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Toward a synthesis of Paleoamerican fluted point cultures in the Carolinas

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Synthesizing data gathered from private and institutional Paleoamerican artifact collections over the last 50 years, this study examines the typological classification and spatial distributions of 375 fluted points from North Carolina. Clovis, Redstone, and Cumberland points are typologically characterized and differentiated. Landmark Geometric Morphometric (LGM) analyses suggest that North Carolina Clovis points are significantly different in shape than Western Clovis points, consistent with conclusions about continental Clovis variation. Moreover, the LGM analysis supports a typological distinction between North Carolina Clovis and Redstone points. We speculate that this morphological distinction is a functional one related to proboscidean extinction. Spatial distributions of these point types across the state, when combined with similar point distributions across South Carolina, reveal distinct geographic patterns. Notably, metavolcanic Clovis points in North Carolina are centered on Uwharrie rhyolite sources in the Piedmont, while Coastal Plain chert Clovis points focus on Allendale chert sources along the Savannah. Redstone points show a limited range and lower frequency than Clovis points, presumably aligning with Younger Dryas climate change and subsequent population decline. This analysis suggests these distributions reflect the foraging ranges of distinct Clovis and Redstone macrobands, emphasizing the Fall Line ecotone as a key prehistoric aggregation zone.

Until recently, much of our understanding of Paleoamerican lifeways in North America was rooted in the Great Plains and Southwest. While those two regions are famous for in situ, stratified, and dated archaeological records of Clovis, Folsom, Planview, etc., the Southeastern United States is less so. Rather, the Southeast is known for the vast densities and distributions of isolated finds of fluted points[1,2] Indeed, Late Pleistocene and Early Holocene archaeology in the Southeast began by describing fluted and other early lanceolate points and plotting their geographic distributions[3,4]. Today, analyzing fluted points primarily recovered from surface contexts remains a productive research strategy for studying this time period in the Southeast, as the excavation of a fluted point site in the region with stratigraphic integrity and containing a substantial artifact assemblage is rare[5]. To this end, several Southeastern states have made systematic attempts to record and interpret the nature and distribution of fluted points, and most state compilations (including contributions from North Carolina) are now contained under the larger database created in 1990 known as the Paleoindian Database of the Americas[6].

An initial effort to record fluted points in North Carolina began about fifty-five years ago by Phil Perkinson[7,8] that resulted in descriptions of approximately 80 points. Subsequently, Rodney Peck began a statewide survey of fluted points eventually incorporating Perkinson's data. Peck's survey is ongoing and intermittent updates are provided in the Piedmont Archaeological Society Newsletter. Both of those surveys are descriptive in nature and neither attempted a statewide synthesis of fluted points such as exists for South Carolina[9, e.g., 10], Georgia[11] Virginia[12], and Tennessee[13] to name a few Southeastern states. Therefore, it was with the goal of addressing previously unexamined issues concerning Paleoamerican adaptations in North Carolina that the senior author began his study in the 1990s. This work resulted in several sporadic reports[14–21]. Along the way the senior author began collaborating with his coauthors who were able to expand the sample size of artifacts by working with collectors (more on this below) unavailable to the senior author as well as contributing their insights into the analysis. This collaboration has significantly expanded the database to 375 points. As such, the authors feel it is time to present a detailed update of our efforts. Thus, the purpose of this paper is to provide a more

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comprehensive account of the North Carolina data focusing on: (1) typological considerations; (2) patterns in stone raw material use and spatial distributions, and (3) the implications these data have for larger issues related to Paleoamerican adaptations in the southeastern United States. Considerations will also be made with respect to how current interpretations may or may not have changed from previous studies.

The data

Points examined in this study were classified as either Clovis (n = 266), Redstone (n = 89), Cumberland (n = 8), fluted preform (n = 9), or indeterminant (n = 3). Typological distinctions are discussed further below. Moreover, although Dalton points are often considered part of the Paleoindian tradition[1,17,22–24], Dalton points (i.e., Hardaway–Dalton) were not included in the study.

The data total 375 points, 266 (70.9%) from 129 private collections and another 109 (29.1%) from 10 institutional collections. Within the latter, at least 80 (73.4%) points were privately collected prior to being donated to various institutions. Published sources from Perkinson[7,8] (n = 83) were also included in the total count. Moreover, Perkinson also graciously provided data on another 21 points he recorded between 1973 and the early 1990s but never published. Excluding the points reported by Perkinson, the vast majority of points were personally examined by one or more of the coauthors who recorded the various attributes (discussed below) that constitute the database. In a few cases, however, this was not possible as some points were included in our survey based solely on a photograph submitted by an individual. In those instances, little more than point type and possibly raw material were recorded along with point location. (Estimates of point dimensions were sometimes obtained if a scale was provided with the photograph). Still, just knowing where a particular fluted point was located proved useful for understanding statewide distributions even if we know more about spatial patterning than we do the specific attributes for those points.

Standard attributes for each point were recorded that might inform on point type. Metric attributes, for instance, primarily focused on artifact dimensions (Fig. 1). Nonmetric attributes addressed basal form, retouch characteristics, artifact condition, and raw material type. When possible, photographs and a rubbing of each artifact were also made.

We provide several links to data in the Supplementary Information including a spreadsheet that includes the various metric and nonmetric data recorded on each NC fluted point (see Supplementary Information, "NC Fluted Point data"). Additionally, there are several links that include images (both obverse and reverse faces)

