scars on the plaster casts can be labelled with a marker during the counting process. Being able to mark each scar eliminates common counting issues, such as missed scars or double counted scars. This procedure also allowed for multiple people to count the same biface to ensure accuracy. Each biface’s scars were also counted at least three times.

Using this method we counted 30 faces each for the Nelson cache, and six post-Clovis caches. The Clovis caches, as stated, were counted from illustrations, and the sample was comprised of the bifaces from the Crook County ($n = 18$ faces), deGraffenried ($n = 10$ faces), East Wenatchee ($n = 20$ faces), Fenn ($n = 26$ faces), Hogeye ($n = 30$ faces), Sheriden Cave ($n = 4$ faces), and Simon ($n = 27$ faces) caches. The

[3] Eren et al. (2015) calculated both total flake scar density and internal flake scar density. Internal flake scar density was calculated because in that study the authors were examining finished and used Clovis points that could have been subject to resharpening, which would have potentially skewed the total flake scar density measure. Here, we only calculate total flake scar density because we are examining cache bifaces which have neither been used nor resharpened.

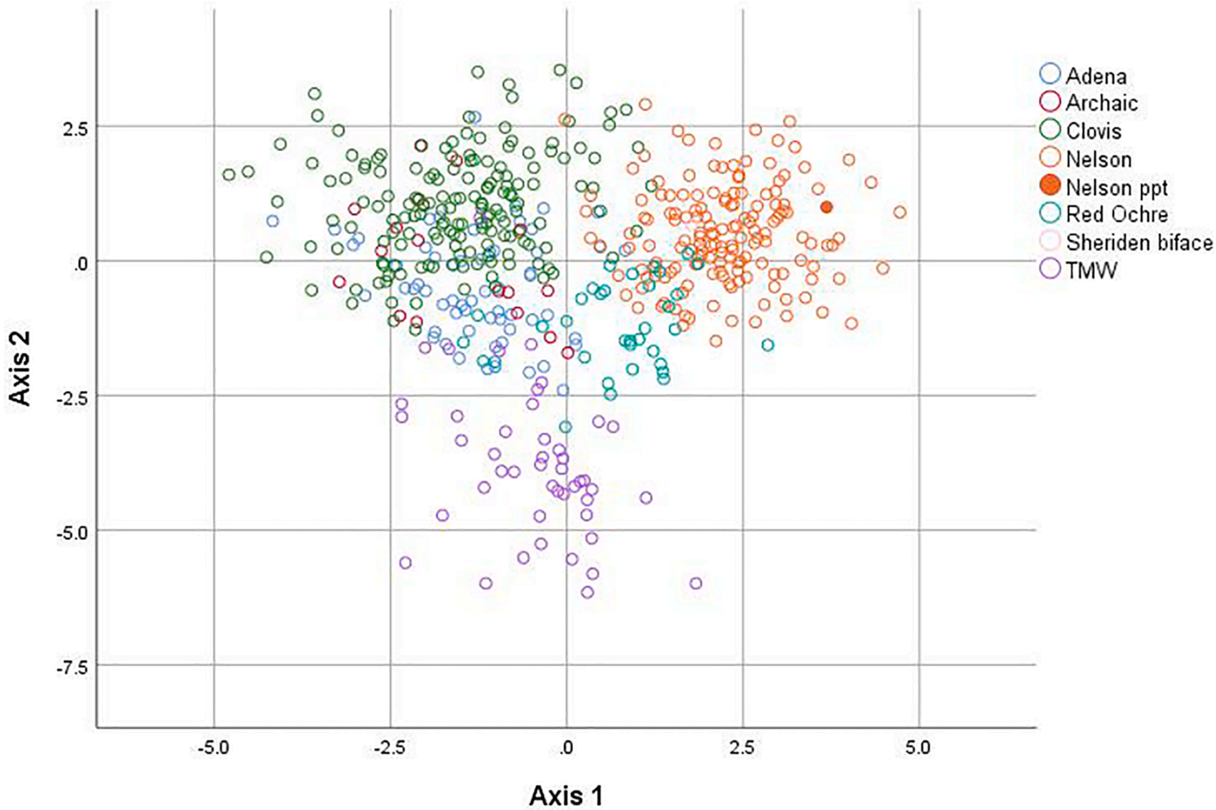

Fig. 9. The first two linear discriminant functions from the canonical variate analysis of 479 cache bifaces by time period (the Nelson cache has an unknown time period and is labeled Nelson and the Nelson biface #2 is identified separately). Axis 1 represents 39.7% of the overall variation in the dataset and Axis 2 represents 28.7% of the overall variation in the dataset.

Table 2
Cross-validated confusion matrix from the canonical variate analysis, 47.06% correctly classified.

	Clovis eastern cache	Clovis Great Lakes	Clovis northeast	Clovis Plains	Clovis southeast	Clovis Southwest	Clovis western cache	Nelson	Total
Clovis eastern cache	6	1	1	1	0	1	0	0	10
Clovis Great Lakes	3	2	4	4	3	4	1	0	21
Clovis northeast	3	11	34	7	4	7	4	0	70
Clovis Plains	3	4	3	17	6	12	9	0	54
Clovis southeast	2	1	4	0	9	1	2	1	20
Clovis Southwest	3	2	3	8	1	8	0	0	25
Clovis western cache	1	3	0	5	0	1	44	0	54
Nelson	0	0	0	0	1	0	0	0	1
Total	21	24	49	42	24	34	60	1	255

selection of Nelson, Clovis, and post-Clovis faces was randomly sampled using www.randomizer.org when the number of faces present in a cache was greater than 30.

For the comparisons of flake scar density between Nelson and Clovis, and Nelson and post-Clovis cache biface assemblages we used Ordinary Least Squares (OLS) regression to estimate best fit lines for each of the groups (Nelson n = 30; Clovis n = 135; post-Clovis n = 180). We created the post-Clovis sample by grouping together the Middle Woodland, Late Woodland, Adena, and Hopewell cache biface assemblages. For the OLS analyses we log-transformed both flake scar count and biface area to normalize both variables. We designated flake scar count as the independent variable and biface area as the dependent variable. After calculating the slopes we used an F-test to carry out pairwise comparison of the slopes. The statistical analyses were carried out in PAST 3.25 (Hammer et al., 2001).

