CLOVIS TECHNOLOGY AND SETTLEMENT IN THE AMERICAN SOUTHEAST: USING BIFACE ANALYSIS TO EVALUATE DISPERSAL MODELS

Ashley M. Smallwood

Kelly and Todd's (1988) "high-technology forager" model predicts Clovis groups were highly mobile populations that left behind behaviorally consistent records of Clovis fluted points as evidence of their short-term occupations. Anderson's (1990, 1996) staging-area model predicts that Clovis settlement was more gradual; groups entered the continent and slowed migration to concentrate territorial ranges around resource-rich river valleys, and these staging areas became the demographic foundations for early cultural regionalization. This study analyzes southeastern Clovis point data and biface assemblages from Carson-Conn-Short, Topper, and Williamson to test the technological implications of these two models. Significant subregional variation exists in Clovis point morphology and biface production techniques. This variation suggests the subregions represent distinct populations who distinctly altered aspects of their technology but maintained fundamental elements of the Clovis tradition. These findings are at odds with the high-technology forager model and more closely fit the staging-area model.

Kelly y Todd (1988) modelo de alta tecnología de forager predice Clovis los grupos fueron poblaciones de sumamente-móvil que dejaron detrás de registros conductistamente-coherentes de Clovis puntos ondulados como evidencia de sus ocupaciones a corto plazo. Anderson (1990,1996) modelo de etapa-área predice que arreglo de Clovis fue más gradual; los grupos entraron el continente y migración ralentizada para concentrar gamas territoriales alrededor de valles recurso-rico de río, y estas puesta en escena-áreas llegaron a ser las bases demográficas para el regionalization temprano cultural. Este estudio analiza los datos del sudeste de punto de Clovis y colecciones de biface de Carson-Corto de Connecticut, el Colmo, y Williamson para probar las implicaciones tecnológicas de estos dos modelos. La variación subregional significativa existe en la morfología de punto de Clovis y técnicas de producción de biface. Esta variación sugiere que las subregiones representan poblaciones claras que alteraron claramente aspectos de su tecnología pero elementos fundamentales mantenidos de la tradición de Clovis. Estas conclusiones están reñidas con el modelo de alta tecnología de forager y más quedan de cerca el modelo de etapa-área.

Traditional models predict that early Paleoindians were highly mobile big-game hunters who continually shifted ranges and were "technology-oriented" (Beaton 1991; Kelly 1996; Kelly and Todd 1988:239). However, with newly excavated sites, many of which are not kill sites, archaeologists have begun to realize that considerable variability existed in Clovis technology, subsistence, and settlement. Nowhere in North America has this change in perception been more evident than in the American Southeast (Anderson 1996, 2005; Broster and Norton 1992, 1993; Broster et al. 1994). Based on relative fluted-point concentrations across the country, Anderson (1990, 1996) has suggested that Clovis groups in this region were more place-oriented and less mobile than predicted by the high-technology/high-mobility models. This paper uses site-level data to test the traditional high-technology/high-mobility models against Anderson's (1990, 1996) "staging-area model," which predicts a gradual, step-wise mode of Clovis settlement.

To investigate the suitability of the staging-area model, I analyze bifacial technological organization represented at three sites located in different areas of the Southeast (Figure 1): Carson-Conn-Short (Tennessee), Topper (South Carolina), and Williamson (Virginia). Carson-Conn-Short is in an area Anderson predicted to be a primary staging area, where colonizing popula-

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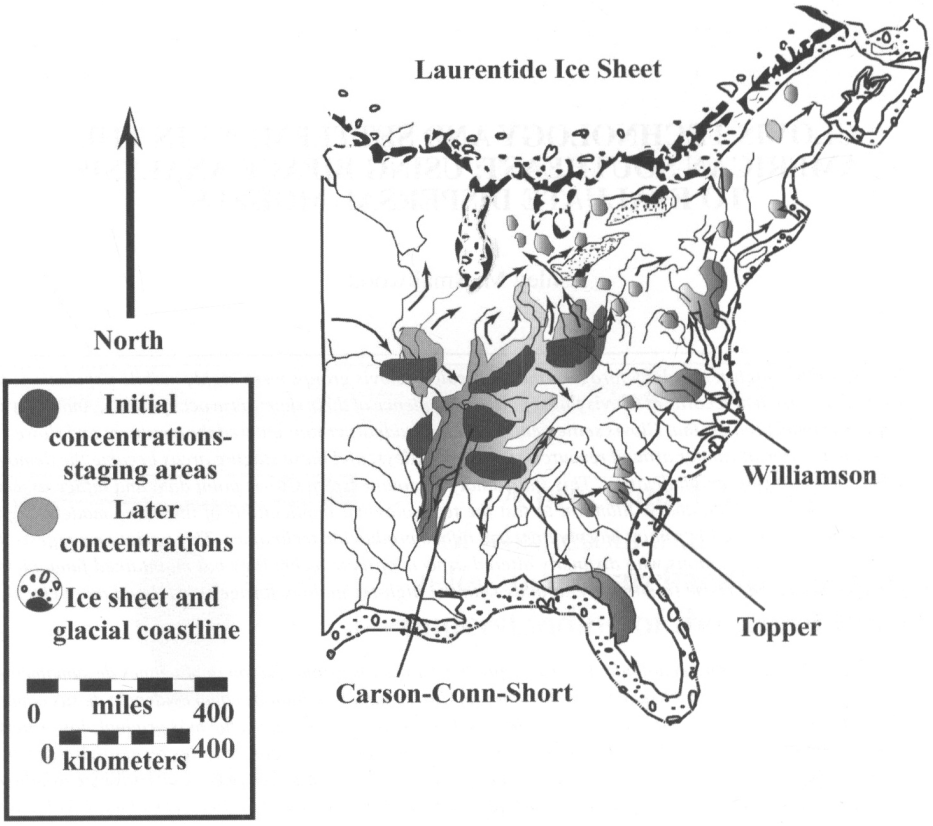


Figure 1. Map of eastern North America showing locations of archaeological sites included in this study, Anderson's hypothesized staging areas, and the late Pleistocene ice sheet and now-submerged glacial coastline.

tions of Paleoindians first concentrated and settled (Anderson 1990:188), while Topper and Williamson are in areas Anderson predicted to be later population concentrations, areas discovered by groups secondarily dispersing from initial staging areas. Besides collections from these sites, I also analyze known fluted points from surrounding counties. The Paleoindian Database of the Americas (PIDBA) is used as a reference for raw material type and metric attributes of the isolated fluted points (Anderson et al. 2010).

My analysis of the lithic reduction sequences represented in the assemblages indicate significant interregional variation in Clovis bifacial technology and finished point morphology, and this suggests incipient cultural regionalization in the American Southeast as early as Clovis times. These patterns are not consistent with the high-technology/high-mobility model, but do fit Anderson's staging-area model.

Modeling Clovis Settlement

Clovis technology is generally recognized for its characteristic bifacial fluted projectile point (Bradley et al. 2010; Collins et al. 2007; Morrow 1995; Stanford 1991; Tankersley 2004; Willig 1991; Wormington 1957). One of the most remarkable aspects of Clovis is its extensive geographic distribution covering all of North America south of the continental ice sheets (Haynes 2002; Tankersley 2004; Willig 1991). Most archaeologists explain the ubiquity of Clovis through human migration (Anderson 1996; Fiedel 2004; Goebel et al. 2008; Haynes 2002; Kelly 1996; Kelly and Todd 1988; Meltzer 2002, 2004; cf. Willig 1991; Waters and Stafford 2007), and the lithic record is essential to understanding human migrations and cultural change. While Clovis point variability can be caused by idiosyncratic behavior or differences in raw material,

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tool use, and rejuvenation (Bradley 1991; Frison 1978; Haynes 1982; Otte 2003; Sackett 1985), there are still aspects of technological variation that may be culturally based (Daniel and Wisenbaker 1989; Flenniken 1985; Larson 1994; Stanford 1991; Tankersley 2004; Willig 1991). I follow O'Brien et al. (2001), who have argued that such similarities represent shared cultural heritage. Further, like Faught (2006), Meltzer (1988), Morrow and Morrow (1999), O'Brien et al. (2001), and Willig (1991), I argue that through either temporal and/or spatial separation, cultural transmission within isolated groups was likely a primary source of regional assemblage variation. The organization of Clovis settlement bears directly on this issue as it would have affected the scale, manner, and frequency of interactions among regional populations. Below I briefly review two contrasting models of Clovis settlement: the "high-technology forager" (HTF) model (Kelly 1996; Kelly and Todd 1988) and the "staging-area" model (Anderson 1996).

High-Technology Forager Model

According to Kelly and Todd (1988), Clovis people migrated into an unpopulated country through the ice-free corridor in western Canada, preadapted with the skills and tools to hunt Pleistocene mammals. Under pressures of a rapidly changing environment, the predisposition for hunting allowed small groups to quickly move across the landscape following familiar resources and avoiding setbacks caused by diminished local food sources and patchiness (Kelly 1996). Clovis people did not adapt locally to environments; rather, these "high-technology foragers" relied on bifacial tools and knowledge of ungulate behavior to rapidly move from one environment to the next (Kelly 1996:231). Clovis migration across North America was quick, through diverse environmental zones, leaving a behaviorally consistent record of Clovis-style fluted points and site types—kill sites, caches, and short-term campsites (Kelly and Todd 1988).

According to the HTF model, the Clovis lifeway was "technology-oriented" rather than "place-oriented" (Kelly and Todd 1988:239). By abandoning dependency on local resources and environments, instead exploiting large herbivores, Clovis people shifted ranges, rarely if ever settled into a particular area for long, and carried a tool kit that allowed them to move far from raw-material sources. Highly mobile Paleoindians relied on a portable technology of long-lasting and multipurpose tools fashioned from high-quality cryptocrystalline raw materials (Goodyear 1989; Kelly and Todd 1988).

The HTF model was the first to emphasize the role of bifaces in Paleoindian mobility patterns (but see Bamforth 2003; Prasciunas 2007). According to this model, the Paleoindian tool kit consisted primarily of bifaces with sharp but durable edges and width-to-thickness ratios that allowed for the removal of large flakes (Kelly 1988). Bifaces served as cores and the weight-to-edge ratio ensured that mobile groups were less burdened by large amounts of stone but still able to produce needed tools (Kelly 1988:719). Kelly and Todd (1988:236) concluded that high mobility and maintainable tools were responsible for what they consider to be a lack of regional variation in fluted-point styles.

Staging Area Model

The discovery of extensive Clovis sites in the Southeast (Broster and Norton 1992, 1993; Broster et al. 1994; Goodyear 1999; Gramly and Yahnig 1991; McAvoy 1992) has led to the reevaluation of Clovis settlement. Anderson's (1990, 1996) staging-area model explains the spread of Clovis technology by means of human migrations, but at a slower pace than the HTF model. Anderson argues that colonizing groups encountered river systems that led them to three major river valleys in the south and east: the Ohio, Cumberland, and Tennessee. Once in these valleys, group migrations slowed. Anderson (1996:36) suggests that groups settled into resource-rich locations, where populations habitually exploited toolstone and a wide range of biotic resources and aggregated for information and mate exchange. As population sizes increased, groups fissioned and dispersed to secondary staging areas, for example to valleys in the Atlantic Coastal Plain (Anderson 1990, 1996), where the process was repeated. These initial and later population concentrations became the foundation for early cultural regionalization (Figure 1) (Anderson 1996:35).

Anderson's (1996) staging-area model accounts for dense concentrations of isolated points

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in major river valleys by suggesting that groups slowed the process of dispersal in these areas but does not directly describe the lithic assemblages that reflect this settlement strategy. There are testable implications, however. The model proposes increasing regionalization caused by relative permanence in staging areas. Therefore, variation should be evident between assemblages from different population concentrations, especially between finished point forms and the processes of their manufacture. Despite the limited number of ^{14}C dates from Paleoindian sites in the Southeast, timing is a significant aspect of this model. The nature and timing of Clovis are still contentious issues but most researchers agree that sometime between 11,500 and 11,000 ^{14}C yr B.P. (Haynes 1992) a major technological change occurred across North America, and recent reevaluations have narrowed the age of the Clovis fluorescence to 11,050 to 10,800 ^{14}C yr B.P., suggesting a minimum span of 400 calendar years (Waters and Stafford 2007). There are no reported ^{14}C dates from the three Clovis sites included in this study, so this paper focuses on the technological, rather than chronological, implications of Anderson's model. Specifically, I evaluate whether stylistic and technological differences exist between regions, which may indicate early cultural regionalization, reduced territorial ranges, and longer occupational spans in subregions than predicated by the HTF model (Anderson 1990).