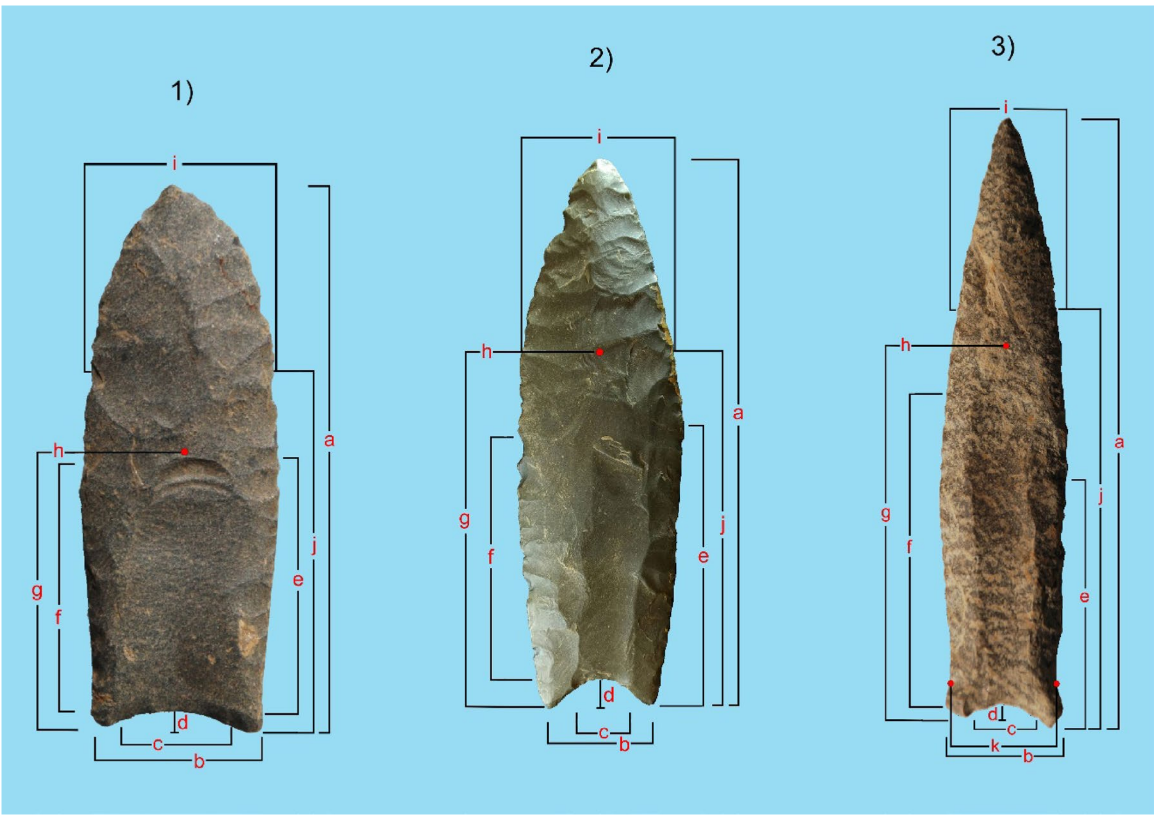

Fig. 1. Point dimensions as measured in this study: (**1**) Clovis; (**2**) Redstone; and (**3**) Cumberland. (a) Maximum length; (b) Base width at ears; (c) Flute width; (d) Basal concavity depth; (e) Haft width height [edge grinding length]; (f) Flute length; (g) Maximum thickness height (maximum thickness to base); (h) Maximum thickness; (i) Mid blade width; and (j) Mid blade height; (k) Basal constriction above ears (only recorded on Cumberland points). *Note*: Points in this figure are not to scale.

of virtually all of the NC fluted points as well. Note that the approximately first 100 points include scans from images in Perkinson 1971 and 1973. Attempts were made to relook at as many of those points as possible and a few of those points were located and rephotographed for this study.

Since so little is known concerning the Paleoamerican occupation of the state, it is difficult to know what proportion of the recovered or recoverable fluted points in North Carolina this sample represents. The number is probably on the low side, however, if fluted point totals from adjacent states of South Carolina (ca. 800), Virginia (ca. 800) and Tennessee (ca. 2400) are any indication[6]. In any case, it represents greater than a four-fold increase over the initially reported totals by Perkinson[7,8].

Finally, from a historical perspective, it is worth noting that at least two of the points in this survey have a scholarly pedigree. NC 31, for instance, was featured in plate 15 of *The Folsom Problem in American Archaeology* by Frank H.H. Roberts, Jr., published in the Smithsonian Annual Report for 1938. Similarly, NC 33 was illustrated (Fig. 10, number 6) in *Ancient Man in North America* (1949), where it was noted that Granville County, NC and adjacent Mecklenburg County, VA, represented a "definite center of concentration for eastern fluted points"[25(pp. 47–48)].

The archaeological contexts of North Carolina fluted points

The provenience of the majority of artifacts was recorded at the county level; however, approximately 37% of the artifacts have the find location or some portion of the county as their recorded provenience. In addition to recording point provenience, the archaeological contexts of points were also classified according to *locational contexts* and *associated contexts* (Table 1). *Locational contexts* provide the archaeological context of the artifact recovery beyond their point provenience that include categories such as surface contexts, disturbed contexts, excavated contexts, river bottom, or unknown. With respect to *locational contexts*, well over half (n = 256, 68.3%) of the points were recovered from surface contexts. Not surprisingly, virtually all these instances were from plowed fields. The *locational context* of another 93 (24.8%) could not be reliably determined, although we might speculate that most, if not all, of them were recovered from plowed fields as well. Another 18 (4.8%) points were recovered from disturbed contexts including construction sites, bulldozer fill, eroded banks, sand borrow pits, and even the digging of a military fox hole, among other instances—all suggesting that most or many of the artifacts were unearthed from subsurface contexts. Another 3 (0.8%) were retrieved from river bottoms. Only a scant minority of 5 (1.3%) points have been recovered via professional excavation in North Carolina. Even in those instances, their recovery from relatively shallow contexts, including two shovel tests, another two recovered from excavations of late prehistoric sites, and another from a historic period plantation—indicates that the identification of discrete and well-defined buried fluted point component in North Carolina remains to be done.

The excavation of points from late prehistoric context includes the Wall site, a Late Woodland Period site located in the Piedmont that includes a single Redstone point (NC 130) excavated from midden contexts[26(pp. 227–228)]. It is unknown whether the point happened to be found at that location by the Wall site occupants or picked up elsewhere and brought to the site. Still, the point was apparently recycled by the Wall site inhabitants as it "shows retouching along most of the lateral margins. The steep lateral retouching created a fresh unpatinated surface which contrasts markedly with the patination rind covering the remainder of the point"[26]. Thus, in this case, the point's midden provenience provides little evidence of whether the point's original context was an isolate or in a Paleoamerican site per se. Similarly, the same could be said for another excavated point (NC 289) that was found in the plowzone excavations of the Town Creek site which includes a Mississippian mound and village site[27].

Our second contextual variable, *associated contexts*, identifies whether the points recovered from the ground surface might represent "isolated finds" (n = 38, 14.8%) or part of a larger "artifact scatter" (n = 144, 56.3%) that includes other Paleoamerican or later period artifacts. The remaining total of 74 (28.9%) points could not be reliably assigned to either isolated finds or artifact scatters. The recovery of fluted points with later materials is a pattern in our data that would seem to run contrary to the more common *isolated finds* recovery pattern for Paleoamerican points that predominates in the Southeast and has been interpreted to be the result of small residential groups of mobile hunter-gatherers who lack the residential permanence or population size to leave significant spatial concentrations of artifacts on the landscape that are subsequently recognized

Locational context	n	%	Associated context	n	%
Surface	256	68.3			
Unknown	93	24.8	Isolated find	38	14.8
Disturbed	18	4.8	Artifact scatter	144	56.3
Excavated	5	1.3	Unknown	74	28.9
River bottom	3	0.8			
Total	375	100.0	Total	256	100.0

