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Characterizing Cumberland fluted biface morphology and technological organization

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ABSTRACT

Cumberland bifaces are frequently referenced in discussions of fluted point technology, Paleoindian chronologies, and Younger Dryas adaptations. However, due largely to the absence of stratified, datable components, limited information exists about Cumberland lithic technology. Only brief descriptions of morphology, reduction sequence, and potential chronologies based on exceptionally small datasets are available in the existing literature. To address these deficiencies, a study of biface morphology and technological organization was conducted based on over 900 fluted Cumberland bifaces. Morphological and technological similarities to other fluted biface types, as well as bracketing radiocarbon ages, suggest that Cumberland bifaces likely date to the early Younger Dryas. Cumberland appears to represent a maintainable technology used by people adapted to an environment with predictable resources. Reconstructing artifact life histories suggests Cumberland technology was related to a logistically mobile settlement strategy.

1. Introduction

Since originally defined by Thomas M. N. Lewis in 1954, Cumberland fluted bifaces have received long-term and widespread interest. They are frequently referenced in discussions of Paleoindian chronologies (Anderson and Sassaman, 2012; Anderson et al., 2010, 2015; Broster et al., 2013; Driskell et al., 2012; O'Brien et al., 2001, 2014) and potential Younger Dryas (YD)-related human adaptations (Anderson et al., 2011; Meeks and Anderson, 2012). However, questions still remain regarding the production, use, and timing of Cumberland bifaces in relation to other Paleoindian technologies. While there is an extensive body of literature devoted to understanding other fluted biface technologies (e.g., Amick, 1999; Bradley et al., 2010; Gingerich, 2013; Waters et al., 2011), research related to Cumberland has been extremely limited. Nearly all previous studies of Cumberland technology were conducted on datasets of fewer than 20 specimens (Boldurian and McKeel, 2011; Cambron and Hulse, 1961; Jolly, 1972; Morse et al., 1964). Thus, until there is a thorough understanding of what Cumberland is, discussions related to its chronological association with other biface types, technological organization, and relevance to YD-related adaptations, will remain speculative.

Cumberland represent the instrument-assisted fluted horizon in the North American Midsouth, and though currently undated, are assumed to be generally contemporaneous with the earliest part of the YD (Anderson, 2004; Anderson and Sassaman, 1996; Anderson et al., 2010, 2015; Bradley et al., 2008; Broster et al., 2013; Ellis and Deller, 1997; Fiedel, 1999; Goodyear, 1999; Meeks and Anderson, 2012; Meltzer, 2009; Tankersley, 1990, 1996). While these bifaces are prevalent throughout the Midsouth, they have only been recovered from surface or disturbed contexts (Anderson et al., 2010, 2011; Goodyear, 1999). Jolly's (1972) study comparing Cumberland and Clovis fluted biface technology in the Middle Tennessee River Valley, though 30 years old, is still the most detailed discussion of the Cumberland biface reduction sequence. However, the small sample size (n = 14) provides limited support for his interpretation of Cumberland technology. Although Bell (1960) states the Cumberland toolkit consists of various unifacial tools, there are currently no known discrete Cumberland assemblages.

The overall objective of this study is to identify, and offer potential explanations for, variability within Cumberland biface technology. The research presented here is the first to comprehensively address the question, “What is Cumberland?” from the perspective of technological organization, and incorporates previous studies of geographic distribution and chronology with new morphological and technological data. One way to link lithic artifacts to behavioral adaptations is to reconstruct how hunter-gatherers organized their lithic technologies (Binford, 1979; Kuhn, 1995; Shott, 1986; Torrence, 1983). Investigating the organization of technology allows us to view technology as a set of behaviors related to human adaptation rather than a set of objects related to a production procedure (Nelson, 1991). As such, studying how bifaces were made, hafted, used, refurbished, and discarded can offer valuable insight into how Cumberland technology was organized (Kuhn, 1995; Nelson, 1991). In turn, the *life histories*, as it were, of Cumberland bifaces can be used to support inferences about behavioral

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adaptations in the Midsouth during the late Pleistocene (Binford, 1979; Nelson, 1991).

2. Geographic distribution

Unlike most other diagnostic point types, there is not a type-site for Cumberland fluted-bifaces. Rather, the genesis of Cumberland as a type is derived from the dense concentration of bifaces recovered along the Cumberland River in middle Tennessee during the early twentieth century. Lewis (Lewis, 1954) coined the name *Cumberland* to describe a large, thick lanceolate fluted-biface, which he saw as similar to Clovis and found throughout the Cumberland River Valley. The core geographic distribution of Cumberland encompasses much of the area between the Tennessee and Ohio Rivers (Fig. 1) (Anderson et al., 2010; Justice, 1987). The conflation of typological names, such as with Barnes in the Great Lakes region, may explain the identification of some Cumberland-like bifaces across a larger territory (e.g., Bradley et al., 2010; Justice, 1987; White, 2006). Notably, the Midsouth is also characterized by an abundance of high-quality cherts (Amick, 1987; Parish, 2011, 2013). The majority of Cumberland bifaces are made from Fort Payne and St. Louis cherts, which naturally occur in tabular and cobble forms from northern Alabama to central Kentucky.

Data available in PIDBA and state surveys suggest that people using Cumberland fluted bifaces had a predilection for major river valleys in the Midsouth, similar to Clovis (Anderson, 2004; Anderson et al., 2010; Barker and Broster, 1996; Breitburg and Broster, 1994; Broster and Norton, 1996). Based on Clovis data, Miller (2011) suggests that rather than sampling or population biases, the distribution of fluted bifaces in the Midsouth reflects a land-use strategy focused on the intersection of rivers, physiographic boundaries, and toolstone sources. It is reasonable to assume that this pattern holds true for Cumberland as well, given the similarities in technological organization between the two types (Tune, 2016).

Though Cumberland bifaces are dispersed throughout the Midsouth, relatively high densities have been documented in certain areas that may represent habitual-use sites. These locations may be similar to aggregation sites associated with Clovis macrobands (Anderson, 1990, 1996; Smallwood, 2012), and may reflect a post-Clovis continuation of macroband aggregation behaviors. The Sandy Springs site, in southern Ohio, is near the northern extent of Cumberland distribution and is located in close proximity to a saline spring (Seeman et al., 1994; Tankersley, 1994). At least 15 Cumberland bifaces have been documented from the site, which has limited evidence for on-site biface reduction and a high percentage of finished bifaces made from non-local raw materials (Aagesen, 2006; Seeman and Prufer, 1982; Seeman et al., 1994; Tankersley, 1989).