The best fit line for the relationship between flake scar count and biface area for the Nelson cache indicates a slope of 0.076, however the slope cannot be statistically distinguished from a slope of zero ($p = 0.701$). The Clovis slope is 0.48 and is significantly different from zero (p = 0.0106). The comparison of the Nelson and Clovis slopes indicates that they are statistically similar (Fig. 12; F = 0.4146, $p = 0.5206$), however, this similarity should be viewed in recognition of the wide confidence interval around the Nelson slope (-0.175, 0.428) (Fig. 12). For the comparison between Nelson and post-Clovis cache bifaces, the slope of the best fit line for the post-Clovis caches is 1.09 and is significant ($p < 0.0000$) and the two slopes are significantly different (F = 17.94, $p < 0.0000$) (Fig. 12).

3. Geochemical sourcing

The majority of the Nelson cache bifaces are visually consistent with chert from the Upper Mercer Limestone (Pottsville Formation,

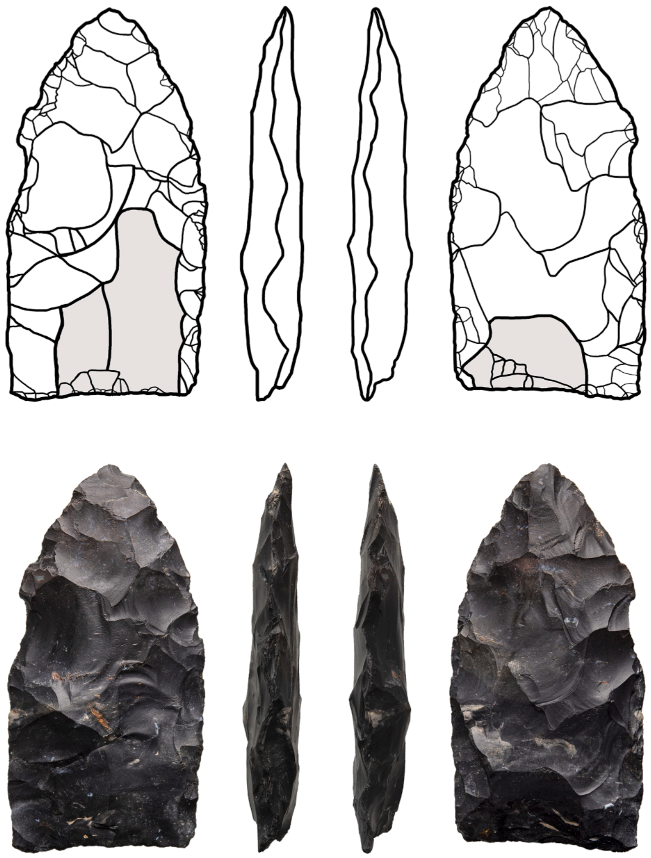

Fig. 10. Nelson cache biface #2 image and illustration. The flute scars are in gray.

Pennsylvanian) which outcrops in Coshocton County, ~50 km east/southeast of where the Nelson cache was found. A lesser number of specimens are visually consistent with chert available in Vanport Limestone (Alleghany Formation, Pennsylvanian), which is well known from the Flint Ridge quarry complex in Licking and Muskingum Counties and the Plum Run quarry in Mahoning County ~50 km south/southeast of where the cache was found.

To assess these visual identifications, we used neutron activation analysis (NAA) on a sample of 16 Nelson cache bifaces to evaluate their likely source. We also used NAA to examine the five flakes that were collected during the 2016 site visit to the location. We compared the compositions of these 21 artifacts to 60 specimens of chert from various quarry areas in the U.S. Midwest. The NAA was conducted at the Archaeometry Laboratory at the University of Missouri Research Reactor (MURR). Here, we present a summary of this analysis; a detailed report can be found in the SOM.

Cache bifaces were sampled at MURR by removing a small portion with a diamond-edged rocksaw. Flakes were removed from source specimens using an antler billet. If needed, the small flakes and cut-sections were further reduced in size by placing them between two tool-steel plates and crushing them in a Carver Press. Several small 50–100 mg fragments were obtained from the crushed specimens. Fragments were examined under low-power magnification, and fragments with metallic streaks or crush fractures were eliminated from consideration. Several grams of the remaining fragments were obtained from each sample and temporarily stored in plastic bags.

Two analytical samples were prepared from each specimen. Portions of approximately 100 mg of rock fragments were weighed into high-density polyethylene vials used for short irradiations at MURR. At the same time, 700 mg aliquots from each specimen were weighed into high-purity quartz vials used for long irradiations. Individual sample weights were recorded to the nearest 0.01 mg using an analytical balance. Both vials were sealed prior to irradiation. Along with the unknown samples, standards made from National Institute of Standards and Technology