Testing Clovis Mobility Models in the American Southeast

The Carson-Conn-Short, Topper, and Williamson sites are ideal locations to identify patterns in technology and point morphology in the three proposed staging areas. First, all three are locations at which stone was readily accessible. This ensures that availability of raw material did not constrain the reduction sequence. Second, the three Clovis assemblages contain manufacturing debris that can be used to reconstruct and identify patterns in reduction strategies. Third, all three assemblages contain numerous bifaces, preforms, and points, so that a more comprehensive understanding of biface morphology can be traced; the intended style and shape is evident in the unbroken preforms, and shapes caused by use and rejuvenation are evident in exhausted, discarded points. As proposed in the staging-area model, each of these sites is a source of high-quality chert found within a major river valley that likely was rich in biotic resources during the late Pleistocene, places where Clovis groups may have settled for extended periods of time (Anderson 1996). In addition, data available on biface morphology and raw material in the Paleoindian Database of the Americas (PIDBA) affords a broader, regional perspective on the site-specific data.

Sources of Data

Carson-Conn-Short Site, Tennessee (40BN190). Carson-Conn-Short falls within a hypothesized initial staging area (Figure 1) (Anderson 1996). It is located on the edge of the Western Valley physiographic region, in terrace ridges along the shore of Kentucky Lake and south of an ancient channel of the Tennessee River (Broster and Norton 1993; Broster et al. 1996). Clovis people at Carson-Conn-Short had access to aquatic resources and large herd animals drawn to the swampy areas for water and forage (Breitburg and Broster 1994; Broster and Norton 1996), as well as high-quality chert (Broster et al. 1994). Nearby outcrops of Fort Payne chert formed in veins and tabular nodules that vary between 30 to 50 mm in thickness (Nami et al. 1996).

Clovis occupation areas seem horizontally separate and stratigraphically below later occupation areas. The Clovis occupation is buried 45 to 68 cm below the surface (Broster et al. 1994), as seen in 10 separate test units that yielded artifacts indicative of the production of fluted points and blades (Broster and Norton 1993, 1996; Broster et al. 1994). To date, 4,691 artifacts have been recovered from surface surveys and 582 artifacts (including 350 tools and cores) from excavations (Broster et al. 1996). There are 38 known Clovis points. For this study, I analyzed eight Clovis points and 124 bifaces from Carson-Conn-Short.

Topper Site, Allendale County, South Carolina (38AL23). Anderson (1996) designates the area surrounding Topper as a secondary staging area, occupied once groups fissioned from an initial staging area (Figure 1). Topper is located in the central Savannah River valley of the Atlantic Coastal Plain. Topper is a multi-component site situated on a sandy terrace above a natural outcrop of Coastal Plain chert (Goodyear and Charles 1984;

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Waters et al. 2009). Coastal Plain chert outcrops on the hillside and at the bottom of the river channel. Rounded nodules have maximum diameters ranging from 300 to 500 mm (Smallwood 2010).

The integrity of the buried Clovis component at Topper has been demonstrated by spatial analysis and refit studies (Miller 2007). Large block excavations (totaling more than 500 m^2) have produced four Clovis points, 174 bifaces and preforms, scrapers and blades, and large quantities of debitage (Goodyear 2006; Smallwood 2010). For this study, I analyzed four Clovis points and 139 bifaces from the Topper site.

Williamson Site, Dinwiddie County, Virginia (44DW1). The Williamson site falls within an area theorized by Anderson as a secondary Clovis staging area and is situated at the interface of the Coastal Plain and Piedmont physiographic regions, between the Nottoway and Appomattox rivers (Figure 1) (Anderson 1996; Peck 2004). The site rests on the south side of Little Cattail Creek, where primary and secondary sources of variegated chalcedony outcrop (Callahan 1979; Hill 1997; Peck 2004). The extensive local outcrops of raw material, described as "Little Cattail Creek chalcedony" and "Williamson chert," are part of a formation comprised of chalcedony, chert, and jasper with small pockets of quartz (McAvoy 1992, McCary 1975). The most sizeable blocks of chert on the Williamson site measure as much as 250 mm in length and can weigh up to 45 pounds. However, the majority of the material occurs as fractured pebble- and cobble-sized blocks (approximately 250–300 mm in size) eroded out of the creek banks and bottom (Joseph McAvoy, personal communication 2010).

Williamson is a large workshop and habitation site with Paleoindian artifacts distributed over more than 4600 m^2 (Peck 2004). Four subsurface examinations confirmed that Williamson has buried cultural deposits on the hillside slope (Haynes 1972), a stratigraphically distinct fluted-point component (Benthall and McCary 1973; McAvoy 1992), and intrasite variation of activity areas representing camp and production tasks (Hill 1997). The total tool assemblage consists of an estimated 150–170 fluted projectile points, 800–1000 end scrapers, and a variety of other tool types. For this study, I analyzed 115 Clovis points and 166 bifaces from the Williamson site.

Paleoindian Database of the Americas (PIDBA). PIDBA provides raw material and metric data for isolated fluted points found in the subregions of this study. While PIDBA contains data contributed by multiple researchers, which introduces the chance of inter-observer error (Prasciunas 2008), it contains valuable data typically not obtainable by individual researchers (Anderson et al. 2010). For this analysis, I included Clovis points from databases recorded by county for the states of Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, Kentucky, and Tennessee. All points used in this study were specifically typed as fluted Clovis points by regional experts, and no untyped fluted or fluted variants (e.g., "Clovis-like" and "unfluted Clovis") were included.

I incorporated a sample of 683 Clovis points from the Carson-Conn-Short subregion, including eight points from Carson-Conn-Short and 675 points from PIDBA. From the subregion surrounding the Topper site, I analyzed a total of 304 Clovis points, including four points from Topper, 24 points I studied firsthand from the Smithsonian Georgia School House collection originally found in Burke, Richmond, and Columbia counties along the Savannah River border (Dennis Stanford, personal communication 2010), and 276 points from PIDBA. The Williamson subregion dataset totals 506 points and is comprised of 115 points from Williamson and 391 points from PIDBA.

Expectations of Mobility Models

As a rapid-mobility model, the HTF model predicts homogeneity in technology and precludes regional distinctions (Kelly and Todd 1988). Therefore, if the HTF model is a fitting explanation of Clovis dispersal in the Southeast, then I expect to see little variation in point morphology, and biface technology should be indistinguishable among the three Clovis assemblages. If the staging-area model is an accurate assessment of dispersal, then I expect relatively more variation between the biface assemblages from the three sites than predicted by HTF. Intersite variation would be the product of population fissioning, followed by discrete groups settling into areas and reducing territorial ranges. To analyze similarities and differences in technology I assess variation among (1) Clovis points from each potential population

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concentration and (2) systems of biface manufacture at each procurement-related site.

If Clovis groups fissioned into discrete populations and settled in for long periods, I expect to see more morphological variation between Clovis points from these three population concentrations than expected by the HTF model (Faught 2006; Goodyear 1999; Lepper and Meltzer 1991). To test this expectation, I collected measurements of point attributes, such as degree of excurvature of the blade element (basal width:body width) and degree of concavity at the point base. These measurements were compared to attribute averages calculated from the PIDBA database of isolated point finds associated with the entire Southeast sample, or the average point measurements from the region as a whole. Stylistic variation in point technology was also examined by comparing point shapes (Morrow and Morrow 1999).

Anderson's (1996) model also predicts that populations resided in staging areas for years or even generations, and this long-term occupation and population concentration implies testable expectations for biface technology. If these site areas represent discrete population concentrations, there should be distinct manufacturing signatures, or techniques that differentiate bifacial tool technologies represented at each site. Distinctions can be detected, for example, by analyzing the incidence of overshot flaking and the manner and timing of end-thinning in the production sequence (Morrow 1995).

Unique features of raw materials could have affected aspects of tool reduction, especially in the initial steps of biface production. Specifically, characteristics such as material blank type, extent of cortex, and transverse cross-section, as well as simple size measurements (e.g., biface length, width, and thickness) are all traits plausibly affected by initial material source conditions. The impact of raw material characteristics in creating the Clovis point form and technology are considered in the analysis.

Methods

Methods for Analysis of Point Morphology

A total of 1,493 Clovis points was used to test for regional style variability. Point morphology was measured using a standard series of metric values: total length, maximum body width, basal width, maximum thickness, and basal concavity depth (Morrow and Morrow 1999; Thulman 2007). Points were compared based on shape ratios like length:width. Morphological equations developed by Morrow and Morrow (1999) were used to measure degree of excurvature of the blade (basal width:maximum width) and indentation of the basal edge (basal concavity depth:basal width). Because the data were not normally distributed, values from each staging area were compared using nonparametric Kruskal-Wallis tests and post-hoc pairwise Mann-Whitney/Wilcoxon Ranked Sum tests. The analysis also compares variation of metric attributes within each potential staging area to determine the aspects of point morphology that vary most and to consider what this variation means. A coefficient of variation was calculated by dividing each characteristic sample standard deviation by the sample mean and multiplying the value by 100 to produce the percent of variation (Bever and Meltzer 2007; Eerkens and Bettinger 2001; Taylor-Montoya 2007). The average values for the Carson-Conn-Short, Topper, and Williamson staging areas were also compared to values of a "regionally average point"—in other words, the averaged measurement calculated for each attribute of Clovis points from the PIDBA database. The regionally average point sample consists of 2,851 Clovis points and excludes those points crafted from raw materials local to each staging-area, as these points are included in staging-area samples.

Methods for Analysis of Biface Technology

A total of 463 bifaces and biface fragments were analyzed to compare tool forms and manufacturing strategies. First, I assigned bifaces to three successive reduction stages (early, middle, and late) based on presence or absence of cortex, extent of flaking, edge sinuosity, flake-removal technique (Waters et al. 2011), and flaking index. These variables helped quantify extent of reduction (Miller 2007; Smallwood 2010). The values of metric attributes and ratios (e.g., length:width) for bifaces by stage of reduction for each potential staging area were also compared using nonparametric multiple and pairwise tests. I also recorded descriptive categorical variables such

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as the extent of cortex, transverse cross-section, planview, and edge shape. Reconstruction of preform production was accomplished through an analysis of the number and direction of thinning techniques. Distinctions in biface reduction strategies were based on the frequency of overface flaking (i.e., thinning flakes that extended across the center axis of the biface toward the opposite edge but either did not over-shoot or were obscured by subsequent flaking) and overshot flaking and timing in the reduction sequence where end-thinning occurred (Bradley 1993; Collins et al. 2003; Smallwood 2010). The statistical significance of the relationship between the potential staging areas and these categorical variables was compared for each stage of biface reduction. Finally, I analyzed width and thickness reduction patterns by calculating the percent lost after each stage of reduction, using the following formula:

$$n = 100 - 100\left(\frac{\text{avg body width for middle stage bifaces}}{\text{avg body width for early stage bifaces}}\right).$$

Where n = the percent lost in reduction.

Results

Point Morphology

Due to small sample sizes, Clovis points specifically from the three sites could not be statistically compared without including the larger PIDBA sample. Nonetheless, point averages for each site are presented separately from regional-scale point comparisons, which include points from the three sites as well as surrounding subregions.