The Parris Collection and Heaven's Half Acre may represent habitual-use sites near the southern extent of Cumberland distribution. The Parris Collection primarily comes from multiple sites in Hardin County, in south-central Tennessee (Tune et al., 2015). Extensive research by noted avocational archaeologist Jim Parris identified a series of fluted biface sites concentrated on remnant levees of the Tennessee River. Heaven's Half Acre represents a series of fluted biface sites near the Tennessee River in northern Alabama. Since the 1950s avocational archaeologists have recovered large numbers of Cumberland and other fluted biface forms from the margins of geomorphic depressions that may have been wet season ponds during the late Pleistocene (Futato, 1996; King, 2007). Both the Parris Collection and Heaven's Half Acre

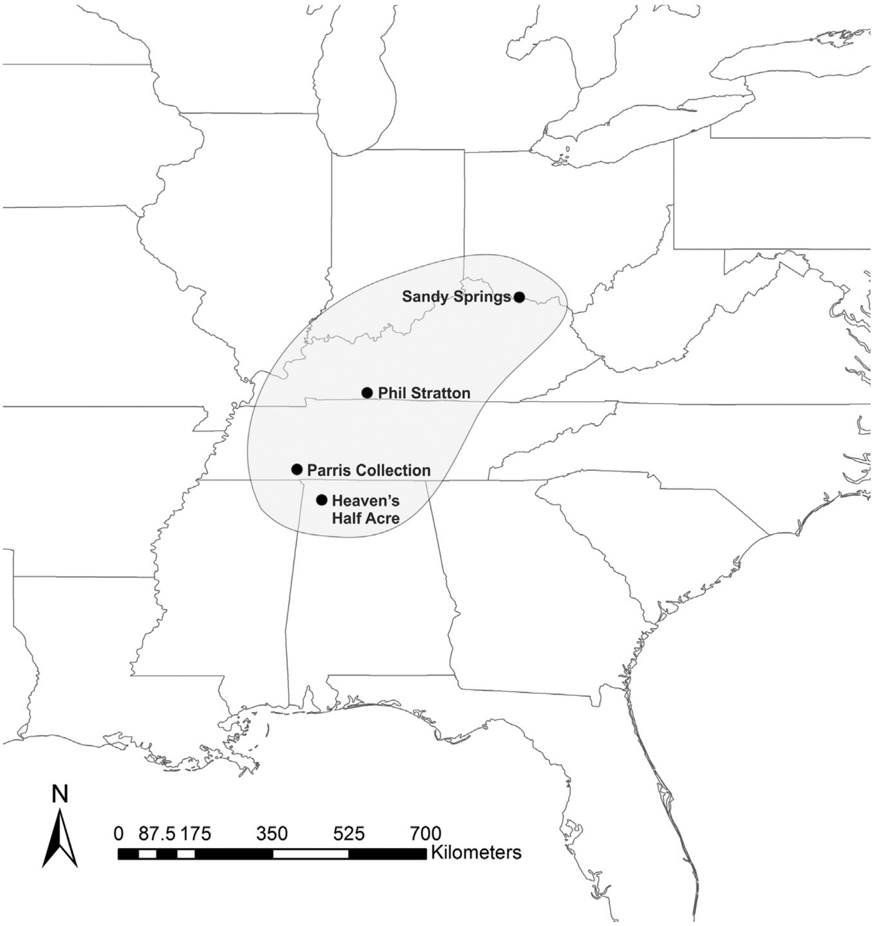

Fig. 1. Generalized core distribution of Cumberland fluted bifaces and sites referenced in text.

assemblages are characterized by impact damage and basal fragments made on locally available raw materials, and likely reflect discard behaviors and possibly toolkit maintenance activities.

3. Chronological considerations

Buried and datable Paleoindian sites are notoriously rare in the Midsouth (e.g., Miller and Gingerich, 2013), and at this time Cumberland bifaces have only been recovered from surface contexts and palimpsest components containing multiple biface types. This situation has prevented Cumberland from being directly dated. Technological similarities to other well-dated, and presumably coeval, biface types in adjacent regions, as well as stratigraphic associations in the Midsouth support a post-Clovis chronology. Based on widely accepted technological chronology, the emergence of instrument-assisted fluted technologies across the continent post-date Clovis and generally corresponds to the earliest part of the YD (Anderson et al., 2010, 2015; Bradley et al., 2008; Ellis and Deller, 1997; Fiedel, 1999; Goodyear, 1999, 2010; Meltzer, 2009; Tankersley, 1990, 1996). Technologically similar Folsom fluted bifaces have been securely dated throughout the Plains and Southwest to 10,700–10,390 ^{14}C yr BP (12,680–12,260 cal yr BP) (Frison and Stanford, 1982; Hill, 2001; Hill and Hofman, 1997; Hofman, 1995; Meltzer, 2006), and correspond well with the expected range of Cumberland in the Midsouth.

Assuming that Clovis immediately precedes instrument-assisted fluting in the Midsouth, as it does in other regions, then it is possible to establish a maximum age for Cumberland, which may also be contemporaneous with other regional fluted technologies such as Redstone. Relying on charcoal-based radiocarbon ages, the age of Clovis in the greater Southeast matches that of other regions, and ranges from 10,980 ± 75 to 10,915 ± 30 ^{14}C yr BP (12,860 ± 90 to 12,760 ± 30 cal yr BP) (Brose, 1994; Goodyear, 2013; McAvoy and McAvoy, 1997; Waters et al., 2009). Therefore, Cumberland is assumed to occur after ca. 12,800 cal yr BP.

Cumberland bifaces (as well as Quad, Beaver Lake, and Dalton) were recovered from the lowest cultural deposits of Dust Cave, northern Alabama (Driskell, 1994, 1996; Sherwood et al., 2004). A heavily reworked Cumberland biface and a Cumberland-like distal biface fragment were recovered from the basal components (Driskell, 1994, 1996; Hollenbach and Walker, 2010; Sherwood et al., 2004). The precise stratigraphic sequence of the Paleoindian bifaces at Dust Cave is unclear, as multiple types co-occur within the same deposits. Dalton, however, generally occurs above other Paleoindian forms (Driskell et al., 2012; Sherwood et al., 2004), and thus, may provide a minimum age for Cumberland. Eight radiocarbon ages on dispersed charcoal in the lowest Quad/Beaver Lake/Dalton component (Zone U) range from 10,500 ± 60 to 10,310 ± 60 ^{14}C yr BP (12,430 ± 120 to 12,140 ± 140 cal yr BP) (Sherwood et al., 2004). As such, ca. 12,100 cal yr BP may represent a minimum age for Cumberland.