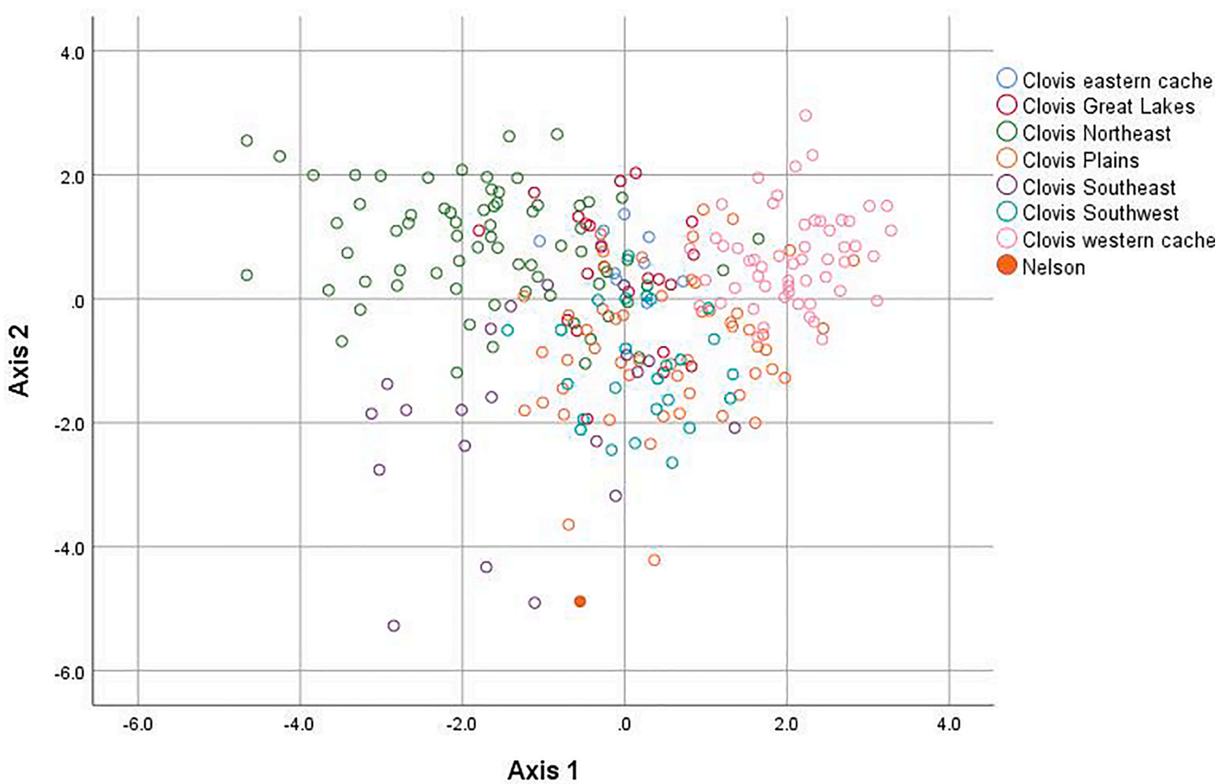

Fig. 11. The first two linear discriminant functions from the canonical variate analysis of 254 Clovis projectile points by region and the Nelson biface #2. Axis 1 represents 41.42% of the overall variation in the dataset and Axis 2 represents 20.9% of the overall variation in the dataset.

Table 3
Cross-validated confusion matrix of group membership. Group classifications to time period are read by row and the diagonal cells show the number correctly classified to time period or to the Nelson cache.

	Nelson	Clovis	Terminal Middle Woodland	Archaic	Adena	Late Woodland	Total
Nelson	134	8	0	2	3	9	156
Clovis	14	113	2	9	24	2	164
Terminal Middle Woodland	2	3	31	3	5	2	46
Archaic	0	8	1	6	0	3	18
Adena	3	17	8	4	24	4	60
Late Woodland	6	1	2	1	1	24	35

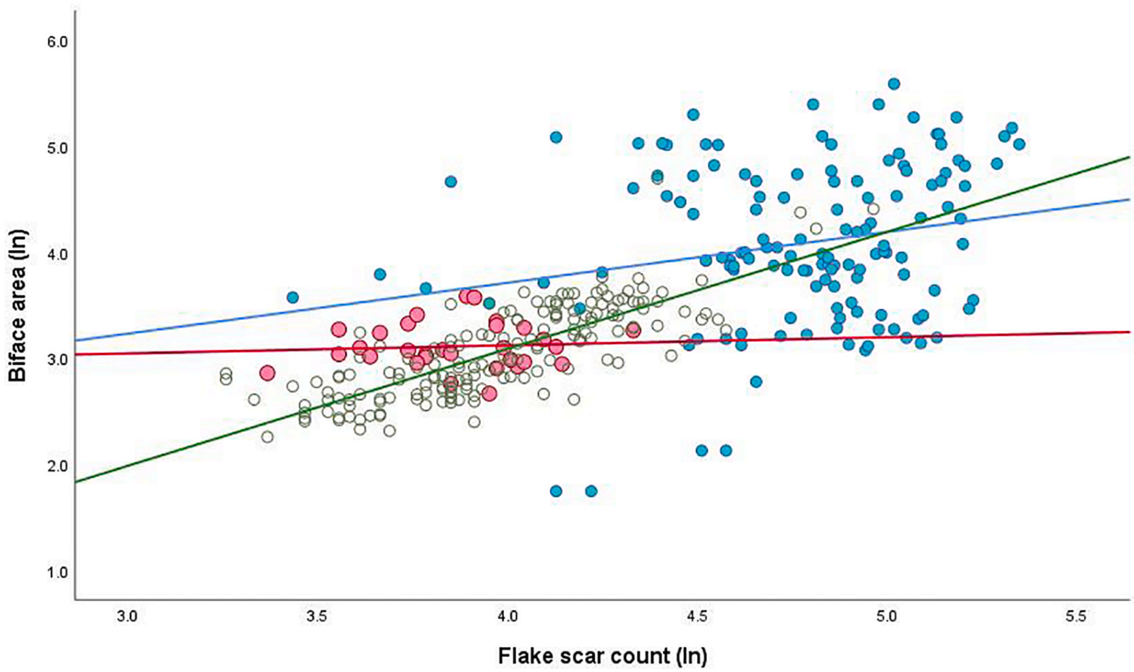

Fig. 12. Bivariate plot of log-transformed flake scar count and biface area. The lines are best-fit lines from the Ordinary Least Squares analyses. Filled red circles and red line is for the Nelson sample, blue circles and blue line is for the Clovis sample, and the open green circles and green line is for the post-Clovis sample of bifaces.

(NIST) certified standard reference materials of SRM-1633b (Coal Fly Ash), SRM-278 (Obsidian Rock), and SRM-688 (Basalt Rock) were similarly prepared.

The results of NAA and subsequent statistical analysis (see SOM) suggest that nearly all of the bifaces have moderate to high probabilities of membership in both the Upper Mercer and Vanport (Flint Ridge) chert groups. In part, this is because the compositional group represented by Vanport (Flint Ridge/Plum Run) chert is extremely variable, and more or less encompasses the compositional variability documented for Upper Mercer chert. The five flakes recovered during the 2016 site visit similarly show moderate to high group-membership probabilities for both the Vanport and the Upper Mercer compositional groups, effectively the same results as for the cache bifaces. The only exceptions to this pattern are four bifaces that are macroscopically and chemically consistent with stone colloquially referred to as 'Flint Ridge White' (aka, Flint Ridge Chalcedony).