Table 1. Fluted point contexts. We have recorded Perkinson's (1971, 1973) site context here as surface scatters since we feel the latter term more aptly describes the archaeological context in which those points were recovered. The term surface scatter is preferred since Perkinson makes clear that those points recorded in his survey as sites were recovered from the surface of "multicomponent sites," which is consistent with the way we use surface scatter. Otherwise, Perkinson recorded fluted point contexts as either isolated find (consistent with the term here) or unknown.

as sites[4(p. 673), 28(p. 236), 29(pp. 11–12), 30(pp. 60–63), 31]. In our case, we think it best to view the category *isolated find* somewhat cautiously, given the number of individuals involved in collecting and the likely variable collecting strategies and surface conditions represented in collecting. Perhaps these instances of purported isolated finds were actually part of a larger surface scatter that was unrecognized or ignored by the collector focused on collecting points rather than noting the context of its recovery? Likewise, the interpretive value of the *associated contexts* in which fluted points were recovered is debatable (Table 1). The occurrence of fluted points within large surface scatters could result from one of several causes, which are difficult to sort out. For example, are these instances of an Archaic reoccupation at the location containing a preexisting discarded isolated fluted point, and thus should be counted as such rather than a site? Or, do these locations represent a Paleoamerican component that includes associated tools and debitage, which, unlike fluted points, are difficult to recognize as Paleoamerican, and not routinely collected, particularly if masked by reoccupation from Archaic groups? Alternatively, a fluted point might have been picked up elsewhere by later groups and recycled by them for their use and eventually lost or discarded (as in the Wall site example above), in which case the present context of that point provides little evidence of its original context. In short, we cannot be sure.

One pattern in the surface scatter data may be significant, however. There are instances where two or more fluted points were recovered from the same field or general location, and we speculate that at least some of these occurrences represent actual sites. Such is the case for the Pasquotank site (Pk1), where four points (NC8-11) were recovered from the same field[32]. The Pasquotank site in the Coastal Plain is a surface scatter of artifacts meticulously collected over several years by one individual who took great care to recover all visible artifacts, even small flakes. This collection provides our only example of a Clovis tool assemblage in the state. While some later Archaic period points were also part of the assemblage, the Clovis component is represented by four fluted points and numerous distinctive unifacial tools—several from the same unique raw material—a fine-grained green siliceous stone that appears to be a rhyolitic tuff—as one of the points (NC 9). Thus, the recognition of the assemblage as a Clovis site was due to the diligence of one individual who revisited the site continuously and collected all visible artifacts and not just points, an atypical collecting behavior. Another such location includes the famous Hardaway site, where three fluted points were recovered[16]. In total, fifteen locations in our data are recorded with more than one fluted point, ranging from 2 to 10 in number (Table 2).

Of interest is that three of the locations with relatively high totals of 4, 7, and 10 points occur in Harnett County near the Fall Line along the Cape Fear River. The recovery of multiple points at locations in Harnett County is likely no coincidence, as its Fall Line location represents a Piedmont/Coastal Plain ecotone along a major river valley akin to those locations postulated by Miller[31] or Anderson and Hanson[33] to represent potential seasonal aggregation loci. More will be said regarding this in the spatial analysis below.

In sum, while North Carolina fluted points are commonly found in surface scatters of artifacts, apart from the examples discussed above, we cannot be certain whether these represent portions of some Paleoamerican site per se or simply isolated points. This conclusion, however, is not meant to undermine the usefulness of documenting surface collected points, whether they are from sites or isolated finds. Rather, as the spatial analysis below will demonstrate, plotting even isolated points reaffirms the importance of examining the distribution of individual points and not just sites across the state.

Typological considerations

Excluding a residual indeterminate category, four biface types were identified in the assemblage, including Clovis, Redstone, Cumberland, and preform. Each of the four types is discussed below.

Point numbers	Site number	County	Number of points
NC 8-11	RLA Pk1	Pasqotank	4
NC 26, NC 149	RLA Md9	Madison	2
NC 60-61	RLA Rk1	Rockingham	2
NC 63-64	unrecorded	Moore	2
NC 65-66	RLA Rh2	Richmond	2
NC 92-93	RLA Cm2	Camden	2
NC 98-99	Unrecorded	Wake	2
NC 182-184	Unrecorded	Northampton	3
NC 205-207	RLA St4	Stanly	3
NC 228-234	31HT200	Harnett	7
NC 235-244	31HT201	Harnett	10
NC247-250	31HT1224	Harnett	4
NC 335-336	Unrecorded	Guilford	2
NC 339, NC 341	Unrecorded	Wake	2
NC 344-345	Unrecorded	Guilford	2

Table 2. North Carolina locations with multiple fluted points. RLA refers to the site number recorded at the Research Laboratories of Archaeology, University of North Carolina, Chapel Hill. Other site numbers refer to the North Carolina Office of State Archaeology site files.

Clovis points

North Carolina Clovis points are characterized by a lanceolate shape, straight-sided fluted base, and shallow basal concavity (Fig. 2). Data indicates that point dimensions fit well within the range of Clovis point metrics across the continent[34(p. 82)] (Supplemental Table S1); however, as discussed in the Landmark Geometric Morphometric (LGM) analysis discussed below, enough significant shape differences exist between North Carolina Clovis and western Clovis points to suggest regional differences exist.

Briefly, the mean maximum length of whole North Carolina Clovis points is 58.1 mm, but can vary widely in length between about 22 and 142 mm. Mean basal width at the ears is 23.8 mm, which is slightly wider than maximum mid blade width at 22.1 mm, consistent with a lanceolate shape. Mean haft length, as defined by averaging the grinding lengths on the left and right side of the base is about 25 mm. Point maximum thickness averages 7.2 mm and occurs about 7 mm beyond the haft (i.e., 33.3 mm from the base). Essentially, this means the points are somewhat front heavy at the blade-base juncture, consistent with other Clovis assemblages[30(p. 67)]. The Mean concavity depth of North Carolina Clovis points is very shallow at about 3 mm. Mean weight of complete points is 14.1 g.

Fig. 2. North Carolina Clovis points: (**a**) NC186; (**b**) NC18; (**c**) NC208; (**d**) NC364; (**e**) NC361; (**f**) NC146; (**g**) NC271; (**h**) NC363; (**i**) NC339.

Type/face	n	Maximum length	Minimum length	Mean
Clovis				
Obverse	117	0.71	0.03	0.37 ± .13
Reverse	91	0.68	0.02	0.29 ± .11
Redstone				
Obverse	40	0.95	0.22	0.57 ± .19
Reverse	38	0.83	0.10	0.45 ± .21
Cumberland				
Obverse	6	0.93	0.26	0.61 ± .24
Reverse	5	0.83	0.22	0.45 ± .24

Table 3. Flute length versus point maximum length ratios by point types. For single-fluted points. Flute lengths are divided by maximum point length.