Points from Main Study Sites. The eight Clovis points analyzed from Carson-Conn-Short are made on Fort Payne chert (Table 1, Figure 2, g–j). Three are complete and five are incomplete. The four Clovis points from Topper are all fragmented (Figure 3, g–i). Two are crafted from Coastal Plain chert, one is made on quartz-plagioclase-porphyritic rhyolite, and the other is made on black rhyolite. Of the 115 points from Williamson, 75 are crafted on chalcedony, 34 on quartz, five on coarse-grained quartzite, three on chert, and one on jasper (Figure 4, g–j). Forty-nine points are complete. Overall, size and shape averages for each of the three sites are comparable to averages calculated for the total point sample, which includes Clovis points from the PIDBA dataset. The differences between the site-level datasets correspond to patterns in the regional point samples.

Points from Potential Staging Areas. The total sample consists of 1,493 Clovis points (Table 1). Point sizes reveal a standard pattern of significant variation in length and width ($p < .000$ for both variables). On average, points from the Carson-Conn-Short subregion are significantly longer than points from the other subregions—12.1 mm longer than the Topper area points and 19.6 mm longer than Williamson area points. Carson-Conn-Short points are also widest, while Williamson points are the narrowest. Carson-Conn-Short points are 2.7 mm wider than Topper points and 4.63 mm wider than Williamson points. Likewise, Carson-Conn-Short (CCS) point bases are 2.34 mm and 3.92 mm wider than Topper (TP) and Williamson (WM) point bases, respectively (CCS vs. TP, $p < .000$; CCS vs. WM, $p < .000$; and TP vs. WM, $p = .006$). Interestingly, when point thickness is evaluated the outcome is much different. Points from the three subregions are equally thin ($p = .145$).

When shape ratios involving body width are considered, points from the Carson-Conn-Short subregion continue to be the most robust, and Williamson points the least robust (Table 1). Interestingly, however, ratio comparisons indicate significant differences in shape proportions. In terms of length-to-width ratio, Carson-Conn-Short points are slender but long, while Topper and Willamson points are comparatively wide but short ($p < .000$). This size trend continues when the ratio of width to thickness is evaluated, with Carson-Conn-Short point shapes being significantly thinner relative to width ($p < .000$).

Ratios featuring basal features reflect a decidedly different pattern (Table 1). Depth of concavity for Carson-Conn-Short area points is significantly more concave than Topper ($p = .010$) and Williamson ($p < .000$) points, but Topper and Williamson depths of concavity do not differ significantly. Interestingly, ratio of depth of basal concavity to basal width follows a different pattern, with the average value for Carson-Conn-Short being significantly higher than Topper ($p = .030$) and higher (but not significantly) than Williamson ($p = .055$). Thus, Carson-Conn-Short

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Table 1. Average Values and Ratios for Metric Attributes of Finished Clovis Points from the Study Sites and the PIDBA Database.

	Carson-Conn-Short n = (8) 675	Topper n = (4) 300	Williamson n = (115) 391	Region-wide Average n = 2,851
Length (mm)	(62.62) 70.59	(n/a) 58.49	(43.90) 50.97	60.20
Width (mm)	(29.45) 29.42	(27.21) 26.73	(24.51) 24.79	26.99
Thickness (mm)	(7.94) 6.99	(6.62) 7.11	(7.08) 7.03	7.02
Basal width (mm)	(26.36) 26.24	(26.17) 23.90	(22.27) 22.32	24.90
Depth of concavity (mm)	(3.20) 3.75	(3.20) 3.24	(2.77) 3.04	3.53
Length:Width	(2.06) 2.53	(n/a) 2.22	(1.94) 2.10	2.23
Width:Thickness	(3.76) 4.26	(4.11) 3.88	(3.52) 3.66	3.84
Basal width:Width	(.92) 0.90	(.96) 0.90	(.94) 0.94	.92
Depth of concavity:Basal width	(.12) 0.15	(.10) 0.14	(.13) 0.12	.14
Depth of concavity:Dominant flute length	(.12) 0.15	(n/a) 0.15	(.14) 0.15	n/a
Dominant flute length:Length	(.41) 0.42	(n/a) 0.43	(.45) 0.41	n/a

Values in parentheses represent counts and average values for points found at study sites; corresponding values are for points from the respective staging areas.

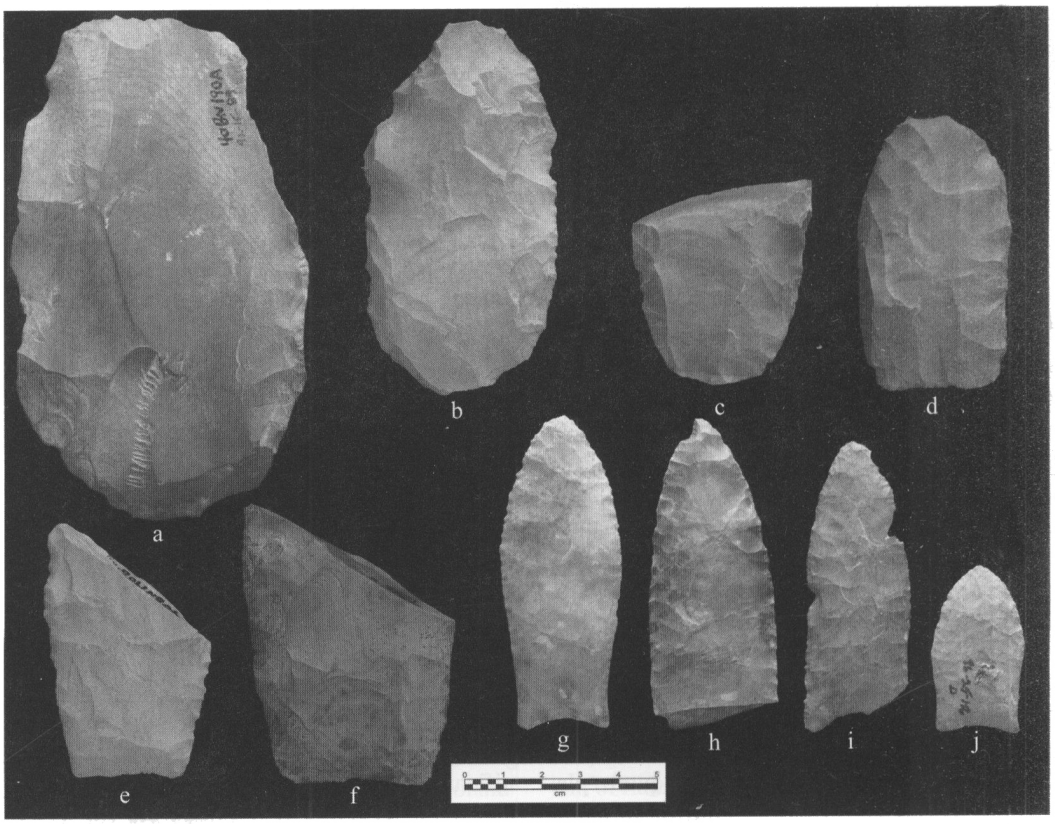


Figure 2. Clovis lithic artifacts from the Carson-Conn-Short site: (a-b) early-stage bifaces; (c-d) middle-stage bifaces; (e-f) late-stage bifaces; (g-j) finished points.

points have more deeply concave bases relative to their basal widths.

Degree of blade excurvature, or basal width to body width, follows a different trend (Table 1). Williamson's blade excurvation ratio is significantly higher than Carson-Conn-Short ($p < .000$) and Topper ($p < .000$). In other words, Williamson point outlines are straight, while Carson-Conn-

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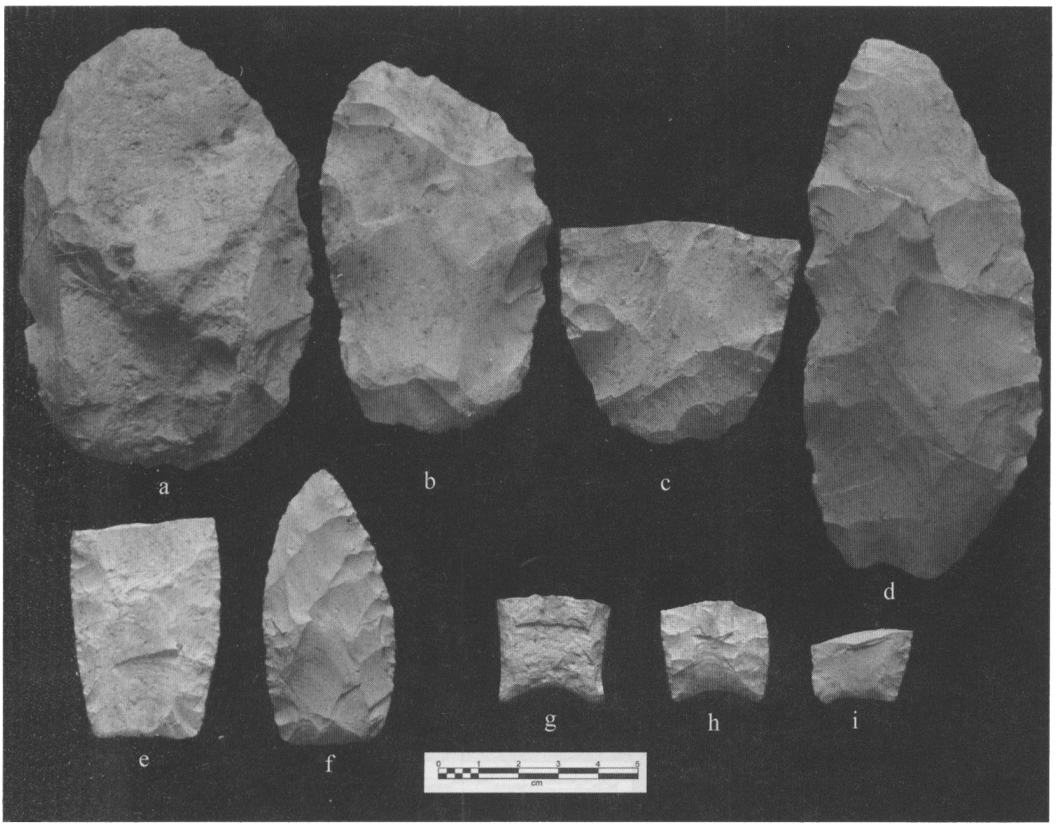


Figure 3. Clovis lithic artifacts from the Topper site: (a-b) early-stage bifaces; (c-d) middle-stage bifaces; (e-f) late-stage bifaces; (g-i) finished points.

Short and Topper expand more from the base upwards. The ratios of dominant flute length to point length and basal depth to dominant flute length do not differ significantly among the assemblages ($p = .728, p = .759$, respectively).

Most of the point size and shape attributes show little variation and have coefficient values of less than 30 percent (Table 2). Of the size attributes, length is the most variable, but this variability is still surprisingly low (less than 35 percent) given effects of use damage, resharpening, and reworking. Coefficient of variation measures are highest for factors involving depth of basal concavity. Depth of concavity and ratios of concavity to basal width and concavity to maximum flute length all vary to a greater degree relative to other point variables. This suggests that concavity was either affected from variance in use and reworking or was not as functionally significant as other point attributes and was flexibly applied (see Taylor-Montoya 2007).

To determine if any of the staging-area point averages are regional outliers, each was compared to regional values. While these relationships are relative, interesting patterns that generally mimic the pair-wise staging-area comparisons are evident. When size measurements of length and width are evaluated, points from the Topper region cluster with the regionally average point (Table 1). Points from the Carson-Conn-Short subregion are decidedly longer and wider and Williamson points are the shortest and narrowest.