4. Presence of ochre

In preparing the bifaces for analysis by NAA, it was noted that several of them contained red/orange/pink residual sediment occluded in flake scars and hinge/step fractures. Qualitative analysis of some of these residues by pXRF indicated that they contained significantly more Fe than the cherts on which the bifaces were made, thereby suggesting that the residues could potentially be a deliberately applied red ochre. Ochre is often used as a catch-all term to include a variety of Fe-oxide–enriched minerals, rocks, and sediments. The use of ochre to coat burials and caches can be considered characteristic of Paleoindian inhabitants of North America (Roper, 1991; Stafford et al., 2003).

In order to determine if the residue adhering to some of the Nelson Cache bifaces is indeed ochre, we employed two analytical methods (X-ray diffraction [XRD] and scanning electron microscopy with energy dispersive spectrometry [SEM-EDS]). XRD allows for the identification of the molecular structure of crystalline materials; whereas, SEM-EDS allows for the evaluation of residue morphology (texture, grain size, and homogeneity) along with semi-quantitative elemental characterization of the residues.

Twelve of the bifaces were evaluated using either XRD, SEM-EDS, or a combination of both methods. The results (see SOM) of these analyses suggest all of the residues contain quartz and Fe- oxide polymorphs, the most-common components of ochre. Residues on bifaces 111 and 128 (CHR284 and CHR287, respectively) showed diffraction peak patterns for hematite, while most other residues showed diffraction peak patterns for goethite. Most of the residues also showed significant peak patterns for common soil-forming minerals. Under SEM, the residues on bifaces 111 and 128 (CHR284 and CHR289) are heterogeneous mixtures of angular and/or platy Fe-enriched particles mixed with similarly shaped particles enriched in Al, K, and Mg, suggesting one of the following possibilities: (1) a mixture of intentionally prepared ochre with the surrounding soil matrix; (2) an unrefined or poorly refined ochre-like material; or, (3) naturally occurring Fe-rich sediment within with the bifaces were deposited. In contrast to the residues on these bifaces, the residue on biface 121 (CHR286) exhibits an exceptionally high Fe content (37–52%) and a fine-grained homogeneous morphology. These characteristics are fully consistent with high-purity (or prepared/refined) red ochre, suggesting that at least one of the examined bifaces contains traces of an ochre coating.

In summary, at least one of the 12 examined bifaces exhibits remnants of what appears to be an ochre coating. Data for the other 11 bifaces remains suggestive, but inconclusive—though only four bifaces were examined in detail under SEM. It is possible that they, as with biface 121, were coated with a refined ochre, but the ochre has been post-depositionally mixed with the surrounding soil matrix. It is also possible that two forms of ochre were used to coat the cache bifaces—one of which was a refined ochre, and the other was an unrefined ochre or Fe-rich sediment. Although the Fe content of the residues appears to be outside of the anticipated range for soils at the site, complementary analyses of soil samples collected during our visit to the site will help to confirm this. These analyses are ongoing and will be reported in full when complete.

5. Microwear analysis

We conducted lithic microwear analysis on all 164 bifaces from the cache, along with five flakes collected in 2016, following Keeley's (1980) method of identifying polishes, striations, microflaking, and rounding diagnostic of use-wear produced on stone tools in controlled experiments. Artifacts were washed for 10 min in an ultrasonic cleaner, first in liquid soap and then tap water, before being mounted on a plasticine base and examined using an Olympus BX51M metallurgical microscope.

This method has been applied to a growing number of Clovis assemblages (Bebber et al., 2017; Eren et al., 2016; Kay, 1999; Loebel, 2013; Miller, 2013, 2014; Miller et al., 2018; Pevny, 2012; Smallwood, 2015; Smallwood and Jennings, 2016; Werner et al., 2017), yet the number of Clovis caches examined remains small (Bamforth, 2014; Hill et al., 2014). Nevertheless, Hill et al. (2014) reconstructed the placement of cache bifaces during packaging, transport, and deposition by recognizing differential distribution of hide or bag wear and stone on stone wear. Those artifacts that were on the outside of the cache, thus in contact with the bag during transport, contained rounded ridges and matte textured hide polish on their outer faces; in contrast, bright, flat stone-on-stone (hereafter SOS) polish was present on their inner surfaces. Artifacts on the interior of the cache bundle contained SOS polish on both surfaces. This pattern led Hill et al. (2014:100) to argue that during conveyance to, and deposition at the site, the artifacts "were not individually wrapped but rather were tightly bundled together or, perhaps, bound into several smaller bundles, inside a transport bag." This argument is intuitively logical, yet in need of further experimental support. In fact, published examples of experimentally produced transport wear on chipped stone tools are exceedingly rare (e.g. Rots, 2010).

5.1. Microwear experiment

In order to assess the different transport wear patterns that develop in bundled versus un-bundled artifacts, we undertook an experiment involving the transport of stone implements in two leather bags. In one bag, seven flint blades were bundled together into three different layers using a strip of leather. Three blades in the inner layer were completely covered by other blades on the outside of the bundle. Two blades were in the middle, partially covered by other blades while part of their dorsal surface was uncovered and potentially exposed to the leather bag. Two blades in the outer layer had their dorsal faces completely exposed to the leather strip and bag, while their ventral surfaces were in contact with other blades. In the other bag, eight blades were freely placed, un-bundled, inside the bag.

The raw materials from which the blades were crafted were fine-grained Midwestern cherts including the Upper Mercer and Flint Ridge materials that constituted the Nelson cache. Each bag was then carried for 50 km over relatively level urban terrain. The blades were then removed from the bags, cleaned, and examined using the same analytical procedures described above. Transport wear was noted on each of the blades. Overall, the transport wear was less developed on the experimental tools than on the Nelson cache bifaces (as described below). This is to be expected, however, considering that the archaeological materials were likely transported over a longer distance and rougher terrain.