The Phil Stratton site, in Kentucky, has been presented as an intact Cumberland site dating older than 14,000 cal yr BP (Gramly, 2008, 2009, 2012, 2013, 2015). However, reanalysis of the existing assemblage and new excavations have documented significant contextual problems with the assemblage and proposed dates (Tune and Melton, 2013). Of the 42 identifiable bifaces, only six are Cumberland. The remaining 36 are Archaic, Woodland, and Mississippian. Based on the diagnostic biface assemblage, the Phil Stratton site does not represent a pure Cumberland site. Rather, the site appears to have been extensively re-occupied beginning in the late Pleistocene and continuing throughout the entire Holocene.

In 2013 I directed an excavation of the site to study the stratigraphy and potentially recover additional artifacts. The 2013 excavation units were placed immediately adjacent to the previous excavation blocks to correlate the geologic profiles and evaluate previous interpretations of the site (Fig. 2). Two units were specifically placed adjacent to a "witness section that was set aside for future investigators" (Gramly, 2013:143). The 2013 excavation documented shallow, deflated deposits that are extensively disturbed by tree roots, bioturbation, and agricultural processes.

Two geologic units were recorded in 2013 at the southern-most edge of the site where deposition is greatest (Fig. 3). The upper Unit 2 (0–25 cm) is a brown (10YR 4/4) silty clay loam with subangular blocky structure, few small roots, abundant iron manganese accumulations, and an abrupt wavy boundary. Unit 2 is composed of eolian sediments redeposited from the erosion of the upper hill slope. The lower Unit 1 (25 + cm) is an oxidized brown clay loam (7.5YR 4/6) with few iron manganese accumulations, common bioturbation features, and an abrupt (erosional), wavy boundary. Unit 1 represents a clay residuum formed from the weathering of the limestone bedrock and is commonly exposed throughout the surrounding area due to erosion by intensive agricultural practices. In some areas of the site Unit 2 is covered by up to 25 cm of recently redeposited fill consisting of a mixture of both Units 1 and 2. Artifacts are deposited throughout Unit 2, and occasionally intrude into Unit 1 through root molds and animal burrows. Artifacts are also present in the redeposited overburden.

Gramly (2012) contends the Cumberland occupation at the Phil Stratton site predates 14,000 cal yr BP based on a series of optically stimulated luminescence (OSL) dates. A critical review of the published literature, however, clearly indicates that such early dates do not correlate with the artifact-bearing deposits. As such, a calibration curve was constructed to correlate the OSL ages with the artifact-bearing deposit (Gramly, 2013, 2015). The OSL calibration curve is based on two unsupported assumptions. First, the modern ground surface at the Phil Stratton site is assumed to be equivalent in age to the end of Peoria Loess deposition, which according to Gramly (2013, 2015) occurred at 12,800 cal yr BP. Peoria Loess deposition has been well-studied throughout the Central Plains and Midwest and its terminus is dated to 16,000–12,000 cal yr BP (Bettis et al., 2003; Johnson and Willey, 2000; May and Holen, 2003; Muhs et al., 1999, 2001, 2008). Second, such a calibration also assumes a constant rate of deposition has occurred without any erosional episodes. However, the Phil Stratton site is located on a highly eroded landform that has been subjected to intense agricultural plowing since the early nineteenth century (Phil Stratton personal communication). Moreover, a major unconformity representing another episode of erosion is clearly visible at the contact of geologic Units 1 and 2 (Fig. 4). Thus, the variable rate of deposition and erosion, as well as the unsupported age of the ground surface refute any interpretations drawn from the OSL calibration curve for the Phil Stratton site.

Furthermore, the OSL ages likely represent pedogenesis rather than the timing of deposition because pedogenic processes mix grains of various ages (Bateman et al., 2007a, 2007b). Pedogenesis is known to compromise the results of OSL dating, specifically in upland geomorphic settings with thick, weathered argillic horizons (Ahr et al., 2013), such as at Phil Stratton. Ahr and colleagues studied the effects of pedogenesis in sandy sediments of upland sites in Texas and found that "pedogenic mixing of particles of various apparent ages, and… changes in environmental dose rate due to weathering" skewed the ages of those samples (Ahr et al., 2013:221). As a result, the OSL ages represent "apparent age estimates rather than true depositional ages" (Ahr et al., 2013:14). Because Phil Stratton is in a similar geomorphic setting, and similar pedogenic processes have affected the sediments, the OSL ages there also likely reflect pedogenesis rather than deposition. Thus, at this time the OSL ages from Phil Stratton do not provide an accurate age of Cumberland occupation.

4. Materials and methods

To identify and interpret variability in Cumberland technology, over 900 Cumberland fluted bifaces were examined. While it is very likely that fluted and unfluted Cumberland bifaces were part of the same technological system, the lack of context and typological similarities to other late Pleistocene biface forms (e.g., Beaver Lake), preclude the analysis

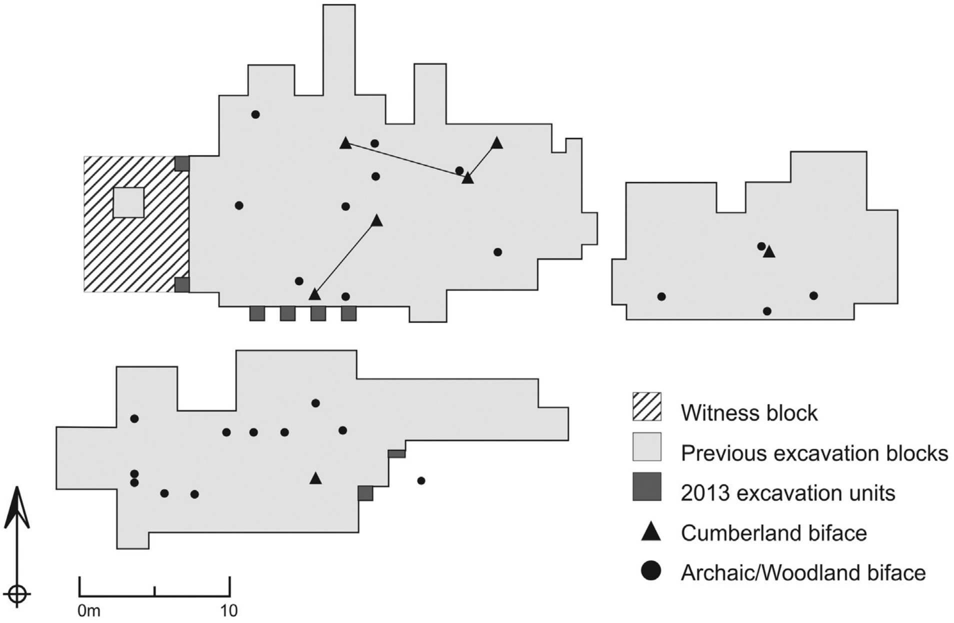

Fig. 2. Phil Stratton site excavation blocks and distribution of identifiable bifaces. Adapted from Gramly (2013).