When mean basal widths are compared, the decreasing size trend continues, but with a slightly different pattern (Table 1). Carson-Conn-Short points are the widest and greater than the regionally average point, Topper points average narrower, and again, the Williamson average is decidedly narrower than the others. Based on basal concavity depth, Carson-Conn-Short points have the deepest basal concavities. Comparisons of thickness change the size trend. Points from the

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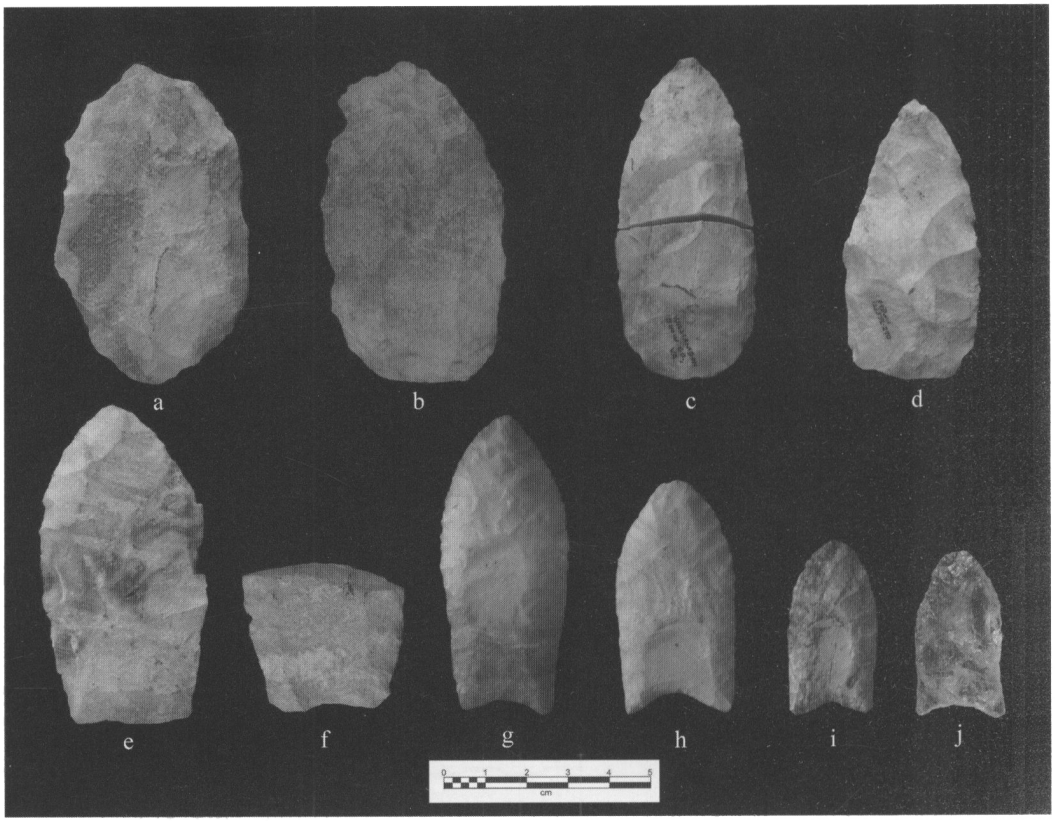


Figure 4. Clovis lithic artifacts from the Williamson site: (a-b) early-stage bifaces; (c-d) middle-stage bifaces; (e-f) late-stage bifaces; (g-j) finished points.

Williamson area are most similar to the regionally average point, Topper area points are much thicker, and Carson-Conn-Short points are thinnest.

Shape ratios of length to width and width to thickness follow the expected pattern based on the standard metric trends. For both shape ratios, the Topper average is most similar to the regionally average point. Again, Carson-Conn-Short points are robust and Williamson points are smallest in shape. Shape ratios that consider basal features produce very distinct relative trends (Table 1). Based on the ratio of basal width to body width, averages from the three potential staging areas are very similar; the regionally average point is the outlier. The average Southeast point is widest at the base relative to body width. The average points from the Topper and Carson-Conn-Short staging areas are comparatively the narrowest at the base. Interestingly, based on basal depth to basal width the average Williamson point is the shape outlier, with a proportionately smaller or shallower depth of basal concavity relative to basal width.

Analysis of Clovis point morphology indicates there may be nuances of variation within what archaeologists consider to be the standard Clovis form. Carson-Conn-Short points are robust, Williamson points are least robust, and Topper falls between the two. Unique basal features also distinguish the points. Carson-Conn-Short points have more deeply concave bases in general and relative to their basal widths. This raises the question: is biface production a standard, shared process or is there also variation in the Clovis production process?

Biface Technology

The total of 463 preforms, bifaces, and biface fragments from the three sites was analyzed. For each stage of reduction (examples are shown in Figures 2–4), I compare the characteristics and conditions of the bifaces from the three sites to

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Table 2. Coefficients of Variation for Metric Attributes and Ratios of Finished Clovis Points from the Three Staging Areas.

	Carson-Conn-Short n = 683	Topper n = 307	Williamson n = 506
Length (mm)	34.11	29.42	31.90
Width (mm)	24.75	15.23	18.23
Thickness (mm)	25.61	20.11	23.76
Basal width (mm)	22.07	15.98	18.59
Depth of concavity (mm)	61.6	52.16	43.75
Length:Width	24.11	22.07	21.43
Width: Thickness	22.54	23.91	23.22
Basal width:Width	12.22	11.11	5.32
Depth of concavity:Basal width	60.00	71.43	33.33
Depth of concavity:Dominant flute length	60.00	66.67	46.67
Dominant flute length:Length	39.60	37.13	36.81

Table 3. Average Values and Ratios of Metric Attributes of Early-stage Bifaces from the Study Sites.

	Carson-Conn-Short n = 31	Topper n = 17	Williamson n = 38
Length (mm)	98.61	111.04	82.98
Width (mm)	62.94	64.78	48.33
Thickness (mm)	23.96	26.49	20.11
Dominant end thin length (mm)	34.36	15.43	23.22
End thin width (mm)	9.42	4.22	4.39
Length:Width	1.57	1.57	1.73
Width:Thickness	2.78	2.74	2.63
Length:Thickness	3.82	3.50	4.42

identify similarities and differences in biface forms and the technological strategies employed in the process.

Early-Stage Bifaces. There are significant differences in early-stage biface sizes and shapes (Table 3). Topper bifaces are the longest and significantly longer than Carson-Conn-Short (p = .029) and Williamson (p < .000), and Carson-Conn-Short bifaces are significantly longer than Williamson bifaces (p = .002). Bifaces from Williamson are the narrowest and significantly narrower than Carson-Conn-Short (p < .000) and Topper (p < .000). Carson-Conn-Short and Topper bifaces do not differ in width. Williamson early-stage bifaces are also significantly thinner than both Carson-Conn-Short and Topper (p = .006, p = .013, respectively). Carson-Conn-Short and Topper are similar in biface thickness.

When the shape ratio of width to thickness is compared, bifaces from the three sites are generally similar. However, based on the ratio of length to width, Carson-Conn-Short and Topper bifaces are similar, but Williamson bifaces are proportionately longer relative to width than the others (WM vs. CCS, p = .005; WM vs. TP, p = .031). In terms of length to thickness, Williamson bifaces are longer than they are thick but only significantly so when compared to thicker Topper bifaces (p = .021). Carson-Conn-Short bifaces have significantly longer early-stage end-thin removals when compared to Topper (CCS vs. TP, p = .001). Carson-Conn-Short also has longer end-thin removals than Williamson but not significantly so (p = .054).

Early-stage bifaces are also significantly different based on the amount of cortex present (p = .027), planview shape (p < .000), base shape (p = .045), edge shape (p = .021), and transverse cross-section (p = .005) (Table 4). Compared to Carson-Conn-Short and Topper bifaces, the Williamson assemblage generally has fewer-than-expected bifaces with cortex on both faces and more-than-expected bifaces with cortex only remaining on one face. The Williamson biface assemblage also contains more-than-expected bifaces with lanceolate-shaped planviews (as opposed to ovoid or

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Table 4. Absolute Frequencies of Bifaces from the Three Staging Areas by Extent of Cortex, Planview, Base Shape, Edge Shape, and Transverse Cross-section, Each Subdivided by Stage of Reduction.

	Carson-Conn-Short	Topper	Williamson	*p*
Extent of Cortex				
Early Stage				.027
None	21	24	20	
Present both faces	17	11	4	
Present one face	13	11	20	
Middle Stage				.438
None	44	54	85	
Present both faces	1	3	3	
Present one face	2	0	5	
Late Stage				.083
None	23	27	27	
Present both faces	1	0	0	
Present one face	0	5	1	
Planview Shape				
Early Stage				.000
Circular	1	1	7	
Lanceolate	2	6	15	
Ovoid	49	35	22	
Straight	0	0	0	
Triangular	0	1	0	
Middle Stage				.003
Circular	0	0	0	
Lanceolate	35	38	85	
Ovoid	12	14	7	
Straight	0	0	0	
Triangular	0	0	0	
Late Stage				.403
Circular	0	0	0	
Lanceolate	20	31	25	
Ovoid	1	1	0	
Straight	1	0	0	
Triangular	1	0	0	
Base Shape				
Early Stage				.045
Concave	0	3	0	
Ovoid	0	1	0	
Rounded	33	27	34	
Square	18	9	8	
Middle Stage				.176
Concave	4	2	11	
Ovoid	0	0	0	
Rounded	14	16	19	
Square	22	22	59	
Late Stage				.044
Concave	2	0	7	
Ovoid	0	0	0	
Rounded	2	2	0	
Square	15	17	16	
Edge Shape				
Early Stage				.021
Convex	35	34	40	
Recurvate	0	2	1	
Straight	17	7	3	

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Table 4 (continued). Absolute Frequencies of Bifaces from the Three Staging Areas by Extent of Cortex, Planview, Base Shape, Edge Shape, and Transverse Cross-section, Each Subdivided by Stage of Reduction.

	Carson-Conn-Short	Topper	Williamson	*p*
Other	0	1	0	
Middle Stage				.006
Convex	32	48	61	
Recurvate	0	3	8	
Straight	15	4	24	
Other	0	0	0	
Late Stage				.000
Convex	11	27	10	
Recurvate	0	0	9	
Straight	13	5	9	
Other	0	0	0	
Transverse Cross-section				
Early Stage				.005
Bi-convex	22	32	29	
Bi-plano	15	8	2	
Plano-convex	15	6	13	
Middle Stage				.142
Bi-convex	28	45	62	
Bi-plano	2	1	8	
Plano-convex	16	11	23	
Late Stage				.602
Bi-convex	14	24	17	
Bi-plano	2	1	1	
Plano-convex	8	7	10	

p-values from chi-square tests.

circular forms) and significantly more bifaces with slightly rounded base shapes. Based on edge shape, early-stage bifaces from Carson-Conn-Short have more-than-expected straight-sided edges and less-than-expected convex edges. In addition, fewer-than-expected Carson-Conn-Short bifaces have bi-convex cross-sections and more have bi-plano cross-sections.

Bifaces from the three sites also differ in the type and frequency of thinning removals (Table 5). The frequency of overface ($p = .050$) and end-thin removals ($p = .033$) significantly differ. The frequency of overshot flaking is generally low and similar among all the sites. However, Topper has more early-stage bifaces without overface removals. Topper also has significantly fewer bifaces with end-thin removals. Carson-Conn-Short and Williamson have overfacing and end-thinning features in similar high frequencies.

Middle-Stage Bifaces and Early-to-Middle-Stage Reduction. By the middle stage of reduction, size relationships among bifaces from the three sites are more similar relative to those of early-stage reduction (Table 6). Biface lengths no longer significantly differ. Williamson biface widths are still significantly narrower than the other sites (WM vs. CCS, $p < .000$; WM vs. TP, $p < .000$). Williamson middle-stage bifaces continue to be the significantly thinnest (WM vs. CCS, $p < .000$; WM vs. TP, $p < .000$). Carson-Conn-Short and Topper bifaces are still similar in average width and thickness.

All the assemblages share a common middle-stage shape in terms of width-to-thickness and length-to-thickness (Table 6). Williamson bifaces, however, continue to be comparatively longer relative to width (WM vs. CCS, $p = .016$; WM vs. TP, $p = .009$). Carson-Conn-Short and Topper middle-stage bifaces share a common shape based on all shape ratios.

Carson-Conn-Short bifaces still have the longest end-thin removals (Table 6), with an average that is significantly longer than Topper ($p < .000$) and Williamson bifaces ($p = .003$). Topper has the shortest average end-thin length. Likewise, Williamson bifaces also have relatively long

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Table 5. Absolute Frequencies of Bifaces from the Three Staging Areas with Overshots, Overfaces, and End Thins, Each Subdivided by Stage of Reduction.