Regardless, diagnostic microwear features were observable on the experimental specimens. The five artifacts in the inner and middle layers contained only SOS polish. All five contained bright spots of SOS polish on their dorsal ridges and ventral face (Fig. 13a). One from the middle layer also contained SOS striations on the dorsal face (Fig. 13b). The two blades on the outer edge of the bundle contained rounded ridges and hide polish on their dorsal surfaces (Fig. 13c). Spots of SOS polish were noted on their ventral surfaces (Fig. 13d).

Overall, these results are consistent with Hill et al.'s (2014) findings in which stone implements on the outer edge of a transported bundle have hide polish on their outer face and SOS polish on their interior face. All other artifacts in the bundle contained SOS polish and/or striations. The wear patterns on the blades in the un-bundled experiment reflected the tendency of the implements to shift positions in relation to the leather bag and other implements. Each of the six artifacts contained evidence for rounding and a matte, diffuse polish on their dorsal ridges (Fig. 13e). We interpret this as evidence for hide wear from contact with the leather bag. Each artifact also contained bright, flat SOS polish on

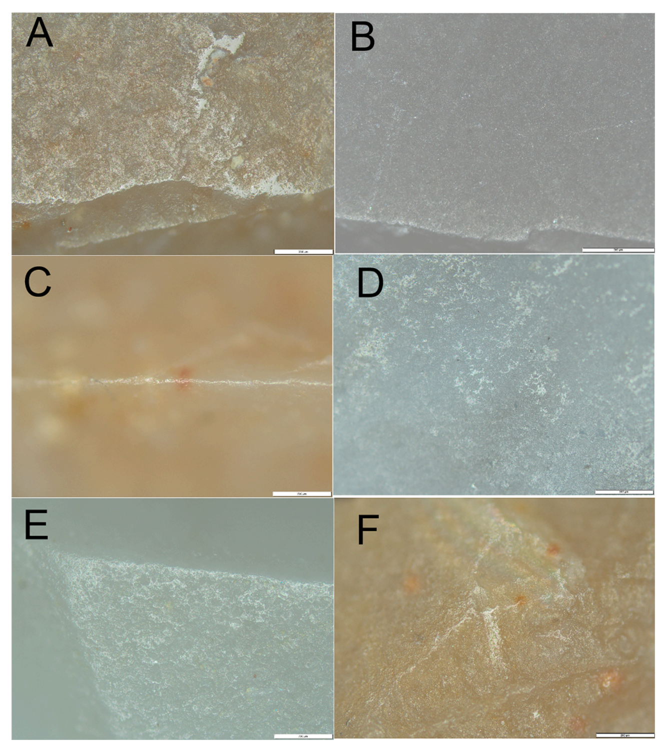

Fig. 13. A) SOS polish on a ridge of an experimental Flint Ridge flint blade tied in the interior of a bundle. Magnification is 100x. B) SOS striations on an Upper Mercer flint blade tied in the middle layer of a bundle. Magnification is 50x. C) Hide wear on a dorsal ridge of a Flint Ridge flint blade positioned on the exterior of a tied bundle. Magnification is 100x. D) SOS polish on the ventral surface of an Upper Mercer blade tied in the interior of a bundle. Magnification is 100x. E) Hide wear on the dorsal ridge of an Upper Mercer blade transported un-bundled with other flint blades in a leather bag. Magnification is 100x. F) SOS polish and striation on the dorsal ridge of a Flint Ridge flint blade transported un-bundled with other flint blades in a leather bag. Magnification is 100x.

the dorsal ridges and ventral face. Two artifacts contained SOS striations on one or more face (Fig. 13f).

In summary, SOS polish on both faces (as the sole polish present) of our experimental blades only occurred when these were in the inner layers of a tied bundle. Blades with hide wear on one face and SOS polish on the other were only located on the outside of a tied bundle. Only un-bundled implements freely jostling around in the bag had SOS wear and hide wear on the same faces. Our results are consistent with other transport experiments. For example, Rots (2010:44-45) transported un-bundled chipped stone implements for anywhere from 7 to 220 days. Rots (2010:45) notes that spots of SOS polish and striations are abundant and randomly distributed. Hide polish on flake ridges also developed, but to a lesser extent than the SOS polish.

5.2. Cache biface microwear

No edge usewear (i.e. that resulting from cutting, scraping, etc.), projectile impacts, or hafting traces were noted on any of the Nelson cache bifaces. All microwear identified and described below is consistent with transport processes, as shown experimentally.

The topography of bifaces consists of two main features, flake ridges and flake scars. Microwear formed on both areas, but is far more common on flake ridges. This is not unexpected as the flake ridges represent high points which are most likely to come into contact when two artifacts come together. The types and locations of microwear on the cache bifaces largely reflect the results of our experiments. Polish experimentally associated with SOS contact was undoubtedly the most common type of microwear observed on the cache bifaces (Table S1). Most SOS microwear occurs on the flake ridges of cache bifaces as bright, flat spots of polish with well-defined edges (Fig. 14a, b, d). These SOS bright spots were also found in flake scars but to a lesser extent (Fig. 14c). Bright striations, created by SOS contact in our experiments, were also noted in flake scars, on plateaus, and extending off of ridges of some cache bifaces (Fig. 14d). Rounding associated with a matte, pitted polish with poorly defined edges was present on some flake ridges (Fig. 14e and f). This is a direct match to the hide polish noted on our experimental implements (compare Fig. 13e and Fig. 13e). In both the experimental implements and the archaeological artifacts, this wear was only present on the high flake ridges.