of unfluted specimens in this study. In time fluted and unfluted Cumberland bifaces may be recognized as part of the same technological system that also includes Beaver Lake, similar to Folsom and Midland bifaces (Amick, 1995; Hofman, 1992; Jennings, 2012; Meltzer, 2006). Primary data collected from collections throughout the Tennessee and Ohio River Watersheds, as well as data from PIDBA, were analyzed to study quantitative and qualitative attributes of Cumberland biface morphology (Table 1). The PIDBA data were previously collected by regional Paleoindian specialists. In turn, the combined datasets were used to study technological elements related to artifact life histories. Assessing biface production, use, reuse, and discard, facilitates interpretations of technological organization and may help explain variability (Andrefsky, 2010). Finally, inferences about settlement strategies were made based on the organization of technological elements.

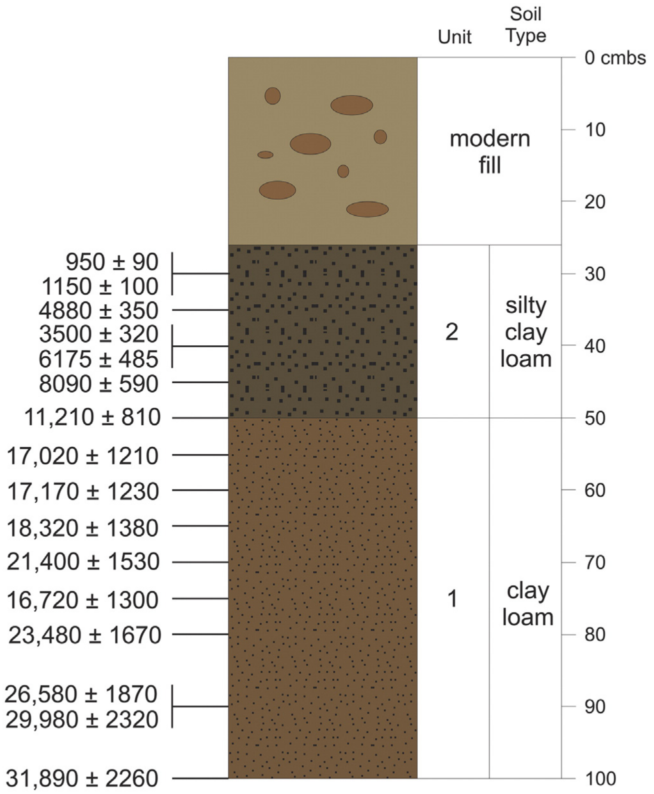

Fig. 3. Generalized profile of the Phil Stratton site with the relative depths of OSL ages reported by Gramly (2013) correlated with the stratigraphic profile documented in the 2013 excavation.

While intact and dateable late Pleistocene archaeological sites are rare in the Midsouth, exceptional fluted biface survey data has been compiled (Anderson, 2004; Anderson et al., 2010; Goodyear, 1999; Miller and Gingerich, 2013). Potential biases and limitations are known for PIDBA datasets and include incomplete data, sample inconsistency, site formation processes, and ground cover (see Anderson et al., 2010 and Prasciunas, 2011 for a detailed discussion of potential biases). Given these limitations, PIDBA datasets are still widely accepted to model regional human behaviors (Anderson and Gillam, 2000; Anderson et al., 2011; Lanata et al., 2008; Meeks and Anderson, 2012; Miller, 2011; Shott, 2013; Smallwood, 2012; Smallwood et al., 2015).

Due largely to their relative scarcity, Cumberland bifaces are known by artifact collectors and PIDBA data contributors as one of the more commonly reproduced biface types. Unfortunately, there is often no easy way of determining modern reproductions from archaeological specimens when they are part of a larger collection (whether public or private). This reality, as well as the broader issues of working with

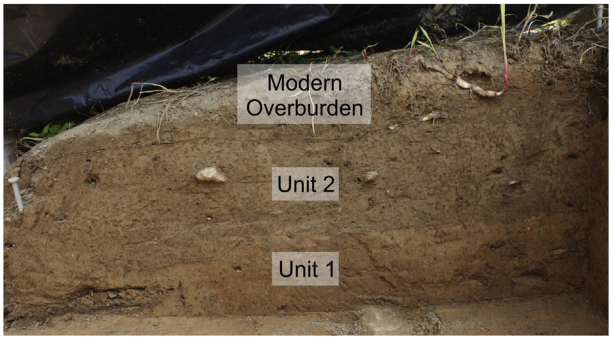

Fig. 4. Stratigraphy documented during the 2013 excavation. East wall of Unit S21/E17 showing abrupt boundary between geologic Units 1 and 2.

Table 1
Collections included in analyses.

Collection	Number of specimens	Curation location	Collection provenience
Discovery Park of America	9	Union City, Tennessee	Tennessee
Guerri Collection	15	Terre Haute, Indiana	Tennessee, Alabama, Kentucky, Ohio
King Collection	88	Cullman, Alabama	Alabama
Parris Collection	39	Savannah, Tennessee	Tennessee
Indian Mound Museum	12	Florence, Alabama	Alabama
Tennessee Division of Archaeology	13	Pinson, Tennessee	Tennessee
Smithsonian National Museum of Natural History	21	Washington DC	Tennessee, Alabama, Kentucky
Stratton Collection	9	Adairville, Kentucky	Kentucky
Tennessee State Museum	9	Nashville, Tennessee	Tennessee
PIDBA, Tennessee	314		Tennessee
PIDBA, Alabama	377		Alabama

private collections, has been the subject of much debate and recently highlighted in the discussion "Pros and Cons of Consulting Collectors" in the SAA Archaeological Record, Volume 15, No. 5. Throughout the research presented here, every effort was made to eliminate artifacts with questionable provenience. Furthermore, in situations where I thought the inclusion of an artifact into this research would directly contribute to its monetary value, I removed it from my datasets.