	Carson-Conn-Short	Topper	Williamson	*p*
Overshots				
Early Stage				.541
0	44	34	40	
1	6	7	2	
2+	2	3	2	
Middle Stage				.131
0	41	49	89	
1	5	8	3	
2+	0	0	1	
Late Stage				.034
0	23	23	27	
1	1	8	1	
2+	0	1	0	
Overfaces				
Early Stage				.05
0	12	21	11	
1	12	13	6	
2+	28	10	16	
Middle Stage				.384
0	8	11	25	
1	11	13	30	
2+	27	33	38	
Late Stage				.036
0	6	7	9	
1	7	4	6	
2+	11	21	13	
End Thins				
Early Stage				.033
0	19	29	16	
1	15	6	19	
2+	18	11	9	
Middle Stage				.001
0	9	30	20	
1	14	16	24	
2+	24	11	50	
Late Stage				.12
0	4	17	4	
1	6	5	7	
2+	14	11	17	

p-values from chi-square tests.

removals, with an average that is significantly longer than Topper biface end-thins ($p = .020$). In terms of descriptive characteristics, middle-stage bifaces from the three sites are also more alike (Table 4). Unlike early reduction, the extent of cortex, transverse cross-section, and base shape are no longer factors distinguishing assemblages. Other characteristics, however, continue to differentiate, with the Williamson assemblage having more-than-expected lanceolate forms and less-than-expected ovoid forms ($p = .003$). The Topper form outline changes to bifaces with convex edge shapes and less straight-sided forms ($p = .006$).

The frequency of overshot flaking remains insignificant, but now overface removals are no longer significantly different (Table 5); all assemblages have evidence of this thinning strategy. Topper knappers still did not use end-thinning techniques as frequently as they did at the other sites ($p = .001$).

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Table 6. Average Values and Ratios of Metric Attributes of Middle-stage Bifaces from the Study Sites.

	Carson-Conn-Short n = 47	Topper n = 57	Williamson n = 94
Length (mm)	76.36	69.49	67.16
Width (mm)	45.99	46.86	35.47
Thickness (mm)	12.04	35.47	10.24
Dominant end thin length (mm)	29.90	15.35	20.44
End thin width (mm)	7.41	4.09	5.02
Length:Width	1.72	1.59	2.06
Width:Thickness	3.91	3.80	3.55
Length:Thickness	6.11	5.29	5.81

Thus, by the end of the early and middle stages of reduction at each site, some biface idiosyncracies potentially related to raw-material-outcrop conditions were corrected for in production. The extent of cortex, transverse cross-section, length, and shape measures (e.g., width to thickness and length to thickness) no longer distinguish the three site assemblages. Patterns of the extent of width and thickness reduction are also relatively similar (Table 7). Based on the percentage of biface width lost from early to middle stages of reduction, Carson-Conn-Short bifaces are reduced by 26.9 percent, Topper bifaces are reduced by 27.7 percent, and Williamson bifaces are reduced by 26.6 percent (Figure 5). The reduction of biface thickness follows the same pattern but to a greater degree, suggesting thinning was a major priority in the earliest stages of reduction. Carson-Conn-Short bifaces are reduced by 49.75 percent, Topper bifaces are reduced by 52.66 percent, and Williamson bifaces are reduced by 49.08 percent (Figure 6). Topper knappers thinned bifaces to a slightly greater extent, but generally from early to middle stage, all three site-average biface forms were reduced with a standard proportion lost. However, the Topper bifaces are still significantly thicker, a characteristic that may be raw-material driven or could be a deliberate difference in reduction strategies.

Late-Stage Bifaces and Middle-to-Late-Stage Reduction. Bifaces in the late stage of reduction are distinguished by size but are less variable in shape than those of earlier stages (Table 8). Williamson bifaces are significantly narrower and thinner (width: WM vs. CCS, $p < .000$; WM vs. TP, $p < .000$; thickness: WM vs. CCS, $p = .004$; WM vs. TP, $p = .008$).

Late-stage biface shapes from the three sites are similar in terms of length to thickness and length to width (Table 8). The width-to-thickness ratio, a ratio not differentiating the sites in the early and middle stages, is now significantly different ($p = .017$). Carson-Conn-Short and Topper are similar based on this shape ratio, but Williamson is significantly narrower relative to thickness (WM vs. CCS, $p = .014$; WM vs. TP, $p = .014$).

Length and width measurements of end-thinning removals are similar among Carson-Conn-Short and Williamson bifaces (Table 8). However, Topper end-thin lengths are significantly shorter than Carson-Conn-Short ($p = .046$) and Williamson ($p = .010$) lengths.

Table 7. Percent Width and Tempo of Reduction for Bifaces from the Three Staging Areas.

	Carson-Conn-Short		Topper		Williamson	
	% Width	Tempo	% Width	Tempo	% Width	Tempo
Early to Middle	26.93	Fast	27.66	Fast	26.61	Fast
Middle to Late	13.20	Slow	17.61	Medium	19.90	Medium
Late to Finished point	26.30	Fast	30.77	Fast	12.74	Slow
	% Thickness	Tempo	% Thickness	Tempo	% Thickness	Tempo
Early to Middle	49.75	Fast	52.66	Fast	49.08	Fast
Middle to Late	16.69	Slow	23.29	Medium	23.63	Medium
Late to Finished point	30.31	Fast	26.09	Medium	10.10	Slow

Tempo defined by the calculation of the percentage of width and thickness lost between successive stages of production.

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Table 8. Average Values and Ratios of Metric Attributes of Late-stage Bifaces from the Study Sites.

	Carson-Conn-Short n = 24	Topper n = 33	Williamson n = 28
Length (mm)	61.72	70.17	53.23
Width (mm)	39.92	38.61	28.41
Thickness (mm)	10.03	9.62	7.82
Dominant end thin length (mm)	26.20	10.83	19.02
End thin width (mm)	5.09	5.81	4.81
Length:Width	1.86	1.85	1.97
Width:Thickness	4.15	4.11	3.68
Length:Thickness	22.67	8.21	15.99

Some descriptive characteristics remain similar while others become more prominent features for differentiating the biface assemblages (Table 4). The extent of cortex and cross-section shape still do not vary significantly, and planview shapes are more standard, too, mostly lanceolate shaped. However, the Carson-Conn-Short assemblage has significantly more bifaces with straight-sided lateral margins, Topper has significantly more bifaces with convex margins, and Williamson has significantly more bifaces with excurvate margins ($p < .000$). Williamson late-stage bifaces are also significantly more concave based ($p = .044$).

Late-stage Topper bifaces have significantly more overshot and overface scars ($p = .034$ and $p = .036$, respectively), but the use of end thinning does not vary and is significantly used to greater degrees than earlier in the reduction process at all three sites (Table 5).

At the transition from middle to late stages, bifaces are comparable in length, but Williamson bifaces are significantly smaller in width and thick-

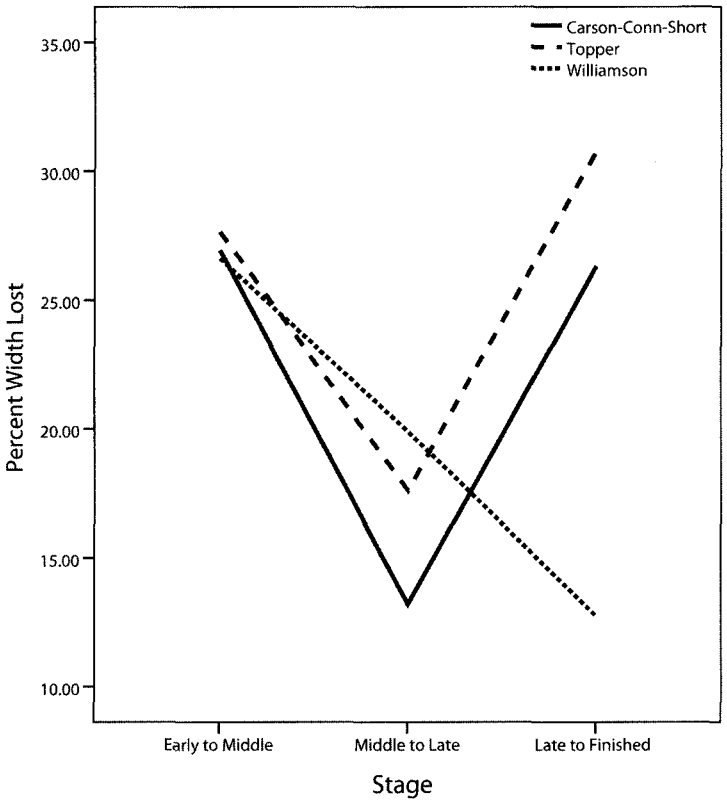


Figure 5. Comparison of the tempo of width reduction (or width lost) through the biface production process at the three study sites.

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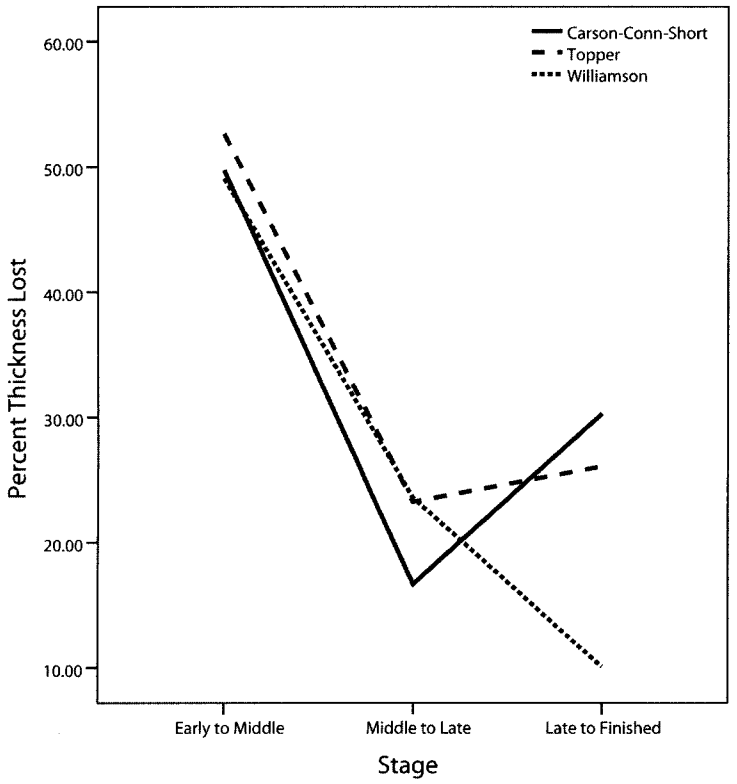


Figure 6. Comparison of the tempo of thickness reduction (or thickness lost) through the biface production process at the three study sites.

ness. Width-to-thickness, ratios, a consistently shared attribute in early- and middle-stages of reduction, diverges. For the first time, the average Williamson biface is significantly narrower relative to thickness. Biface shapes remain similar in length to thickness; at this transition, differences of length to width are standardized and no longer differentiate the assemblages. By the transition from the middle-to-late stages, all biface shape differences have been corrected. In other words, during the reduction process, from the early-to-late stages, at some point in production each shape ratio became a non-significant factor. By the late stage, bifaces from all three sites have shared commonalities in shapes. Other characteristics that could be raw-material driven, like extent of cortex and transverse cross-section, are also not significant factors after the early stage and remain so through the late stage. The most notable changes at the production transition occur in edge shape and thinning strategies. The three assemblages are distinguished by the predominance of unique forms—straight-sided bifaces, convex-sided bifaces, and recurvate-sided bifaces. Thinning strategies suggest that important technological differences are present. For the first time in the reduction process, Topper knappers focused on thinning as a major production goal, and they began to use overshot and overface flaking more frequently than seen at the other two sites. Interestingly, unlike the previous early-to-middle-stage transition, patterns of width and thickness reduction are not as standard among the assemblages (Table 7). Based on percentage of biface width lost, less material was removed with the middle-to-late-stage transition. Carson-Conn-Short bifaces are reduced only by 13.2 percent, Topper bifaces are reduced by 17.6 percent, and Williamson bifaces are reduced by 19.9 percent (Figure 5). The reduction of biface thickness follows a similar pattern; Carson-Conn-Short bifaces are reduced by 16.7 percent, Topper bifaces are reduced by 23.3 percent, and Williamson bifaces are reduced by 23.6 percent (Figure 6). Therefore, at

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this point in production, Williamson bifaces were reduced the most by width and thickness, but there is a general decreasing trend in the extent of reduction for all three assemblages.