Type/face	n	Maximum length (mm)	Minimum length (mm)	Mean
Clovis				
Obverse length	144	58.6	1.6	21.2 ± 8.8
Obverse width	134	22.7	4.3	13.2 ± 3.8
Reverse length	115	42.3	1.1	16.8 ± 6.8
Reverse width	105	23.4	5.0	12.4 ± 4.0
Redstone				
Obverse length	48	82.6	13.6	37.4 ± 15.0
Obverse width	43	25.0	5.0	13.5 ± 3.5
Reverse length	47	62.2	7	29.5 ± 13.9
Reverse width	44	20	5.5	13.0 ± 3.4
Cumberland				
Obverse length	76.7	76.7	18.0	42.5 ± 23.1
Obverse width	11.4	11.4	5.3	9.4 ± 2.2
Reverse length	43.2	43.2	22.0	29.5 ± 8.5
Reverse width	11.6	11.6	9.8	10.9 ± .07

Table 4. Flute dimensions (mm) by point type for single-fluted points.

Most North Carolina Clovis points are singly fluted (Supplemental Table S2). Approximately 63% are singly fluted on the obverse face and 54% are singly fluted on the reverse face. Still, an appreciable percentage of points exhibit more than one flute per face (ca 37% on obverse face; ca 46% on reverse face), predominantly represented (ca 25%) by double flutes on either face, followed by faces with 3 flutes (ca 8% per face). A minority of points exhibited 4 or 5 flutes per face. Mean primary flute lengths range between 29 and 37% of maximum point length (Tables 3 and 4).

Of course, these are the statistical averages, and one must be cautious in relying too much on such measures as being representative of a North Carolina Clovis type. Indeed, one might suspect that variability exists in point dimensions by raw material, and this is the case, at least for point maximum length. A boxplot of point lengths by stone type (as lumped into the three raw material categories outlined below) suggests that while there is an overlap in the distribution of point lengths by stone type, quartz points tend to be shorter in length at discard or loss than either chert or metavolcanic points (Fig. 3b). For example, median values for both metavolcanic stone (60.0 mm) and chert (52.1 mm) points are greater than quartz (43.8 mm) points. In fact, the median value of quartz lies below the box lengths (i.e., the interquartile distribution) of both metavolcanic stone and chert. We infer that the relatively smaller size of quartz Clovis points are related to the presumably smaller "package size" of quartz and/or its more highly variable flaking quality than either metavolcanic stone or chert. Moreover, there appears to be no significant difference in the maximum length of metavolcanic and chert points, as they exhibit overlap in their respective interquartile ranges. Likewise, the overall range of scores as indicated by their respective box whiskers and outliers also have similar ranges.

Still, the overlap in the distributions among the three stone types, suggests a size range at which points become unusable. And while Fig. 3b illustrates maximum point length at loss or discard, we suspect it also indirectly reflects the relative order of point lengths by raw materials at manufacture as well.

Other than maximum length, however, boxplots of other Clovis point metrics indicate that stone type is not a significant factor in point variability (Figs. 3 and 4). One interpretation of this observation is that a standard "template" probably existed for the required dimensions of hafting points, regardless of raw material. This is perhaps best illustrated by the remarkable similarity in the boxplot distributions of haft widths and basal width

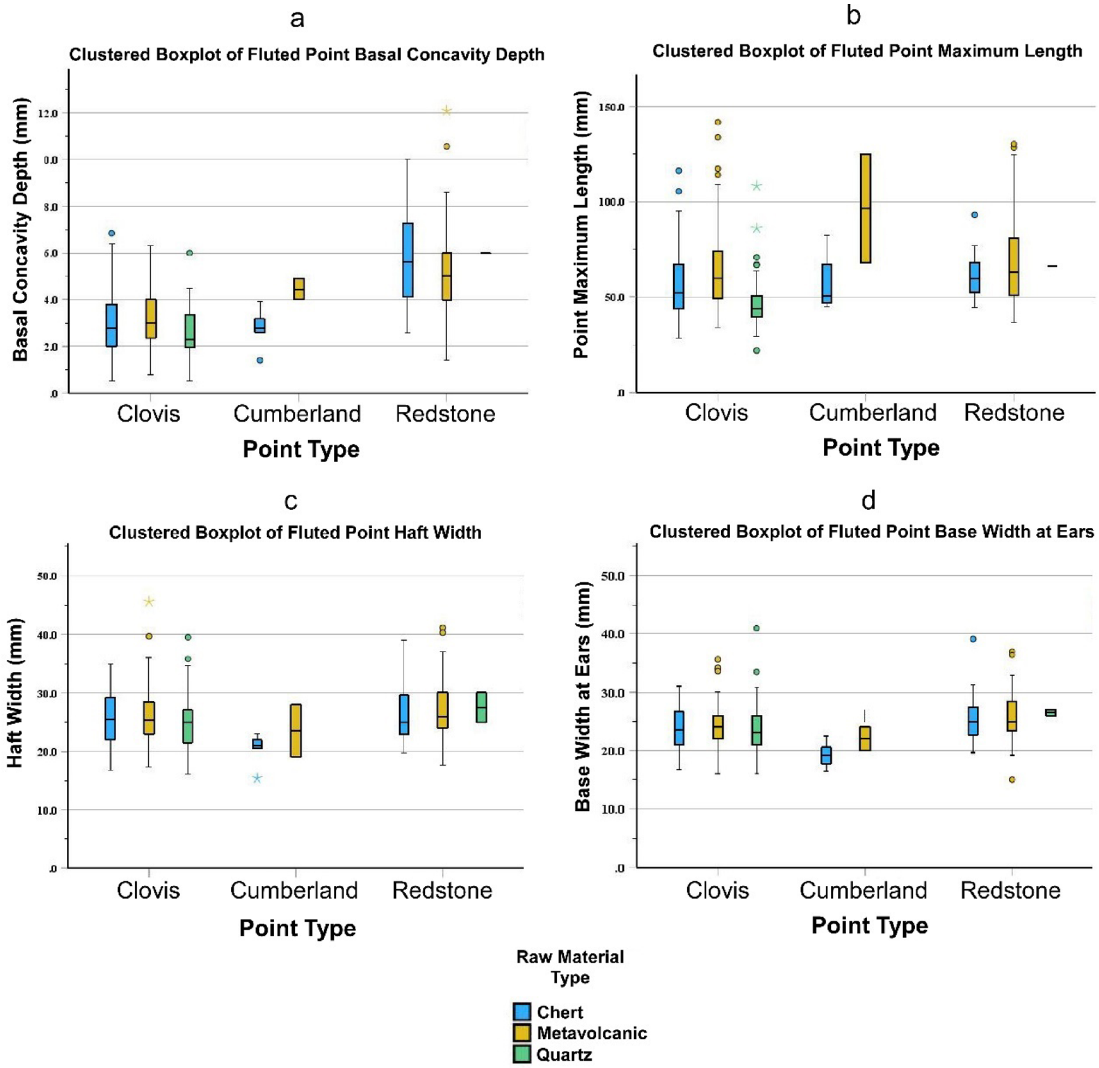

Fig. 3. Boxplot of point dimensions by type and raw material: (**a**) basal concavity depth; (**b**) point maximum length; (**c**) point haft width; (**d**) point base width at ears.

at ears by stone type (Fig. 3c,d). In other words, points were configured to fit the requirements of hafting rather than the other way around.