4.1. Methods for characterizing morphology

Assessing biface morphology is a productive way to identify and document the range of variability within biface technologies. The morphological study presented here is based on primarily analysis of 216 finished Cumberland fluted bifaces (Table 2). An additional 691 finished Cumberland bifaces record by other researchers and documented in PIDBA were also included in this study. All maximum measurements and morphological ratios used in this study are documented only on complete specimens. Basal width, waist width, depth of basal concavity, and depth of basal concavity-to-basal width are documented from basal fragments and complete specimens.

I characterize Cumberland biface morphology using a standard set of metric variables and morphological ratios (Eren et al., 2011; Jennings, 2013; Morrow and Morrow, 1999; Smallwood, 2012; Thulman, 2006). For each finished biface, I recorded the maximum length, maximum width, maximum thickness, basal width, waist width, face-angle, flute length and width (when possible), inner flute thickness, depth of basal concavity, weight, presence/absence edge grinding, and blank form (when possible). I calculated morphological ratios such as length-to-width, width-to-thickness, depth of basal concavity-to-basal width, and lateral indentation index (LII) for each biface. Presumably the most standardized attributes reflect the elements most critical to the overall technological system. As such, I calculated a coefficient of variation (CV) for all attributes as a way to measure relative standardization (Eerkens and Bettinger, 2001). Coefficient of variation provides a statistical technique to assess standardization between samples by comparing standard deviation to the mean (Eerkens and Bettinger, 2001). The smaller a CV value is, the more standardized the sample is.

Table 2
Cumberland bifaces included in analyses.

Condition	Collections	PIDBA		Total
		Tennessee	Alabama	
Complete	85	206	104	395
Base	76	59	155	290
Midsection/distal	27	28	108	163
Fragments	0	16	6	22
Preforms	28	5	4	37
Total	216	314	377	907

4.2. Methods for studying technological organization

To understand how Cumberland bifaces were made, used, reworked, and discarded I recorded flaking pattern, basal grinding, thermal alteration, fluting elements, and post-fluting reduction, as well as patterns in fracture types, reworking, and abandonment. These attributes reflect elements of provisioning strategies as they are related to organization (Pitblado, 2003).

While patterns in the nature and frequency of fracture types potentially reflect functional behaviors, patterns of reworking and repair also reflect provisioning strategies; thus, I documented type and frequency of reworking. I calculated technological ratios such as average grinding length-to-maximum length and average flute length-to-maximum length for complete bifaces. I documented the apparent reason for abandonment to understand why and when Cumberland bifaces were deemed no longer useful.

4.3. Methods for interpreting settlement strategies

While the interpretation of Cumberland settlement strategies presented here is framed in terms of provisioning strategies – *provisioning places* versus *provisioning individuals* – it is important to emphasize that this is not a dichotomy, but rather represents a continual range of variation (Kuhn, 1990). Furthermore, it should be noted that provisioning strategies are not static, but are flexible enough to be altered to meet seasonal or fluctuating demographic needs (Binford, 1980). This is particularly relevant when one considers the evidence that late Pleistocene populations in the Southeast were likely regularly aggregating in macroband groups (Smallwood, 2012). Though Smallwood (2012) focuses specifically on Clovis settlement patterns, it is likely that Cumberland settlement patterns were similar, especially given the similarities in technological organization between the two technologies (Tune, 2016). Furthermore, large Cumberland assemblages from sites such as Sandy Springs (Aagesen, 2006; Seeman and Prufer, 1982; Seeman et al., 1994; Tankersley, 1989), and collections such as the Parris Collection (Tune et al., 2015) and Heaven's Half Acre (King, 2007) may provide evidence of potential Cumberland aggregation behaviors similar to Clovis.

Residentially organized strategies are marked by frequent moves between short-term residential camps with continual transport of tools in environments where resource distribution is unknown or unpredictable (Kuhn, 1992). To ensure tools are available when they are needed, technology is structured around the concept of provisioning individuals with "personal gear" (Binford, 1979). As such, bifaces are expected to be used to the point of exhaustion and exhibit extensive rejuvenation when they are discarded, which results in a high ratio of complete to broken bifaces (Table 3, Pitblado, 2003). Conversely, a logistically organized strategy is structured around the provisioning of specific places on the landscape. Environments where resource distribution is known or predictable, and future needs can be expected, favors a logistically organized strategy (Kuhn, 1992). As bifacial tools become dull or break, they are replaced rather than reworked resulting in a relatively low complete-to-broken biface ratio (Pitblado, 2003).

5. Characterizing Cumberland

5.1. Cumberland biface morphology

Cumberland bifaces exhibit standardized basal elements and greater variation in length. The least variable attributes of Cumberland biface morphology are maximum width (23.83 mm), basal width (20.95 mm), and inter flute thickness (5.43 mm) with CVs less than 20% (%) (Table 4). Maximum thickness (7.58 mm), and waist width (19.85 mm) are the next most standardized attributes, with CVs less than 25%. The average maximum length is 75.07 mm, with a CV of 33%. The average basal concavity depth is 3.17 mm with a CV of 51%, while the ratio of basal concavity depth-to-basal width has a CV of 67%.

Based on morphological ratios, Cumberland bifaces are over three times longer than they are wide; likewise, width-to-thickness is approximately 3.25:1. Waist width-to-basal width and the lateral indentation index (LII) both have a CV less that 30%. Waist width-to-maximum width has a CV of 31%. These morphological ratios reflect the characteristically “waisted” shape of Cumberland bifaces, and further reflect standardization in hafting methods.

Face-angle was recorded for 80 complete and finished specimens. Face-angle quantifies the expansion of the lateral edges of bifaces by measuring the angle of the lateral edges to the base (Roosa and Ellis, 2000). Essentially this measurement further quantifies the relationship between basal and maximum width. Therefore, laterally reworked bifaces should be more variable, while distally reworked bifaces should be more standardized. The average face-angle of Cumberland bifaces is 92.60 degrees, and is the least variable attribute (CV = 4%). The overall morphological characteristics indicate that Cumberland bifaces were primarily reworked from the distal end. This characteristic is similar to other Paleoindian point types such as Folsom, which typically exhibit little resharpening of the lateral margins and are reworked from the tip (Ahler and Geib, 2000).