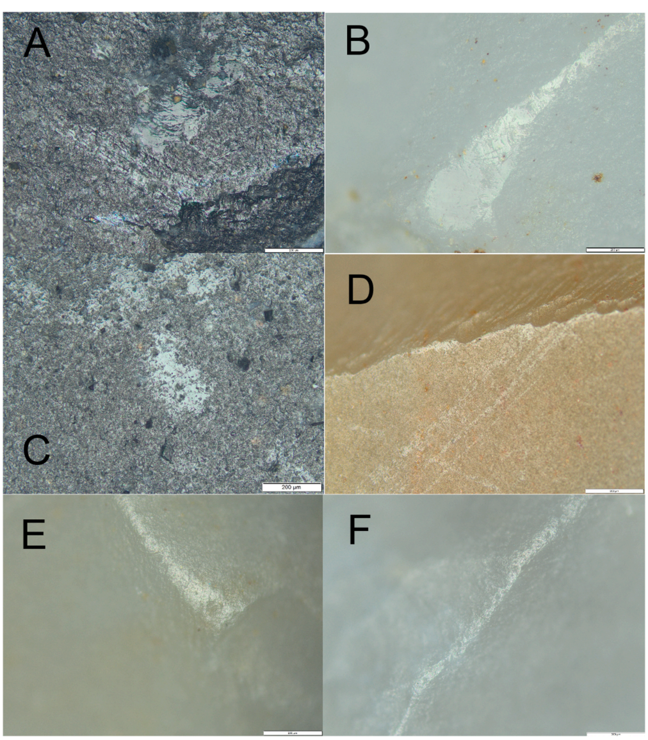

Fig. 14. A) SOS polish on a flake ridge of an Upper Mercer cache biface (#56). Magnification is 100x. B) SOS polish on a flake ridge of a Flint Ridge cache biface (#84). Magnification is 100x. C) SOS polish in a flake scar of an Upper Mercer cache biface (#39). Magnification is 100x. D) SOS striations and polish on a flake ridge of a Flint Ridge cache biface (#67). Magnification is 100x. E) Hide wear on a flake ridge of a Flint Ridge cache biface (#68). Magnification is 100x. F) Hide wear on a flake ridge of an Upper Mercer cache biface (#11). Magnification is 100x.

The most common microwear pattern among the cache bifaces is the occurrence of SOS polish on the flake ridges of both sides. This pattern was present as the sole form of microwear on 130/164 cache bifaces. Nine additional cache bifaces had SOS polish on the ridges of both sides along with SOS wear in flake scars or in the form of striations on one or both sides. Additionally, six cache bifaces had SOS polish on the flake ridges of one side, yet no evidence of microwear was noted on the opposite face. Overall, 145 cache bifaces contained evidence of SOS contact.

In contrast, only one cache biface (#108) had hide wear on both faces. Another cache biface (#55) had hide wear on the flake ridges of one face, but with no evidence of microwear on the other face. One cache biface (#32) had hide wear on one face, with SOS wear on the flake ridges of the opposite face. Nearly an even number of cache bifaces had hide wear on both faces with SOS polish on one of these faces (n = 6), SOS polish on both faces with hide wear on one face (n = 4), and hide and SOS wear on both faces (n = 4). SOS and hide wear with generic polish on the opposite face was noted for one cache biface (#23). Two cache bifaces contained no evidence of transport wear (#42 and 103).

There are important differences in transport wear patterns relative to raw material type: SOS polish was the sole form of microwear on the majority of bifaces made of Upper Mercer chert (144/153). The remaining Upper Mercer bifaces contained some combination of hide and SOS wear, often on the same face of the artifact. As just noted, no visible signs of wear could be detected on two bifaces, and both were made of Upper Mercer chert. That could suggest these bifaces were crafted on site; biface #42 in fact retains its original flake surface. It may be no coincidence then that the flakes we recovered in 2016 were also of Upper Mercer chert. However, efforts to refit these flakes to the bifaces were unsuccessful.

Eleven cache bifaces were manufactured from a material visually consistent with Flint Ridge flint. Unlike the Upper Mercer bifaces, none of the Flint Ridge cache bifaces had SOS polish on the flake ridges of both sides as the sole form of wear. Only one cache biface of Flint Ridge flint (#67) had SOS polish on the ridges and in the flake scars on both of its faces. In other words, one of the 143 cache bifaces solely containing SOS wear was manufactured from Flint Ridge flint. The other ten Flint Ridge cache bifaces contained evidence of hide wear. One (#108) had solely hide wear on both faces. Six had hide wear on both sides and SOS wear on one or two sides. One had hide wear on one face and SOS wear on the opposite face (#121). Three had SOS wear on both faces and hide wear on one face. In general, this pattern reflects that seen in our transport experiments with the un-bundled artifacts.

None of the artifacts contained evidence of extensive patination or other post-depositional surface modification from the natural environment. Bright streaks of metallic residue were observed on thirty of the cache bifaces. Luckily, this did not cause significant damage to, or breakage of, the artifacts as Kay (1999) noted for the Keven Davis cache in Texas. The metallic residue probably resulted from incidental contact with the implements used during excavation.

In summary, the only wear traces identified on the cache bifaces were those related to transport. Only two bifaces, and all five flakes showed no evidence of transport wear. Thus, it is possible that the manufacture of some cache bifaces did occur on site. The vast majority (n = 162) of cache bifaces showed evidence of transport to the site. The major difference in transport wear patterns conforms to the differences in raw material used to manufacture the cache bifaces. The majority of Flint Ridge bifaces contain a mixture of hide and SOS wear. This indicates that the faces of each biface come into contact with different materials (the hide bag in which they were transported and other stone implements) while jostling around in the bag. These eleven Flint Ridge bifaces appear to have been placed un-bundled into one or more bags for transport and eventual deposition.

In contrast, the majority of Upper Mercer bifaces display evidence, in the form of SOS polish on the ridges of both faces, of being in contact solely with other stone tools during transport. Some of the Upper Mercer bifaces also have hide wear on their flake ridges. Unlike the pattern described by Hill et al (2014) for the Carlisle cache, in which the inner and outer faces of bifaces on the outside layer of the bundled cache were able to be identified via SOS and hide wear respectively, hide wear often occurred on both surfaces and in conjunction with SOS polish on the Upper Mercer bifaces. This indicates that the Upper Mercer artifacts were not tied in place but free to jostle around. That the majority of Upper Mercer bifaces solely exhibit SOS polish may be due to the sheer number of artifacts in the transport container. In other words, the turnover rate for biface movement may not have been great enough to shift bifaces from the interior of the container to the outside, in order to come into contact with hide.