Finished Points and Late-Stage to Finished Point Reduction. As noted above, on average, finished fluted points differ in terms of size and shape. Points from the Carson-Conn-Short area are significantly larger in length and width and more robust in shape while finished points from the Williamson region are the shortest and narrowest with the least robust shapes. Topper falls between the two (Table 1). These characteristics are unexpected because late-stage bifaces are not significantly different in length and shapes ratios of length to width or length to thickness. Further, Carson-Conn-Short points are distinguished by unique basal features; the point bases are significantly more concave and have deeper basal concavities in proportion to basal widths. Williamson points are widest at the base in comparison to the blade or body width.

In the transition from late-stage biface to finished point, significant differences in technology are apparent. The extent of width and thickness reduction notably varies from the pattern in the previous transition (Table 5). Instead of a continued decrease in the percentage lost with width reduction (Figure 5), Carson-Conn-Short (26.3 percent width loss) and Topper (30.8 percent width loss) knappers actually used thinning nearly twice as much as they did in the middle-to-late-stage-production transition. Williamson knappers, however, decreased the extent of width reduction and removed less material than previously (only 12.7 percent width lost). Reduction patterns for thickness are also unexpected (Figure 6). Carson-Conn-Short bifaces are reduced in thickness significantly more (30.3 percent thickness loss); they are thinned nearly twice as much as they were in the middle-to-late-reduction process. Topper knappers also increased the extent of reduction (26.1 percent thickness loss) but not to the same degree as Carson-Conn-Short. Finally, Williamson bifaces follow the expected trend, and the percentage of biface thinning decreases from the late stage to final stage of point production (only 10.1 percent thickness lost). Thus, through evaluating the extent of width and thickness reduction as a process, three different reduction patterns have emerged. Each assemblage has a unique pattern in the timing and pace, or *tempo*, for narrowing and thinning the biface form.

The overall width and thickness lost in production from early stage to finished point for each site followed a similar pattern (Table 5). In terms of width, Topper bifaces are reduced the most from the early-stage state (58.7 percent), Carson-Conn-Short were reduced slightly less than Topper (53.3 percent), and Williamson knappers reduced width the least relative to early stage width (48.7 percent) (Figure 5). Based on thickness reduction patterns, Topper knappers also reduced thickness to the greatest extent (73.2 percent), Carson-Conn-Short knappers thinned less (70.8 percent), and again, Williamson knappers reduced thickness the least (65.0 percent) (Figure 6).

Discussion

This study evaluates Anderson's (1996) staging-area model for Clovis settlement in the Southeast in light of the competing HTF model (Kelly and Todd 1988). With the use of finished point data from the three subregions, coupled with site-level biface data from the three sites, the discussion that follows first addresses the role raw material played in determining biface forms, and second, recognizes aspects of technology and point morphology that characterize Clovis in the Southeast. The final part of the discussion addresses the implications for biface technology derived for the HTF and staging-area models.

The Role of Raw Material in Biface and Point Production

While there are differences in toolstone conditions at the three sites, analysis of reduction sequences shows that initial material characteristics did not directly determine final point shape by the middle stage of reduction. The effects of toolstone did not distinguish the three assemblages in terms of the extent of cortex or blank cross-section shape. Through reduction, potential raw-material shape limitations were also overcome. Early-stage bifaces from Carson-Conn-Short and Topper share a common shape, and in spite of inherent differences between the tabular Fort Payne chert at Carson-Conn-Short and nodular Coastal Plain chert at Topper, knappers at both sites produced

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similar biface shapes early in production. Width-to-thickness ratio at Williamson was also not affected by raw material conditions, but the Little Cattail Creek chalcedony outcrop at Williamson may have contributed to greater variation early in reduction. Initially, shape ratios of length to width and length to thickness significantly differed between Williamson and the other sites. However, by the middle stage of reduction, these shape ratios were no longer significantly different, again demonstrating that toolstone variability did not directly affect final point shape. Therefore, distinctions in point design were the intentional products of reduction techniques and strategies.

Shared Aspects of Clovis Technology and Point Morphology in the Southeast

There are aspects of the Clovis lithic reduction sequence that are shared regionally. Early-stage bifaces are relatively similar in shape, and overshot and overface flaking as well as end thinning were shared strategies used early in production. By the middle stage of production, Clovis bifaces were similar in length, and shape limitations of raw-material outcrop conditions were overcome. Overface and overshot flaking techniques continued to be used regularly as thinning strategies, and end thinning was also employed but the extent of its use varied among sites. Bifaces in the late stage of production were lanceolate in form and had shared proportional shape ratios. Finished Clovis points from the three subregions are all similar in thickness; this was a significant aspect of shared Clovis point design. The points have end-thinning flake scars, or final flute scars, characteristic of "classic" Clovis technology, and the ratios of flute length to maximum point length are about 40 percent for all three subregions.

Is There Morphological Variation among Clovis Points from the Three Subregions?

There is morphological variation among Clovis points from the Carson-Conn-Short, Topper, and Williamson subregions. Carson-Conn-Short points are generally the most robust in length, width, and basal width, and this pattern is not only evident in terms of size but also in ratios of shape. Carson-Conn-Short points are disproportionately narrow relative to their blade length. Williamson points represent the opposite size extreme, an outcome that at first seems predictable based on raw-material package size, but Williamson points have relatively wider basal widths relative to body widths, suggesting their shape was stylistic or the product of unique resharpening behavior. Perhaps Williamson points were left in the haft longer, leading to more resharpening episodes and significantly larger base-to-blade width proportions. Either way, if Clovis point production varied, it follows that unique regional patterns of variation should also be expected throughout a point's life history with the continued process of use, resharpening, and reworking (Bever and Meltzer 2007). Other attributes of the base demonstrate that there are fine distinctions caused from variation in the design of the haft element. The depth of basal concavity significantly distinguishes finished points from the three subregions, with Carson-Conn-Short points being the most concave. Moreover, average flute length on Carson-Conn-Short points is less than half the maximum point length, indicating more deeply concave bases are not associated with full-face fluting, a trait suggested to characterize presumed later point styles in the East (e.g., fluted points from Vail and Redstone-type points) (Daniel and Goodyear 2006; Goodyear 2006). Finally, based on size and most shape attributes, Topper area points generally fall between Carson-Conn-Short and Williamson area points.

These differences in point morphology become even more interesting when the degree of variation within each subregion is evaluated (Table 2). Attributes involving depth of basal concavity are the most variable relative to other factors for all staging-area samples. In a similar study of late Paleoindian point variability, Taylor-Montoya (2007) also found that basal concavity produced the highest coefficient of variation (see also Bever and Meltzer 2007), and after eliminating factors of unpatterned modification, he concluded that the dimensions of basal concavity may be due to stylistic factors in haft construction. Thus, the high variation of basal morphology measured in the present study could be a product of individual stylistic variation among knappers in each potential staging area, and based on significant differences in mean basal attribute measures, this stylistic variation produced meaningful spatial patterns to distinguish the Carson-Conn-Short, Topper, and Williamson subregions.

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Are There Distinct Manufacturing Signatures, or Techniques that Differentiate Regional Bifacial Technologies?

Preferences for Thinning Techniques. One of the most significant factors differentiating reduction sequences is the type of thinning strategy preferred at each site. At Carson-Conn-Short, knappers used overshot and overface flaking but relied on end thinning as the predominant thinning strategy early on and throughout the production process. End-thin removals were significantly long and wide in the early and middle stages. End thins removed material along the longitudinal axis and tabular edges. Contrary to this, Topper bifaces were thinned primarily using overface and overshot flaking. Topper knappers used end thinning significantly less in the early and middle stages of production. Further, it is not until the late stage that thinning with broad removals became a major production objective. Williamson knappers used both thinning strategies. Early-stage bifaces from the site have evidence of overface and end thinning, but overface flaking was used to a greater degree. By the late stage, Williamson bifaces were predominately reduced with end-thin removals, and these removals were relatively similar in length to average scars found on Carson-Conn-Short bifaces. This variation in techniques suggests that the decision-making process of reduction was not based on a standard, patterned series of removals, but by thinning preferences specific to each site.

Distinctions in the Tempo of Reduction. Not only are there divergences in preferred thinning strategies, but there are also distinct manufacturing signatures based on the timing and pace of thinning, referred to here as the tempo of reduction (Table 7, Figures 5 and 6). When the entire range of biface manufacturers is evaluated, each site appears to have a unique signature for the tempo of production. Carson-Conn-Short knappers focused reduction strategies to thin bifaces most early in the reduction process, and end thinning was the primary technique used to reduce biface width and thickness. The extent of width reduction decreases twofold from middle to late stages, but increases equally again with finished point forms. Therefore, Carson-Conn-Short knappers thinned and narrowed quickly while maintaining length. They focused least on width and thickness reduction midway through the process, instead shaping biface edge shape and planview. And, finally, Carson-Conn-Short knappers thinned again while uniquely shaping basal elements with deep concavities in the final stages of production. The Carson-Conn-Short reduction tempo follows a fast-slow-fast reduction pattern for both width and thickness, producing a point significantly different in robustness compared to the other sites.

The tempo of biface production at Topper is slightly different from the tempo at Carson-Conn-Short and produces a different morphological outcome. Topper knappers started with wide and thick early-stage bifaces. The extent of width and thickness reduction from the early-to-middle stages is the highest at Topper relative to the other sites, and Topper knappers began the thinning process with overshot and overface flaking in the middle stage of reduction. From the middle to late stages of production, the extent of width and thickness reduction slightly decreases but not nearly as much as seen at Carson-Conn-Short. Then, from the late to finished point stages, Topper knappers shaped excurvate lateral margins and dramatically increased efforts to narrow the biface, a pattern consistent with a significant increase in overfacing and overshooting. However, at this point in reduction, width was reduced more than thickness. Because Topper knappers thinned more during the first two stages, they crafted finished points similar to the average thicknesses of points from the other regions. Thus, Topper biface widths were reduced by a fast-medium-fast tempo, while biface thicknesses were reduced by a fast-medium-medium tempo of reduction.

The tempo of reduction at Williamson follows a notably distinct pattern compared to Carson-Conn-Short and Topper. At Williamson, the extent of width and thickness reduction in the early stage is similar to reduction at the other sites. Further, early reduction strategies are also consistent. Williamson knappers, like Carson-Conn-Short knappers, used end thinning as the main technique early in reduction; however, Williamson knappers consistently produced significantly shorter end thins. Consistency in the early stage gave way to a distinct manufacturing sequence in later stages. In the middle stage of production, Williamson bifaces were already shaped as lance-

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olates; at the other sites bifaces did not take this form until the late stage. Additionally, while Carson-Conn-Short and Williamson bifaces were both reduced by predominantly using end thinning, they were not narrowed and thinned at the same tempo. At the middle stage, Williamson bifaces were the same size as Carson-Conn-Short bifaces, but Williamson knappers reduced biface width and thickness approximately 1.5 times more than Carson-Conn-Short during the middle-late transition. They also narrowed and thinned relatively more than at the Topper site. The late-to-finished reduction pattern is also distinct. Although Williamson and Topper knappers had a similar intended final goal (finished points are similar in length, width, and thickness), Williamson knappers reduced width and thickness markedly less than Carson-Conn-Short and Topper knappers. Therefore, Williamson biface widths and thicknesses were achieved through a unique fast-medium-slow reduction tempo.