Moreover, our results are consistent with the findings of previous studies[35–37] which show that variation in stone raw material does not play an important role in variation in projectile point dimensions. In other words:

> "This suggests raw materials were selected on the basis of physical properties that allowed flintknappers to manufacture specific point forms that were designed to meet a set of performance criteria. There is no evidence to suggest the alternative plausible situation where projectile point form varied in response to the availability of raw materials. This then suggests the lithic economies of Paleoindians allowed enough access to high-quality raw materials to be selective, such that the manufacture and design of points was driven by decisions about engineering and performance (and likely aesthetics)"[37(p. 597)].

Redstone points

Originally recognized by avocationalists in Alabama[38(pp. 108–109)], the Redstone point in North Carolina is similar in form to Redstone points from elsewhere in the mid-South including South Carolina, Tennessee, and Virginia[e.g.,3, 39] and to Gainey points[40] more commonly found in the Great Lakes region[41] and Midwest[42]. Heretofore Redstone points had been often misclassified as possible Clovis points owing to the prominent flutes. For example, this misclassification was present in the South Carolina fluted point database until it was corrected in 2005[43]. About the same time, the North Carolina database was updated recognizing Redstones there also[18]. In the Carolinas, Redstone points exhibit a relatively deep basal concavity and trianguloid form that is accompanied by a distinctive, often single flute that approaches full facial fluting on resharpened points[17,18,43] (Fig. 5a–f). Technologically, this reflects an instrument-assisted method of fluting where a punch-like device was placed in the concavity with a prepared platform to indirectly strike or by pressure to precisely remove a flute like the way

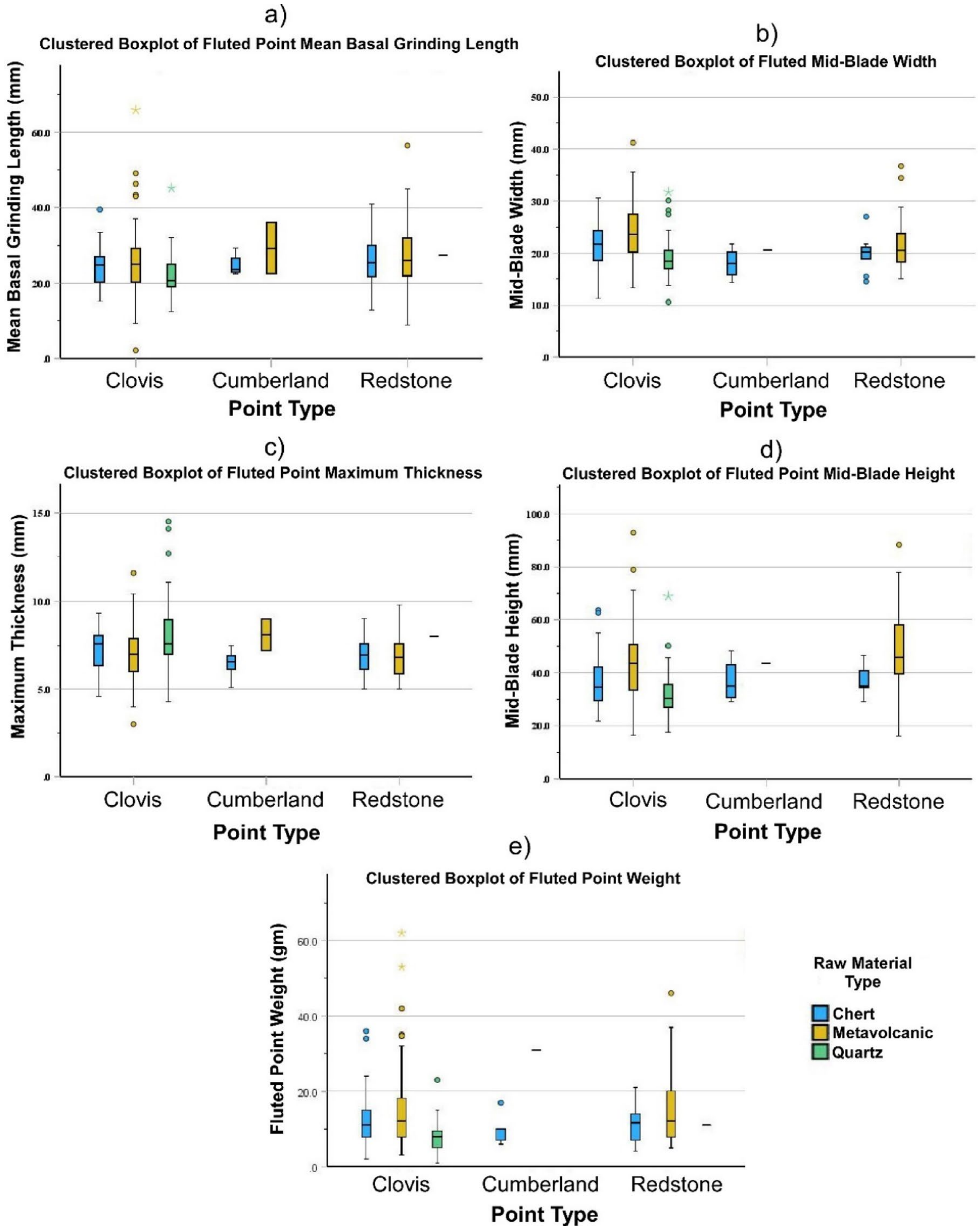

Fig. 4. Boxplot of point dimensions by type and raw material (cont.): (**a**) point mean basal grinding length; (**b**) point mid-blade width; (**c**) point maximum thickness; (**d**) point mid-blade height; (**e**) whole point weight.

Folsom points were fluted[44,45]. Technologically, we feel that this is a qualitative trait that distinguishes Redstone from Clovis (Supplemental Fig. S1). Moreover, as discussed in the LGM analysis below, Clovis and Redstone points are statistically significantly different in their entire shape, and the shapes of their hafts and blades. The morphological differences between Clovis and Redstone points likely reflect functional differences as discussed in the conclusions below.