6. Discussion and conclusion

On its face, the Nelson cache bears only a limited resemblance to the specimens from the iconic Clovis caches of western North America – but then a number of the specimens in those caches are themselves unusual relative to more utilitarian Clovis assemblages (Speth et al., 2013). Even so, some of the individual Nelson bifaces (e.g. specimen numbers 1–5) are lanceolate in shape, unmistakably fluted, and if dropped into a more utilitarian Clovis assemblage, particularly one that included bifaces in early stages of manufacture, these would not seem out of place. Nonetheless, a Clovis affiliation is not so obvious for the majority of the Nelson biface specimens, all of which, as we have shown, bear some resemblances to specimens in both Clovis and post-Clovis age caches.

In terms of their morphology and aspects of their technology, the Nelson cache bifaces are reminiscent of Clovis: they have a lanceolate shape and evidence of end-thinning or fluting. However, such is true of some of the specimens in the post-Clovis age caches. Likewise, in their morphometrics the Nelson bifaces do not fall within any particular temporal morphospace, but in fact align with more than one, including Clovis and Late Woodland. The presence on the Nelson bifaces of overface and (rarer) overshot flakes, as well as red ochre, are likewise equivocal with regard to age.

Where the evidence of affiliation of the Nelson bifaces is less equivocal is in the measure of flake scar density: the Nelson bifaces are statistically more similar to the Clovis than the post-Clovis cache specimens. In addition, like specimens in Clovis caches the Nelson bifaces appear to have been made on large flakes. Whether that is also the case for post-Clovis caches cannot be determined, since those are all finished specimens, and in the finishing process evidence of the early stages of their production and of the original stone upon which they were knapped has been erased. Yet, the fact that all of the comparative post-Clovis caches are comprised solely of finished forms is quite distinct from the Nelson cache which, like many Clovis caches, includes bifaces in multiple stages of manufacture (Kilby and Huckell, 2014; Wilke et al., 1991). Indeed, it is because a number of the possible Clovis caches contain only bifaces and preforms that “are not entirely reliable as diagnostics” (Kilby, 2008:38), that makes assigning an affiliation to them difficult.

Likewise, the Nelson early stage bifaces are technologically quite consistent with the finished fluted points seen in Clovis sites in the Midwest, which are also made on smaller flakes, as for example in the projectile points from the Paleo Crossing site (Eren et al., 2018b), Leavitt (Shott, 1993), and Weed sites (Deller and Ellis, 2010) (see also Wernick, 2015). A number of the Nelson cache specimens closely resemble the Sheriden Cave flake as well (Fig. 8) (Redmond and Tankersley, 2005)[2].

Regardless of its affiliation, there are distinctive aspects of the Nelson cache: the bifaces were fashioned, and apparently rather quickly, from flakes derived from what was likely to have been both cobble and tabular pieces of stone. Its manufacturing process gave the cache a decidedly expedient and utilitarian appearance – unlike, for example, the finely made specimens and the large stone ‘platters’ that are part of the Fenn cache (Frison and Bradley, 1999). Likewise, the selection of the stone for manufacture was somewhat lax: at least ~10% of these specimens, including ones made on relatively ‘higher quality’ stone, had cleavage planes or other flaws (see discussion about raw material quality in Eren et al., 2014b). Yet, even with such flaws in the stone the pieces were transported at least 50 km, which suggests that the knappers were sufficiently skilled that they could work around the flaws (there is, in fact, evidence of this, e.g. specimen numbers 6, 15, 17 and 104); or, that they were more concerned with having a large enough supply of stone to fall back on if needed; or, that the distances back to the sources were not that far that they could not be easily re-visited. None of the post-Clovis age caches, it should be noted, were marked by a comparable incidence of flawed stone.

Based on the transport wear patterns, both the Upper Mercer and Flint Ridge stone was transported in containers that resulted in stone-on-stone (SOS) and hide wear, though there was a disproportionate degree of each: unlike the Upper Mercer specimens, the Flint Ridge specimens displayed relatively more hide wear than SOS wear. Although that difference sheds some light on how they were transported (e.g. that the Flint Ridge pieces were at the bottom or outer edges of the bag, which possibly may also be the source of the ochre), it is not evident from this difference which of the sources might have been visited last prior to arriving at the place where the cache was deposited. The much larger number of Upper Mercer bifaces (93% of the assemblage), however, could suggest that source was the final stop prior to the cache being put in place. Along with the transported items, additional Upper Mercer stone was carried as well, since there is evidence (the presence of flakes and the absence of transport wear) that two of the bifaces in the cache were manufactured on site.

Returning to the possibility that this is a Clovis age cache – a possibility we have been unable to *disprove*, even if we have been unable to fully demonstrate it – it is noteworthy that in its morphology and technology, it is consistent with Clovis assemblages known from this region. If the cache is utilitarian and logistical (e.g. a re-supply locality), as opposed to having had a ritual function (for which there is no apparent evidence), it implies it was intended for retrieval at a later time. Whether that indicates “a degree of confidence on the part of those who placed the cache that future movements were predictable” (Kilby and Huckell, 2014:218) or the opposite, that movement was unpredictable, and it was not known whether stone would be available where travel would take them, and the cache insured they would not have to return all the way back to the source (e.g. Meltzer, 2002), cannot be discerned. Although groups may not have been long residents in this region (Eren, 2011; Eren et al., 2018b) neither possibility can be precluded.

6.1. Implications for Clovis foragers

Based on the entirety of the evidence, we strongly suspect, though unfortunately cannot confirm, that the Nelson cache is Clovis in age and affiliation. If that is correct, however, it has interesting implications for Clovis period technology and adaptations in eastern North America. We close with a few comments in this regard, with the explicit proviso that the Nelson cache may not be of Clovis age.