Evaluating Dispersal Models

The lack of homogeneity in point morphology and biface manufacturing sequences presented here is at odds with rapid-mobility models of Clovis settlement. The HTF model may be a more fitting interpretation of settlement in the Plains and Southwest, but the expectations are inconsistent with the variation found in this study of the American Southeast. The staging-area model of Clovis settlement implies two key expectations—points should stylistically vary in morphology, and biface production should have subregionally distinct manufacturing signatures. Based on the analyses presented here, both of these expectations are met. In the Clovis point template, there are nuances of variation in point shape and design. Further, while there were differences in raw-material conditions that may have initially impacted early-stage biface production, these differences were quickly corrected by the middle stage of production. In the point production process, Clovis knappers at each site used diagnostic Clovis techniques, but the preferred thinning strategy and tempo of reduction varied. The variation identified in this study constitutes the first technologically based evidence in support of the staging-area model of settlement in the American Southeast.

Anderson's (1990, 1996) model also predicts colonization routes or directionality in the settlement process based on varied distributions of Clovis projectile points, and therefore, assumes potential differences in site chronologies. While assessments of the timing of occupations and colonization of the Southeast are handicapped by the lack of radiocarbon dates, the directionality implied in Anderson's model can be considered in terms of intersite comparisons. Anderson's model predicts the Carson-Conn-Short subregion was an initial population concentration, Topper was a secondary population concentration, settled after Carson-Conn-Short (Anderson 1990), and Williamson was also a later population concentration, presumably settled after the Topper area. Therefore, if Anderson's predictions for timing and directionality are correct, then morphology and production at Carson-Conn-Short should represent early Clovis technology in the region, and these factors should be most similar to characteristics at Topper. Finally, style and technology represented at Williamson should have been influenced directly by behaviors at Topper, and only indirectly by behaviors at Carson-Conn-Short.

Based on the size and shape of finished points, Carson-Conn-Short and Williamson represent the opposite extremes of patterns, making Topper the intermediate form. This is a relationship consistent with the directionality implied in the model. Further, when it comes to biface-to-point production, not just final form, Carson-Conn-Short and Williamson knappers reduced bifaces based on distinctly different tempos of reduction, but they shared preferred thinning strategies. Variance in the tempo of reduction suggests that the two groups had a shared knowledge of end thinning and had similar goals in tool production, but the decision-making process of reduction differed. In terms of tempo, the timing and pace of reduction at Topper falls between the other areas. Perhaps, as Clovis groups settled into increasingly disparate subregions, there was a restructuring in the process of Clovis biface production that created differences in procedural aspects while maintaining strong affinities to the original Clovis template. Based on these technological trends, this restructuring could have occurred in accordance with the directionality of Anderson's settlement model.

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However, morphological characteristics of the basal elements of points obfuscate this relationship and obscure patterns of directionality and timing. Fluted forms with distinctly concave bases have been found at sites that post-date the Clovis period (MacDonald 1968), leading some researchers to suggest an increase in basal concavity was associated with a technological shift marking the cultural transition from the early to middle Paleoindian periods (Daniel and Goodyear 2006; Goodyear 2006). If this hypothesis is correct and Clovis points in the region gradually gave way to more concave-based points, then Carson-Conn-Short area Clovis points, with the deepest average basal concavity and highest ratio of basal concavity to basal width, may in fact be later Clovis forms. The trend of less concave to more concave is reversed from the predicted Carson-Conn-Short to Topper to Williamson direction of settlement, and the predicted initial population concentration is the morphological outlier. Thus, when concavity is considered in terms of size and point shape, the trend does not follow the directionality implied in the staging-area model. As an alternative, this morphological variation could be the cumulative effect of variation over time. As Anderson's model predicts, Carson-Conn-Short was the first staging area inhabited in the Southeast, and thus, Clovis people occupied this area for the longest period of time. The long site history at Carson-Conn-Short could have led to incremental innovations in the design of the hafting element, and this may explain the high degree of basal variation among Clovis points from the area. Further, based on the ratio of depth of concavity to basal width, Carson-Conn-Short also clusters with the regional average—a trend consistent with the model prediction that Carson-Conn-Short was an initial population concentration. One other aspect of technology also obscures patterns of directionality. Topper knappers end thinned bifaces significantly less often than both Carson-Conn-Short and Williamson knappers, and instead overshooting and overfacing were key in late-stage thinning. In terms of preferred reduction techniques, Topper is the regional outlier.

Unfortunately, considerations of the staging-area model's predictions for the timing of Clovis settlement and directionality of subsequent population fissioning into separate subregions admittedly fall short without reliable radiocarbon dates from the region. Now that significant technological differences have been identified suggesting separate population concentrations, further analysis of the directionality of raw materials and organization of entire tool assemblages are needed to fully understand the timing and process of Clovis settlement in the Southeast.

What about Cultural Transmission of Clovis Technology across a Pre-existing Population?

An obvious problem with the staging-area model is that of equifinality—its testable implications may not be easily distinguished from those of a Clovis diffusion model. Willig (1991:92) suggested that the "pan-continental pattern" of Clovis tool kits and fluted point forms could be due to the spread of a technology that was regionally adapted by pre-existing groups of people in unique microenvironments. Could such a model explain the Clovis record in the Southeast? Certainly, pre-Clovis sites have been proposed for this region (Bradley and Stanford 2006; Dunbar 2006; Goodyear 2005; McAvoy and McAvoy 1997), so it behooves us to consider an alternative explanation.

The evidence for variation in point morphology among the three assemblages analyzed in this study could be the result of the spread of Clovis point technology through an extant population. Technological distinctions in biface production, like the preferences for thinning strategies and differences in reduction tempos presented here, could also reflect the transmission and regionalization of Clovis technology among contemporary populations.

Cultural transmission theory offers a plausible mechanism for explaining variation in a shared technology. An analogous case may be Bettinger and Eerkins's (1999) investigation of the transition from atlatl to bow and arrow in the Great Basin of western North America. They suggested that variability in point forms may represent differences in the manner in which the technology was culturally transmitted. In this vein, if Clovis technology was culturally transmitted through an open social system of extant populations, then point makers could have initially adopted Clovis technology but then independently modified point form and reduction techniques to meet their unique needs. Short of developing a new model

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that carefully develops and explicitly predicts the archaeological implications of cultural transmission of Clovis technology through pre-existing populations, I cannot rule out the possibility that my results support such an explanation.

Conclusion

The staging-area model predicts Clovis settlement in the American Southeast was a gradual, step-wise process that led to discrete population concentrations of Clovis groups settled into resource-rich locations. These population concentrations or staging areas became the geographic centers and demographic foundations for early cultural regionalization. The analysis presented here applies regional and site-level data to evaluate this model. Based on the analysis of point and biface assemblages, the Carson-Conn-Short, Topper, and Williamson regions shared technological traits diagnostic of Clovis; however, there is subregional variation within Clovis fluted-point form and technology. Each subregion is characterized by distinctions in point morphology and biface production that appear to be culturally based. The presence of heterogeneity suggests the subregions represent distinct groups who uniquely altered aspects of their technology but maintained basic elements of the Clovis tradition.

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References Cited

Anderson, David G.
1990 Paleoindian Colonization of Eastern North America: A View from the Southeastern United States. In *Early Paleoindian Economies of Eastern North America*, edited by Kenneth Tankersley and Barry Isaac, pp. 163–216. Research in Economic Anthropology Supplement 5.
1996 Models of Paleoindian and Early Archaic Settlement in the Lower Southeast. In *The Paleoindian and Early Archaic Southeast*, edited by David G. Anderson and Kenneth E. Sassaman, pp. 29–57. University of Alabama Press, Tuscaloosa.
2005 Pleistocene Human Occupation of the Southeastern United States: Research Directions for the Early 21st Century. In *Paleoamerican Origins: Beyond Clovis*, edited by Robson Bonnichsen, Bradley T. Lepper, Dennis Stanford, and Michael R. Waters, pp. 29–42. Texas A&M University Press, College Station.

Anderson, David G., D. Shane Miller, Stephen J. Yerka, J. Christopher Gillam, Erik N. Johanson, Derek T. Anderson, and Ashley M. Smallwood
2010 Paleoindians in North America: Evidence from PIDBA (Paleoindian Database of the Americas). *Archaeology of Eastern North America* 38:63–90.

Bamforth, Douglas B.
2003 Rethinking the Role of Bifacial Technology in Paleoindian Adaptations on the Great Plains. In *Multiple Approaches to the Study of Bifacial Technologies*, edited by Marie Soressi and Harold L. Dibble, pp. 209–228. University of Pennsylvania Press, Philadelphia.

Beaton, J. M.
1991 Colonizing Continents: Some Problems from Australia and the Americas. In *The First Americans: Search and Research*, edited by T. D. Dillehay and D. J. Meltzer, pp. 209–230. CRC Press, Boca Raton, Florida.

Benthall, Joseph, L., and Ben C. McCary
1973 The Williamson Site: A New Approach. *Archaeology of Eastern North America* 1(1):127–134.

Bettinger, Robert L., and Jelmer Eerkens
1999 Point Typologies, Cultural Transmission, and the Sread of Bow-and-Arrow Technology in Prehistoric Great Basin. *American Antiquity* 64231–242.

Bever, Michael R., and David J. Meltzer
2007 Exploring Variation in Paleoindian Life Ways: The Third Revised Edition of the Texas Clovis Fluted Point Survey. *Bulletin of the Texas Archeological Society* 78:65–99.

Bradley, Bruce A.
1991 Flaked Stone Technology and Typology in the Northern High Plains. In *Prehistoric Hunters of the High Plains*, 2nd Edition, edited by George C. Frison, pp. 369–395. Academic Press, New York.
1993 Paleoindian Flaked Stone Technology in the North American High Plains. In *From Kostenki to Clovis: Upper Paleolithic-Paleoindian Adaptations*, edited by O. Soffer and N. Praslov, pp. 251–262. Plenum Press, New York.

Bradley, Bruce A., and Dennis Stanford
2006 The Solutrean-Clovis Connection: Reply to Straus, Meltzer and Goebel. *World Archaeology* 38:704–714.

Bradley, Bruce A., Michael B. Collins, and Andrew Hemmings
2010 *Clovis Technology*. International Monographs in Prehistory, Archaeological Series 17, Ann Arbor.

Breitburg, Emanuel, and John Broster
1994 Paleoindian Site, Lithic, and Mastodon Distributions in Tennessee. *Current Research in the Pleistocene* 11:9–11.

Broster, John B., and Mark R. Norton
1992 Paleoindian Projectile Point and Site Survey in Tennessee: 1988–1992. In *Paleoindian and Early Archaic Period Research in the Lower Southeast: A South Carolina Perspective*, edited by David G. Anderson, Kenneth E. Sassaman, and Christopher Judge, pp. 263–268. Council of South Carolina Professional Archaeologists, Columbia.

https://doi.org/10.7183/0002-7316.77.4.689 Published online by Cambridge University Press

1993 The Carson-Conn-Short Site (40BN190): An Extensive Clovis Habitation in Benton County, Tennessee. *Current Research in the Pleistocene* 10:3–4.

1996 Recent Paleoindian Research in Tennessee. In *The Paleoindian and Early Archaic Southeast*, edited by David G. Anderson and Kenneth E. Sassaman, pp. 288–297. University of Alabama Press, Tuscaloosa.

Broster, John B., Mark R. Norton, Dennis J. Stanford, C. Vance Haynes, Jr., and Margaret A. Jodry

1994 Eastern Clovis Adaptations in the Tennessee River Valley. *Current Research in the Pleistocene* 11:12–13.

1996 Stratified Fluted Point Deposits in the Western Valley of Tennessee. *Proceedings of the 14th Annual Mid-South Archaeological Conference Special Publications 1*, edited by Richard Walling, Camille Wharey and Camille Stanley, pp. 1–11 Panamerican Consultants, Inc., Memphis

Callahan, E.

1979 The Basis of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts. *Archaeology of Eastern North America* 7:1–180.

Collins, Michael B., Dale B. Hudler, and Stephen L. Black

2003 Research Design for Pavo Real. In *Pavo Real (41BX52): A Paleoindian and Archaic Camp and Workshop on the Balcones Escarpment, South-Central Texas*, edited by Michael B. Collins, Dale B. Hudler, and Stephen L. Black, pp.7–21. Studies in Archeology 41, Texas Archeological Research Laboratory, University of Texas at Austin, and Archeological Studies Program, Report 50, Environmental Affairs Division, Texas Department of Transportation, Austin.