Briefly, mean maximum length of whole Redstone points is 69.6 mm, but can range between 37 and 135 mm in length (Supplemental Table S1). The overall trianguloid shape of the point is accentuated by a mean basal width at the ears of 25.9 mm which is wider than maximum mid blade width at 21.24 mm. Mean haft length,

Fig. 5. North Carolina Redstone points: (**a**) NC217; (**b**) NC119; (**c**) NC215; (**d**) NC2; (**e**) NC123; (**f**) NC345 and Cumberland points: (**g**) NC191.

as defined by averaging the grinding lengths on the left and right side of the base, is 27.2 mm. Point maximum thickness averages 6.8 mm and occurs about 12.5 mm beyond the haft (i.e., 39.7 mm from the base). Point maximum thickness on Redstone points occurs further up on the blade than Clovis points primarily due to the proportionally greater flute length of Redstone versus Clovis points. Mean weight of complete points is 13.9 g.

Approximately 64% are singly fluted on the obverse face and 68% are singly fluted on the obverse face (Supplemental Table S2). Double flutes are less common occurring on the obverse and reverse faces of just less than a quarter of Redstone points. A minority of points exhibit three or four flutes. Mean primary flute lengths range between 45 and 57% of maximum point length, somewhat greater than that of Clovis points (Tables 3 and 4).

Mean concavity depth of Redstone points is relatively deep at about 5.3 mm, which contributes to its distinctiveness from other fluted points. In fact, the median value of the concavity depths of Redstone points by stone type lie well above the box lengths (i.e., the interquartile distribution) of Clovis points (Fig. 3a).

Cumberland points

Sample size of North Carolina Cumberland points is small but they are similar in form to Cumberland points common to the mid-South[3(pp. 239–240), 38(p. 36), 13,46,47]. They represent a medium to large point, relatively narrow in width that exhibits full facial fluting with a constriction at the base forming distinct rounded ears (Fig. 5g).

Mean maximum length is 70.1 mm but they exhibit a wide range of variability (45–125 mm) presumably due to small sample size (Supplemental Table S1). A similar range of variability is present in mean weight at 13.5 ± 9.4 g. Mean basal width at ears is 20.1 ± 2.6 mm. Unlike Clovis and Redstone points, Cumberland points exhibit a constriction just above the ears (mean = 18.1 ± 2.5 mm) that result in a more "eared" form than either Clovis or Redstone. All the points in our sample exhibited a single flute (Supplemental Table S2). Akin to Redstone points, Cumberland points feature relatively long flutes between 45 and 61% of maximum point length (Tables 3 and 4). Otherwise, point dimensions are similar to Clovis and Redstone points (Figs. 3 and 4).

Landmark geometric morphometric analysis

The Clovis and Redstone points were also analyzed using Landmark-based Geometric Morphometrics (LGM)[48–50], a method often used in archaeology for comparing shapes of stone tools, in particular fluted points[51–57]. The benefits of LGM are that it isolates shape from the confounding effects of size, facilitates statistical analyses, and allows rigorous comparisons among types and explorations of tool use-life. Here, we used it to compare North Carolina Redstone and Clovis points; there were too few Cumberland points for rigorous comparisons. The North Carolina Clovis points were also compared with 74 non-cache Clovis points from sites in Western North America[58].

The LGM datasets included 83 complete Clovis and 25 Redstone points from North Carolina. We also included 22 Redstone points found in South Carolina that were made on raw materials from North Carolina in order to create the required comparably sized data sets for the statistical analyses[59]. All images had no damage that affected LM placement, scales, and measured lateral grinding.

It is common to conceptualize fluted points as consisting of blade and haft modules that are defined by the distal extent of grinding. Although distinct modules, the blades and hafts work in concert to enable the proper functioning of the tool[60(pp. 175–180)]. We defined the outline of the points with 23 total landmarks (LMs) following the process in Thulman et al.[58]. Figure 6 shows the LM configuration; LMs 1 and 4 mark the blade/haft transition. LGM analyses employ entire shapes as single multivariate units of spatial relations and interrelations of the landmarks that define them[61].

LGM eliminates the need to rely on a set of "traits," such as linear dimensions, angles, ratios, or categorical data, which usually are limited shape descriptors[49,50,62,63]. Our 100 Clovis point shapes were translated, rotated, and rescaled to unit size for comparative analyses through generalized Procrustes analysis (GPA), which minimizes the distances between homologous LMs on each shape through a generalized least squares process[50]. All analyses were run in the geomorph[64] and Morpho[65] packages in R 4.4.1[66] and RStudio v.2023.06.1[67]. (See Supplemental Information "*Detailed LGM explanation*" and "*Data and R code to conduct LGM*".)

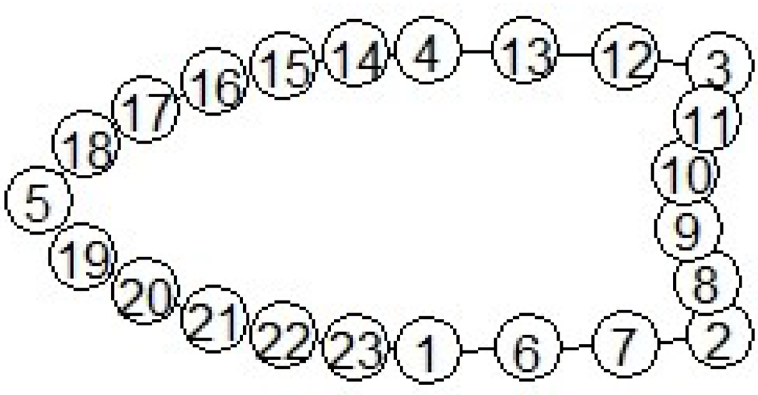

Fig. 6. Landmark configuration.

The Redstone and Clovis points were compared through an analysis of variance (ANOVA) in which the null hypothesis was no difference in the point shapes of the groups. The ANOVA rejects the null hypothesis of "no difference" and confirms the entire Clovis and Redstone shapes are significantly different ($F = 6.1722$, $df = 129$, $p = .002$, $\alpha = .05$), as are their blade ($F = 11.018$, $df = 129$, $p = .001$, $\alpha = .05$) and haft shapes ($F = 3.0781$, $df = 129$, $p = .039$, $\alpha = .05$). The conclusion is that these point types are very different, but whether those differences are due to different uses or functions or simply a matter of drifting style is unknown. A canonical variates analysis (CVA) showed little overlap in the shapes with a cross-validated classification accuracy of 92%. Also, the North Carolina and Western Clovis datasets are significantly different ($F = 52.549$, $df = 157$, $p = .001$, $\alpha = 0.05$) with a CVA cross-validated classification accuracy of 100%. The differences are illustrated in Fig. 7, which shows how homologous LMs in the consensus shapes for each type change from North Carolina to Western Clovis points. The size of the change was magnified 3 times to make the differences clearer. In general, the Western points have shorter and narrower hafts and blades.