Late Pleistocene people using Clovis technology are generally considered to be among the first widely successful populations inhabiting North America (Meltzer, 2021). Their flexible, maintainable, and resilient toolkit likely facilitated their movements through, and exploitation of, largely unknown and unpredictable territory (Ellis, 2008; Eren, 2013; Kelly and Todd, 1988; Meltzer, 2021; Thomas et al., 2017). In addition to their distinctive flaked stone fluted projectile point, their stone tool assemblages included large bifaces and bifacial thinning flakes, prismatic blades and blade cores, and unifacially flaked scrapers and engravers (Bradley et al., 2010; Eren and Buchanan, 2016; Jennings and Smallwood, 2019; O'Brien et al., 2016a; Smallwood and Jennings, 2015). There is also archaeological evidence for a variety of implements made from bone, antler, teeth, ivory, and plant materials (Adovasio, 2018; Adovasio et al., 2001; Bradley et al., 2010; O'Brien et al., 2016b).

Caches are another distinctive component of the Clovis repertoire, but they are relatively rare (Collins, 1999; Meltzer, 2002) – again, there are only 10 securely culturally affiliated instances. Save for the small tool cache from Sheriden Cave, Ohio (Redmond and Tankersley, 2005), all of these caches have been found west of the Mississippi River (Huckell and Kilby, 2014: Figure 1.1) (Fig. 1), although whether that geographic pattern is meaningful or a consequence of recognition or sampling bias is not known. Likewise, and as previously noted, there are multiple interpretations of the purpose of Clovis caches (Collins, 1999; Huckell and Kilby, 2014; Kilby and Huckell, 2013; Meltzer, 2002, 2021; Speth et al., 2013).

In addition to finished fluted points Clovis caches also include unfinished projectile points, bifaces and bifacial cores, blades and blade cores, and the occasional flake or flake tool. Most cache pieces are made of lithic raw material from geological sources hundreds of kilometers away from where the cache was found (Kilby, 2014: Table 11.2; the de Graffenreid cache, found within a kilometer of the source, is a notable exception). In some cases, the stone is of such high quality and of varied materials and/or variegated colors (e.g. the specimens in the Drake and Fenn caches), that it appears to have been selected for its aesthetic quality. In a few instances (Anzick, East Wenatchee, Sheriden Cave) the cache includes bone rods, which are sometimes scored or etched (Huckell and Kilby, 2014; Kilby, 2008; Lyman and O'Brien, 1999; Redmond and Tankersley, 2005).

On a continental scale it may seem incongruous that the Nelson cache – if it is Clovis in age – only contains bifaces. However, the fact that these bifaces are principally made on flakes is fully consistent with Clovis period technology in Ohio and the Lower Great Lakes region, where large, flat flakes, often knapped from bifaces, appear to be the Clovis toolkit's foundation. Eren and Andrews (2013) quantitatively demonstrated that Lower Great Lakes foragers transported flakes rather than biface cores. Fluted points in the region were regularly made from large flakes (Eren et al., 2018b), as were other tool forms (Eren, 2013). And to reiterate, the Sheriden Cave cache exhibits a large flake morphologically and technologically identical to several in the Nelson cache. A fluted point, or some other tool, could have easily been produced from the Sheriden Cave flake.

The Lower Great Lakes Clovis focus on the large, flat flake entirely conforms to the hypothesis that these foragers were broadly unfamiliar with landscape. While stone outcrops in the region may not have been difficult for Clovis colonizers to find (Meltzer, 2003:231), prior to exploration and settlement colonizers would not know whether stone outcrops existed there at all, and once one was found, where the next outcrop might be. In other words, a toolstone-rich landscape in reality may be toolstone poor relative to a forager who is unfamiliar with it (Eren and Andrews, 2013). The rational decision in this situation would be for colonizers to "gear up" as efficiently as possible (Ellis, 2011; Sellet, 2004). The regular use of large, flat flakes would have solved this problem. Kuhn (1994) proposed a mathematical model of forager transport efficiency which states that it is more efficient to carry several small tools or tool-blanks than a core-tool (see also Jennings et al., 2010; Eren and Lycett, 2012; Prasciunas, 2007; Surovell, 2009). This is because carrying a core or core-tool results in a forager unavoidably carrying waste. When flakes are removed from the core, platforms must be prepared, which wastes stone. Since there also exists the chance of breaking the desired flake, a forager is unintentionally transporting waste in the form of potential flake removal mistakes. Even more concerning would be, in the case of a bifacial core, the possibility of breaking the core itself via a perverse fracture (Miller, 2006; Bradley et al., 2010). Alternatively, by carrying around several small tool-blanks, a forager can avoid carrying the waste inherent to core-tools and instead fill that weight quota with extra tool-blanks. Other benefits of large, flat flakes include their increased resharpening capacity; their ability to remain sharper, longer; and their flexibility to be used for a variety of tasks or turned into a variety of tools (Andrews et al., 2015; Eren, 2013).

Caching, too, has been proposed to be a risk-mitigating behavior for colonizers unfamiliar with the landscape (Meltzer, 2002, 2021). Mobile Clovis foragers may have left "resupply depots" in certain spots as they moved across the region to avoid having to backtrack in the event that new stone outcrops were not found in the regions into which they were moving. Thus, a cache like Nelson, which is comprised of bifaces made from flakes, appears to be melding two risk-mitigating behaviors into one. This sort of technological risk-mitigation may have allowed Clovis foragers of the Lower Great Lakes region to partially offset the risks that come with long-distance mobility, exploration, and landscape learning necessary for successful colonization (Eren and Andrews, 2013; Eren et al., 2019; Meltzer, 2002, 2003, 2004, 2021; Miller et al., 2018).[4]

Whatever its affinities, the Nelson cache best fits the utilitarian category of caches. And if it is a Clovis utilitarian cache, its form, technology and presence is consistent with a colonization pulse into the recently deglaciated Lower Great Lakes landscape.

CRediT authorship contribution statement

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[4] We note that a third possible Clovis cache was said to have been found around 1900. Vietzen (1973:32) reports a "cache of 12 Paleo-Indian spearheads" found in South Amherst, Ohio made from a "dark gray Onondaga chert". Vietzen (1973) reports that the points range from 6.35 cm to 7.62 cm in length – sizes comparable to the small Clovis points of Ohio and the Lower Great Lakes region. We do not know the whereabouts of this cache, or if it even existed, but we currently have no good reason to doubt its reality given the 1973 publication date and alleged discovery over a century ago.

Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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