5.2. Cumberland biface technology

This study focuses on technological attributes that are related to basal treatment and flaking techniques. Cumberland bifaces, on average, are ground to 25.47 mm from the base, or 35% of the total length (Table 5). The average flute length is 46.32 mm, or 60% of the total length. The average flute width is 11.49 mm. Average flute length, however, is considerably variable (CV = 45%), while flute widths are more standardized (CV = 29%). The variation documented in flute dimensions further suggests that Cumberland bifaces were distally reworked, with only minor modification to the lateral edges after completion. Basal beveling occurs in 49% of Cumberland bifaces examined, while 51% are not beveled. This characteristic is likely related to basal preparation prior to fluting, which has also been previously noted on Clovis bifaces (Broster et al., 2013; Collins, 1990; Waters et al., 2011; Waters and Jennings, 2015).

Collateral flaking is the dominant flaking pattern (81%) documented on complete, finished specimens. This is an important aspect of Cumberland technology due to the creation of a midline ridge typically running the length of the biface. Interestingly, 5% of Cumberlands studied exhibit occasionally overface flaking similar to Clovis bifaces. These overface flake scars are likely remnants of percussion flaking during initial bifacial reduction. Overface flaking does not appear to be an intentional reduction method for the production of Cumberland bifaces.

Table 3
Expected characteristics of provisioning strategies.

	Provisioning individuals	Provisioning place
Mobility	Residentially	Logistically
Intensity of use	Intensive	Non-intensive
Rejuvenation	High	Low
Reason for discard	Exhausted	Broken
Complete:broken	High	Low

Table 4
Morphological characteristics of Cumberland bifaces.

	Average	Maximum	Minimum	CV
Maximum width	23.83	52.17	10.00	0.17
Basal width	20.95	35.61	10.00	0.18
Maximum length	75.07	167.88	24.91	0.33
Waist width	20.78	40.50	13.97	0.22
Waist width:basal width	0.85	1.23	0.00	0.24
Waist width:maximum width	0.74	1.14	0.00	0.31
Length:width	3.14	6.02	1.12	0.26
Depth of basal concavity	3.17	11.02	0.00	0.51
Depth of basal concavity:basal width	0.15	1.33	0.00	0.67
Maximum thickness	7.58	19.00	2.82	0.21
Width:thickness	3.23	7.40	1.16	0.22
Lateral indentation index	0.07	0.10	0.02	0.26
Inter flute thickness	5.43	8.16	3.45	0.18
Face-angle	92.60	101.35	82.05	0.04

Thermal alteration, identified by the presence of potlid fractures, occurs in low frequency (11%) and was likely not related to the production process. Thermal alteration is only identified on biface fragments. Many of the potlid fractures are located along the margins of transverse breaks, suggesting that heating occurred after they were discarded. Other specimens, such as one of the bifaces from the Phil Stratton site, explosively fractured into multiple fragments that have been refitted indicating thermal alteration occurred at the time, or after, the biface was discarded.

5.3. Cumberland biface reduction sequence

Of the complete Cumberland bifaces available for analysis, 93% (n = 79) exhibited a biconvex transverse cross section. The remaining 7% (n = 6) were plano-convex in cross section. This pattern appears to be related to initial blank form used for the production of bifaces. The overwhelming majority (89%; n = 76) of complete bifaces were made from bifacial blanks. Just 11% (n = 9) of the complete bifaces, including all plano-convex specimens, were made on flakes. Bifaces made on flake blanks were identified based on the remnants of the original ventral face of the flake or pronounced longitudinal curvature.

Preforms were initially shaped into a rowboat form with convex lateral edges and a straight to convex base. Initial reduction and shaping was completed with large, random percussion flake removals (Fig. 5A, B). The convex lateral edges typically exhibit little or no waisting. Early in the reduction sequence flaking may extend across the midline, similar to Clovis overface flaking (Fig. 5B); however, this is rarely present on finished Cumberland bifaces. Once the general shape is obtained, one face is selected for fluting. Typically, each face was prepared and fluted individually. This likely represents a risk management strategy to minimize time and energy in case the first fluting attempt catastrophically broke the preform (Flenniken, 1978). This was also recognized by Jolly (1972), and is exemplified in the example illustrated by Boldurian

Table 5
Technological characteristics of Cumberland bifaces.

	Average	Maximum	Minimum	CV
Average grind length	25.47	69.85	0.00	0.44
Average grind length:maximum length	0.35	0.80	0.00	0.39
Average flute length	46.32	118.61	7.00	0.45
Average flute length:maximum length	0.60	1.00	0.00	0.41
Average flute width	11.49	27.58	4.00	0.29

and McKeel (2011:110, Fig. 4). The practice of preparing and fluting one face at a time has also been documented in Folsom technology, and interpreted as a cost minimizing strategy (Flenniken, 1978). Systematic collateral pressure flakes were removed to create a distinct midline ridge. The ridge serves to guide the removal of the channel flake and ensure that it travels the desired distance. Other researchers have noted the importance of the midline ridge and suggest that it is the most distinguishing feature of Cumberland preforms (Cambron and Hulse, 1961; Jolly, 1972). Immediately prior to fluting, the base is beveled and a prominent striking platform is created. Similar to Folsom (Sellet, 2004), the distal ends of some Cumberland preforms are blunted suggesting the use of an anvil or brace during fluting. If the removal of the first flute is successful, then the second face is prepared for fluting following the same process. It should be noted that on approximately 20% of bifaces examined only one face is fluted. Once the channel flakes have been successfully removed, another episode of lateral pressure flaking is done to shape the final form (Fig. 5C). During this final step the distinctive waisted shape is created through intensive lateral pressure flaking, that also reduces and standardizes the flute width.

The sample of preforms available for study is inherently fragmented because only broken preforms would have typically been discarded prior to completion. The sample of 52 preforms analyzed consists of 41 basal fragments, 9 nearly complete specimens, 1 midsection, and 1 distal tip fragment. The most common reason for abandonment was catastrophic breaks caused by plunging channel flakes. Because the preforms were discarded at various points in the reduction sequence, most measurements exhibit a high rate of variation. However, certain morphological characteristics may be distinguishing features of Cumberland preforms (Table 6). The ratio of basal width-to-maximum width is 3:4 with a relatively low CV of 19%.