We do not know for certain how the points were used, although it is likely they were resharpened as the blades were broken or dulled through use. Unless points were made in a variety of sizes and discarded without resharpening, we can infer that all the points in the dataset were either discarded because they were at the end of their use-life and could no longer be resharpened or were lost before they were exhausted. Assuming the points were not single-use, the length and width variation in the dataset occurred through resharpening. Further, whereas blades could be resharpened, the hafts could also be modified by reshaping. The process of resharpening and reshaping can change the overall shape of the point but also the relative shapes of the haft and blade (Fig. 8).

Assuming smaller points were resharpened more often than larger points, we can reconstruct a continuum of changes in shape through use. The relationship between changing shapes and sizes is called allometry. An allometric relationship means that shapes change as size changes[58]. In contrast, in an isometric relationship, shapes do not change with size. Allometry can occur if a blade gets shorter and narrower through resharpening but the haft is unchanged, perhaps because the point is resharpened when the point is still attached to the

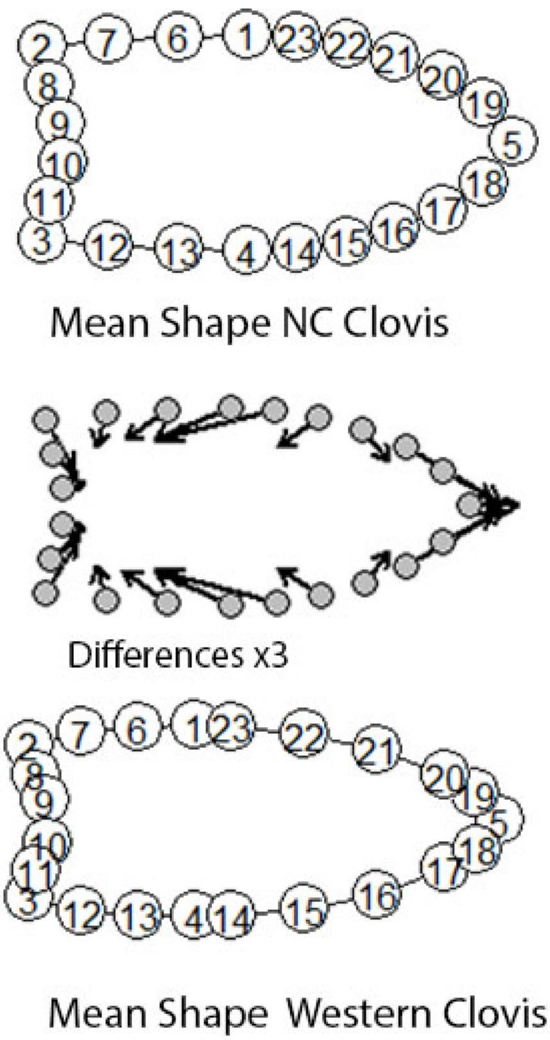

Fig. 7. Mean LGM configurations for North Carolina (top) versus Western Clovis (bottom) points, and the landmark location differences between them. Differences are exaggerated 3× to better show the variation.

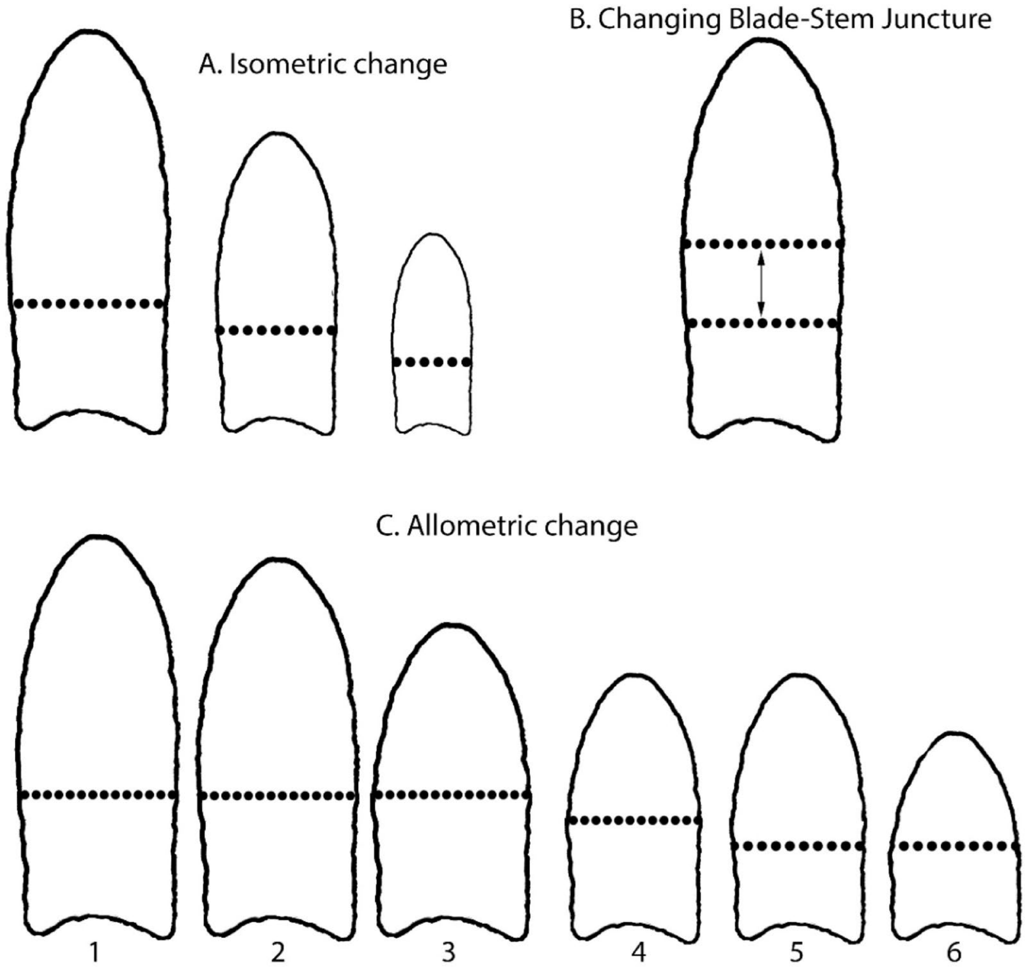

Fig. 8. Isometric versus allometric relationships in point shapes: (**A**) Isometric change as blade gets shorter and narrower in parallel with haft (shape does not change with size); (**B**) changing the blade stem juncture changes the relative sizes of blades and hafts; (**C**) Illustrative sequence of allometric changes as blade gets shorter but haft remains unchanged (1–3) and blade and haft are narrowed (4), haft is shortened (5) and blade is shortened (6).

handle, the point gets smaller and the overall shape changes (Fig. 8c). In contrast, isometry occurs if the blade gets shorter and narrower in concert with the haft because the point is removed from the handle and the entire point is reshaped and then reattached (Fig. 8a). These are different ways of thinking about how tools are used and maintained and reflect different culturally-specific designs and perhaps different functions.