Collins, Michael B., John Lohse, and Marilyn Shoberg

2007 The de Graffenried Collection: A Clovis Biface Cache from the Gault Site, Central Texas. *Bulletin of the Texas Archeological Society* 78:101–123.

Daniel, I. Randolph, Jr., and Albert C. Goodyear

2006 An Update on the North Carolina Fluted Point Survey. *Current Research in the Pleistocene* 23:88–90.

Daniel, I. Randolph, Jr., and Michael Wisenbaker

1989 Paleoindian in the Southeast: The View from Harney Flats. In *Eastern Paleoindian Lithic Resource Use*, edited by C. Ellis and J. Lothrop, pp. 323–344. Westview, Boulder.

Dunbar, James S.

2006 Paleoindian Archaeology. In *First Floridians and Last Mastodons: The Page-Ladson Site in the Aucilla River*, edited by S. David Webb, pp. 403–435. Florida Museum of Natural History, University of Florida, Gainesville.

Eerkens, Jelmer, and Robert L. Bettinger

2001 Techniques for Assessing Standardization in Artifact Assemblages: Can We Scale Material Variability? *American Antiquity* 66:493–504.

Faught, Michael K.

2006 Paleoindian Archaeology in Florida and Panama: Two Circum-Gulf Regions Exhibiting Waisted Lanceolate Projectile Points. In *Paleoindian Archaeology: A Hemispheric Perspective*, edited by J. Morrow and C. Gnecco, pp. 164–184. University Press of Florida, Gainesville.

Fiedel, Stuart J.

2004 Rapid Migrations by Arctic Hunting Peoples: Clovis and Thule. In *Settlement of the American Continents: A Multidisciplinary Approach to Human Biogeography*, edited by C.M. Barton, G.A. Clark, D.R. Yesner, and G.A. Pearson, pp. 79–84. The University of Arizona Press, Tucson.

Flenniken, J. J.

1985 Stone Tool Reduction Techniques as Cultural Markers. In *Stone Tool Analysis: Essays in Honor of Don E. Crabtree*, pp. 91–132. University of New Mexico Press, Albuquerque.

Frison, George C.

1978 *Prehistoric Hunters of the High Plains*. Academic Press, San Diego.

Goebel, Ted, Michael R. Waters, and Dennis H. O'Rourke

2008 The Late Pleistocene Dispersal of Modern Humans in the Americas. *Science* 319:1497–1502.

Goodyear, Albert C., III

1989 A Hypothesis for the Use of Cryptocrystalline Raw Materials among Paleoindian Groups of North America. In *Eastern Paleoindian Lithic Resource Use*, edited by C. Ellis and J. C. Lothrop, pp. 1–9. Westview, Boulder.

1999 The Early Holocene Occupation of the Southeastern United States: A Geoarchaeological Summary. In *Ice Age Peoples of North America: Environments, Origins, and Adaptations of the First Americans*, edited by R. Bonnichsen and K. L. Turnmire, pp. 432–481. Oregon State University Press, Corvallis.

2005 Evidence for Pre-Clovis Sites in the Eastern United States. In *Paleoamerican Origins: Beyond Clovis*, edited by R. Bonnichsen, B. Bradley, D. Stanford, and M. Waters, pp. 103–112. Center for the Study of the First Americans, Texas A&M University.

2006 Recognizing the Redstone Fluted Point in the South Carolina Paleoindian Point Database. *Current Research in the Pleistocene* 23:112–114.

Goodyear, Albert C. III, and Tommy Charles

1984 *An Archaeological Survey of Chert Quarries in Western Allendale County, South Carolina*. Research Manuscript Series 195. South Carolina Institute of Archaeology and Anthropology, University of South Carolina, Columbia.

Gramly, Richard M., and Carl Yahnig

1991 The Adams Site (15Ch90) and the Little River, Christian County, Kentucky, Clovis Workshop Complex. *Southeastern Archaeology* 10:134–145.

Haynes, C. V., Jr.

1972 Stratigraphic Investigations at the Williamson Site, Dinwiddie County, Virginia. *The Chesopiean* 10(4):107–113.

1982 Were Clovis Progenitors in Beringia? In *Paleoecology of Beringia*, edited by D. M. Hopkins, J. V. Matthews, Jr., C. E. Schweger, and S. B. Young, pp. 383–389. Academic Press, New York.

1992 Contributions of Radiocarbon Dating to the Geochronology of the Peopling of the New World. In *Radiocarbon after Four Decades*, edited by R. E. Taylor, A. Long, and S. Kra, pp. 355–374. Springer-Verlag, New York.

Haynes, Gary

2002 *The Early Settlement of North America: The Clovis Era*. Cambridge University Press, Cambridge.

Hill, Phillip J.

1997 A Re-examination of the Williamson Site in Dinwiddie County, Virginia: An Interpretation of Intrasite Variation. *Archaeology of Eastern North America* 25:159–173.

Kelly, Robert L.

1988 The Three Sides of a Biface. *American Antiquity* 53:717–734.

1996 Ethnographic Analogy and Migration to the Western Hemisphere. In *Prehistoric Mongoloid Dispersals*, edited by T. Akazawa and E. J. Szathmary, pp. 229–240. Oxford University Press, Oxford.

Kelly, Robert L., and Lawrence C. Todd

1988 Coming into the Country: Early Paleoindian Hunting and Mobility. *American Antiquity* 53:231–244.

Larson, M. L.

1994 Toward a Hollistic Analysis of Chipped Stone Assemblages. In *Raw Material Economies among Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 7–31. University of Kansas Publications in Anthropology 19, Lawrence.

https://doi.org/10.7183/0002-7316.77.4.689 Published online by Cambridge University Press

Lepper, Bradley T., and David J. Meltzer
1991 Late Pleistocene Human Occupation of the Eastern United States. In *Clovis Origins and Adaptations*, edited by R. Bonnichsen and K. L. Turnmire, pp. 175–184. Center for the Study of the First Americans, Oregon State Univeristy, Coravallis.
McAvoy, Joseph M.
1992 *Nottoway River Survey: Part I: Clovis Settlement Patterns: The 30 Year Study of a Late Ice Age Hunting Culture on the Southern Interior Coastal Plain of Virginia*. Archeological Society of Virginia Special Publication, No. 28. Dietz Press, Richmond.
McAvoy, J. M., and L. D. McAvoy
1997 *Investigations of Site 44SX202, Cactus Hill, Sussex County, Virginia*. Research Report Series No.8, Virginia Department of Historic Resources, Richmond.
McCary, Ben
1975 The Williamson Paleo-Indian Site Dinwiddie County, Virginia. *The Chesopiean* 13(3–4):48–132.
MacDonald, George F.
1968 *Debert: A Paleo-Indian Site in Central Nova Scotia*. Anthropological Papers 16. National Museum of Canada, Ottawa.
Meltzer, David J.
1988 Late Pleistocene Human Adaptations in Eastern North America. *Journal of World Prehistory* 2:1–53.
2002 What Do You Do When No One's Been There Before? Thoughts on the Exploration and Colonization of New Lands. In *The First Americans: The Pleistocene Colonization of the New World*, edited by N.G. Jablonski, pp. 27–58. California Academy of Sciences, San Francisco.
2004 Modeling the Initial Colonization of the Americas: Issues of Scale, Demography, and Landscape Learning. In *The Settlement of the American Continent: A Multidisciplinary Approach to Human Biogeography*, edited by C. Michael Barton, Geoffrey A. Clark, David R. Yesner, and Georges A. Pearson, pp. 123–137. University of Arizona Press, Tucson.
Miller, D. Shane
2007 Site Formation Processes in an Upland Paleoindian Site: The 2005–2007 Topper Firebreak Excavations. Unpublished Master's thesis, Department of Anthropology, University of Tennessee, Knoxville.
Morrow, Juliet E.
1995 Clovis Projectile Point Manufacture: A Perspective from the Ready/Lincoln Hills Site, 11JY46, Jersey County, Illinois. *Midcontinental Journal of Archaeology* 20:167–191.
Morrow, Juliet E., and Toby A. Morrow
1999 Geographic Variation in Fluted Projectile Points: A Hemispheric Perspective. *American Antiquity* 64:215–230.
Nami, Hugo G., Mark R. Norton, Dennis Stanford, and John B. Broster
1996 Comments on Eastern Clovis Lithic Technology at the Carson Conn Short Site (40BN190), Tennessee River Valley. *Current in the Pleistocene* 13:62–64.
O'Brien, Michael J., J. Darwent, and R. L. Lyman
2001 Cladistics is Useful for Reconstructing Archaeological Phylogenies: Paleoindian Points from the Southeastern United States. *Journal of Archaeological Science* 28:1115–1136.
Otte, Marcel
2003 The Pitfalls of Using Bifaces as Cultural Markers. In *Multiple Approaches to the Study of Bifacial Technologies*, edited by Marie Soressi and Harold L. Dibble, pp. 183–193. University of Pennsylvania, Philadelphia.
Peck, Rodney M.
2004 *Eastern Fluted Points*. 3rd Edition. Rodney M. Peck, Kannapolis, NC.
Prasciunas, Mary M.
2007 Bifacial Cores and Flake Production Efficiency: An Experimental Test of Technological Assumptions. *American Antiquity* 72:334–348.
2008 *Clovis Projectile Point Distribution: Separating Behavior from Sample Bias*. Ph.D. dissertation, Department of Anthropology, University of Wyoming, Laramie.
Sackett, James R.
1985 Style and Ethnicity in the Kalahari: A Reply to Wiessner. *American Antiquity* 50:154–159.
Smallwood, Ashley M.
2010 Clovis Biface Technology at the Topper site, South Carolina: Evidence for Variation and Technological Flexibility. *Journal of Archaeological Science* 37:2413–2425.
Stanford, Dennis J.
1991 Clovis Origins and Adaptations: An Introductory Perspective. In *Clovis Origins and Adaptations*, edited by R. Bonnichsen and K. L. Turnmire, pp. 1–14. Center for the Study of the First Americans, Oregon State University, Corvallis.
Tankersley, Kenneth B.
2004 The Concept of Clovis and the Peopling of North America. In *The Settlement of the American Continent: A Multidisciplinary Approach to Human Biogeography*, edited by C. Michael Barton, Geoffrey A. Clark, David R. Yesner, and Georges A. Pearson, pp. 49–63. University of Arizona Press, Tucson.
Taylor-Montoya, John J.
2007 Quantitative Variation in Late Paleoindian Projectile Points: A Perspective from Central Texas. *Bulletin of the Texas Archeological Society* 78:161–176.
Thulman, David K.
2007 A Typology of Fluted Points from Florida. *The Florida Anthropologist* 60(4):165–177.
Waters, Michael R., and Thomas W. Stafford, Jr.
2007 Redefining the Age of Clovis: Implications for the Peopling of the Americas. *Science* 315:1122–1126.
Waters, Michael R., Steven L. Forman, Thomas W. Stafford, Jr., and John Foss
2009 Geoarchaeological Investigations at the Topper and Big Pine Tree Sites, Allendale County, South Carolina. *Journal of Archaeological Science* 36:1300–1311.
Waters, M. R., C. D Pevny, D. L. Carlson, W. A. Dickens, A. M. Smallwood, S. A. Minchak, E. Bartelink, J. M. Wiersema, J. E. Wiederhold, H. M. Luchsinger, D. A. Alexander, and T. A. Jennings
2011 *A Clovis Workshop in Central Texas: Archaeological Investigations of Excavation Area 8 at the Gault Site*. Texas A&M University Press, College Station.
Willig, Judith A.
1991 Clovis Technology and Adaptation in Far Western North America: Regional Pattern and Environmental Context. In *Clovis Origins and Adaptations*, edited by R. Bonnichsen and K. L. Turnmire, pp. 91–119. Center for the Study of the First Americans, Oregon State University, Corvallis.
Wormington, H. Marie
1957 *Ancient Man in North America*. Denver Museum of Natural History, Popular Series 4. Peerless, Denver.

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