5.4. Patterns in Cumberland breakage and rejuvenation

Just over half (54%) of all finished Cumberland bifaces analyzed are fractured in some way. The majority of these (n = 290, 61%) are basal fragments, while distal tips, midsections, and miscellaneous fragments account for the remaining 39%. On specimens where data were available, 25% of bifaces were missing at least one ear, excluding recently

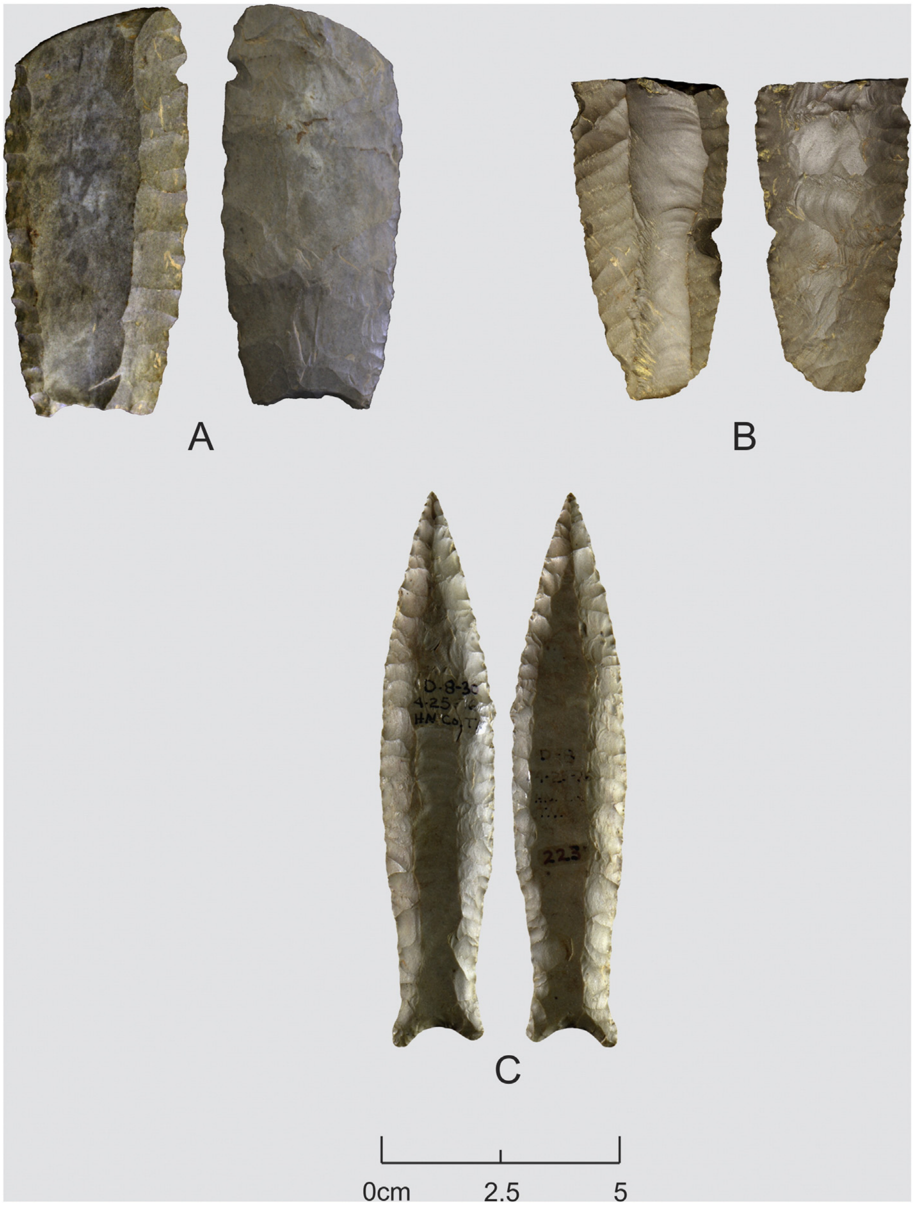

Fig. 5. Examples of Cumberland preforms and a finished biface. A, Smithsonian National Museum of Natural History, Tennessee; B, Pinson State Archaeological Park (TDOA), Tennessee; and C, Parris Collection, Hardin County, Tennessee.

broken specimens, which may be related to shock damage during impact. Thirteen percent exhibit impact damage to the tip based on the presence of "reverse flute scars," burination to the distal lateral edge, or crushing. The majority (70%) of Cumberland basal fragments were transversely broken. Heating accounts for almost 10% of the fractures.

Of the complete, finished Cumberland bifaces analyzed, 28% exhibited some type of rejuvenation (Fig. 6). This does not include bifaces reworked into other tool types. Of reworked specimens, 18% retained evidence of impact damage near the distal tip, suggesting that Cumberland bifaces were typically rejuvenated back into their original function (Fig. 6B).

6. Cumberland technological organization and behavioral inferences

6.1. The Cumberland technological system

The two attributes most directly related to hafting are fluting and lateral grinding. Surprisingly, flute length (CV = 45%) and the lateral grinding length (CV = 45%) are two of the most variable attributes of Cumberland bifaces. Thus, the length of flutes and grinding initially do not appear be significant to function. However, if the technological ratios of flute length-to-maximum length and length of grinding-to-maximum length are considered, then these two attributes become more informative. The proportions of these measures are more standardized than the specific lengths of the individual attributes. Furthermore, the technological ratios of flute length-to-maximum length and lateral grinding length-to-maximum length remain constant even after rejuvenation. Morphological ratios such as maximum length-to-width change significantly as bifaces are reduced (Kuhn and Miller, 2015). Thus, it appears that technological ratios are informative and may reflect aspects of hafting and artifact use-lives. Cumberland bifaces have a relatively small width-to-thickness ratio compared to other late Pleistocene fluted bifaces (see Bever and Meltzer, 2007; Smallwood, 2012), resulting in a more robust morphology.

The majority (80%) of complete Cumberland bifaces are over 55 mm long, while the majority (82%) of Cumberland basal fragments are less than 60 mm long. As such, it appears that the minimum threshold related to discard is approximately 55–60 mm. Bifaces above that range are expected to be resharpened, if possible, while below that length they are expected to be discarded (Fig. 7). Catastrophic transverse fractures typically occur below 55 mm. Based on technological ratios and assuming that lateral grinding reflects hafting, there is only a slight correlation between hafting and maximum length ($r = 0.54$, $r^2 = 0.30$), suggesting that longer bifaces did not necessarily have longer hafts. Using the ratio of grinding length-to-maximum length, functional blade length can be inferred. The typical Cumberland biface was hafted 35% of its total length, with the remaining 65% serving as the functional blade. If the threshold for complete Cumberland biface length is 55–60 mm, then the minimum functional blade length is calculated to 37.75–39.00 mm. Once this threshold was reached, either because of breakage or exhaustion, the biface was likely replaced.

Table 6
Morphological characteristics of Cumberland preforms.

	Average	Maximum	Minimum	CV
Maximum width	35.15	57.29	26.29	0.21
Basal width	25.85	35.61	17.59	0.18
Waist width	28.10	37.60	20.28	0.22
Maximum thickness	8.14	11.14	4.89	0.18
Waist width:basal width	0.83	0.99	0.64	0.13
Depth of basal concavity	2.71	6.47	0.60	0.73
Depth of basal concavity:basal width	0.09	0.18	0.03	0.61
Inter flute thickness	5.09	6.91	3.79	0.21
Average flute width	17.92	28.82	11.97	0.26

Fig. 6. Cumberland bifaces in various stages of rejuvenation. A, Smithsonian National Museum of Natural History, Alabama; B, Trinity site, Lewis County, Kentucky; C, Parris Collection, Hardin County, Tennessee.

6.2. Biface morphology

Based on CVs for maximum dimensions and morphological ratios, the most standardized attributes of Cumberland bifaces are related to the basal element. This is not unexpected given that the haft element is subject to morphological constraints imposed by specific hafting techniques (Judge, 1970; Keeley, 1982; Roosa, 1977). While lateral and

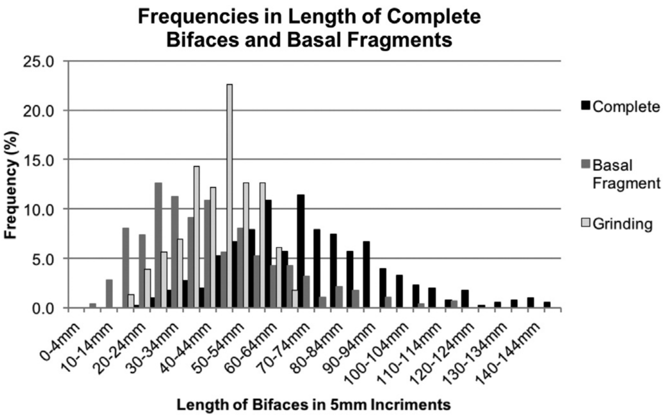

Fig. 7. Frequencies in the lengths of complete Cumberland bifaces and basal fragments.

distal resharpening of the blade element changes the overall morphology, the hafted basal element is less frequently modified (Bever and Meltzer, 2007; Meltzer and Bever, 1995).

In spite of overall basal morphology being generally standardized, basal concavity is highly variable. This pattern of variability in basal concavity may be related to several factors including being tailored to individual foreshafts, stylistic elements of haft construction, and rebasing of broken bifaces (Ellis, 2004; Smallwood, 2012; Taylor-Montoya, 2007; White, 2013). Daniel and Goodyear (2006) and Goodyear (2006) suggest that increased basal concavity is related to a technological shift marking the cultural transition from the early to middle Paleoindian periods. While this pattern may hold true in the Clovis-to-Redstone transition in the Coastal Plain, it does not appear to be the case with Clovis-to-Cumberland in the Midsouth. Based on Smallwood's (2012) comprehensive study of regional Clovis morphology, Cumberland bifaces have slightly less basal concavity than Clovis bifaces.

6.3. Breakage patterns and rejuvenation

Cumberland bifaces appear to have been primarily resharpened from the distal tip. Distal resharpening is reflected in the standardization of face-angle and width dimensions, and the variability in length dimensions. Similar patterns of rejuvenation have also been noted on other post-Clovis fluted biface types such as Barnes and Folsom (e.g., Ahler and Geib, 2000; Deller and Ellis, 1992; Ellis, 2004; Judge, 1973). While biface morphology may be influenced by factors related to raw material, this does not appear to be the case in the Midsouth. The ubiquity of toolstone throughout much of the Midsouth (Amick, 1987; Parish, 2011, 2013), reduces potentially limiting factors caused by availability, quality, or general package size of local toolstone (Kuhn, 1995).

Patterns of rejuvenation documented in Cumberland bifaces indicate that they were designed to be maintainable tools. The relatively constant widths of the bifaces, as well as the flutes, indicate that minimal resharpening occurred along the lateral margins after the biface was completed. The standardization of basal elements suggests that rejuvenating broken or dulled bifaces typically occurred with the biface in the haft. This suggests that Cumberland bifaces were not multifunctional tools, but rather were designed almost exclusively for piercing, as may be the case for other post-Clovis fluted biface types.

6.4. The organization of technology and settlement organization

The ubiquity of toolstone in the Midsouth neutralizes potential effects of resource availability, so that patterns in biface technologies more likely reflect organization strategies rather than differential access to raw materials (Kuhn, 1995). The patterns evident in overall biface morphology, hafting, breakage, rejuvenation, and discard, reflect a logistically mobile settlement strategy based around the provisioning of places. As such, Cumberland bifaces were likely specialized piercing tools used by task groups on hunting forays. Similar to Folsom, Cumberland groups likely made and maintained bifaces as part of a gearing-up strategy during periods of downtime (Sellet, 2004, 2013). The low ratio of complete to broken Cumberland bifaces indicates that transverse breaks were catastrophic. Although, making minor repairs to impact damaged bifaces could extend use-life. It is likely, however, that this is only part of a larger, more complex, landuse strategy that incorporated flexible provisioning strategies related to seasonal resource structure and demographic fluctuations associated with aggregation events.

7. Conclusion

Cumberland biface technology is prevalent throughout the Midsouth, specifically the Highland Rim of southern Kentucky, central Tennessee, and northern Alabama. Unlike other late Pleistocene technologies, Cumberland bifaces have never been recovered from intact, single component contexts associated with datable materials. The co-occurrence of Cumberland and other Paleoindian biface types in the same layer at sites such as Dust Cave is enigmatic. Additional sites with intact stratigraphy must be excavated to understand the intricacies of Paleoindian chronology in the Midsouth United States. Currently, there is a lack of tools and debitage, subsistence data, and radiometrically supported chronologies associated with Cumberland technology.

While Cumberland data is primarily limited to bifaces lacking context, analyses of over 900 bifaces indicate that Cumberland technology was designed as part of a logistical settlement strategy used by people mapping on to specific places on the landscape. The ubiquity of lithic raw materials and largely predictable distributions of resources allowed people using Cumberland technology to logistically map onto the woodland landscape of the Midsouth. Based on bracketing radiocarbon ages and technological similarities to other, well-dated biface technologies, Cumberland appears to be a post-Clovis manifestation contemporary to the earliest part of the YD (ca. 12,800–12,100 cal yr BP). However, more research is needed to further support this assertion. The hypotheses presented here should be further tested with additional technological studies of Cumberland sites with preservation of more complete toolkits and debitage.

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