The phenomenon of allometry is well-accepted in point analysis[68–71] and probably accepted intuitively by most chipped stone analysts concerned with the spectrum of human interactions with their tools[72,73]. Allometry requires shape change as size changes[61]. For stone tools, the size and shape changes would occur through resharpening. It is possible that the size-related shape differences resulted from a practice of making tools of different sizes which each size category having specific haft and blade configurations and then discarding them when dull. In other words, if Clovis points were made in different sizes, then the designs were different, meaning there was no single Clovis-design but rather a Large Clovis-design, a Medium Clovis-design and so on. Such a practice could result in the same size-shape distributions we find in the North Carolina and Western Clovis records. A reduction sequence in lanceolate points is complicated because the relative sizes and shapes of the hafts and blades could be easily changed by abrading a sharp blade edge, which would lengthen the haft and shorten the blade, thereby changing the relative shapes of each (Fig. 8b). The lanceolate design provides the user with greater flexibility in modifying the blade-haft configurations than with a notched haft design.

Here, we assume the Clovis points were resharpened and not made in different sizes with different designs. Regardless, the results show significant differences whether through resharpening or initial designs. There is a clear difference between the use-lives of Clovis and Redstone points. The test for allometry is a multivariate regression between the dependent differences in shape on independent differences in size[62]. Here, we used centroid sizes of the entire point and each module. We tested for allometry on the entire point, blade, and haft shapes, to determine where changes were occurring. Like the Western Clovis sample[58(pp. 9–10)] the North Carolina results show allometry ($F = 3.6983$, $df = 82$, $p = .0207$). However, for the Redstone sample, we cannot reject the null hypothesis of isometry ($F = 0.4261$, $df = 47$, $p = .708$). Both the Redstone blades and hafts were also isometric. We infer that the reduction strategies for Clovis and Redstone points were significantly different. For whatever reason, it was important for the Redstone point makes to maintain the "Redstone shape" throughout their use-lives, perhaps necessitating points being removed from the hafts for resharpening.

In sum, the LGM analysis confirms the visual assessment that Redstone and Clovis points in North Carolina are significantly different in shape but also highlights the points were used differently (see Supplemental Information, "*Response to circular reasoning critique*"). Whether Redstones from elsewhere in the Southeast follow the same resharpening patterns is unknown. Our finding that North Carolina Clovis points are significantly different in shape, whether due to differences in initial or resharpening techniques, than Western Clovis points supports Buchanan et al.[52] conclusions about continental Clovis variation.

Preforms

Nine specimens appear to be preforms including one complete example with the remaining artifacts exhibiting lateral snaps on the base or base-blade portion. Preforms represent the final stage of point manufacture. They are identified by fluting on at least one face, a lanceolate shape, and bifacial flaking more characteristic of percussion than final thinning and shaping. All of the specimens in the collection are made from metavolcanic stone and are presumed to be Clovis preforms, but that remains to be determined[74,75].

While we do know that metavolcanic stone, probably from the geologic outcrops of the Uwharrie Mountains (see stone raw material discussion below), represents a primary raw material source for Clovis and subsequent fluted point manufacture, we do not yet know what initial core or blank form North Carolina Clovis points were derived from. Given the bedrock nature of these outcrops, however, we speculate that these quarry sources were locations where large flake blanks were derived and subsequently turned into preforms or even large bifacial flake tool cores. This is a fluted point manufacturing sequence identified for Clovis points elsewhere in North America [e.g.,76,77]. The few preforms identified in this study could have been manufactured through a sequence of flaking that began with a large bifacial core or large flake blank, consistent with such a strategy.

In particular, there are 13 Clovis specimens and 3 Redstone specimens in the sample that suggest a production strategy whereby points were made also on relatively small flake blanks as evidenced by a remnant portion of the ventral flake surface observed on one face of the point and, in some cases, with traces of force ripple marks also evident on the face. In all cases, these specimens tend not to have the full bifacial flaking patterns as seen on preforms or finished points. Rather, these points tend to exhibit less invasive flaking on the apparent ventral surface of the flake preform in the form of marginal flaking or "nibbling" along the flake blank edges to finalize the lanceolate morphology (Fig. 2g–i). Note also it appears that, where observed, ripple marks seem to originate from the point base, suggesting that the base is the location of the flake bulb of percussion, whereby the flake becomes thinner towards the point tip. This blank orientation stands in contrast to that observed on points on flake blanks in the central Great Plains[78(p. 249)].

Elsewhere in North America, the use of flake blanks as a stage of fluted point production has been proposed to represent a technological strategy focused on lithic conservation, where flakes are substituted for bifacial preforms in order to maximize stone raw material use from distant sources [e.g., 77–79(p. 130)]. That is, Clovis knappers used flakes as point blanks instead of continuing to work cores into preforms at greater distance from stone sources. Using flakes as blanks allowed curated cores to continue being used to produce flakes for other expedient tools.

The degree to which flake preforms played a major role in the organizational strategy of North Carolina fluted point production is difficult to say. Still, the presence of 16 specimens attributed to having been produced from flake blanks, is suggestive of the lithic conservation strategy noted for the Great Plains. The distribution of the distance 13 Clovis points manufactured from flake blanks were located from their possible stone source is presented in Supplemental Table S3. For example, seven Clovis point flake blanks were made from metavolcanic stone. Assuming their source was from one of the major quarry locations in the southern Uwharries, points on flakes were recovered from between about 100 and 200 km from their source, except for one specimen located only 35 km away. Another five points were manufactured from chert flake blanks, all of which exhibited variable colors and textures and were distributed from the Coastal Plain to the Mountain. With the exception of one possible Knox chert point, the sources of these are difficult to identify except to note they almost certainly lie outside the state. The possible Knox chert point was recovered from Alamance County in the Piedmont. If this source is accurate, it lies an estimated 370 km to the west. A final single quartz point was located in the Coastal Plain, but given the widespread availability of quartz in the state, its source location may or may not be nearby. Finally, three Redstone metavolcanic points were recovered between the Piedmont and Mountain regions, all probably over 100 km from their source. In short, these data are suggestive of the use of point manufacture from flake blanks at distances of over 100 km from the source, consistent with the notion of the use of flake blanks as a way to maximize the use of knappable stone from distant sources. Of course, it should be emphasized that fluted points presumably made from preforms were found distributed over the state at the same distances as those made from flake blanks (see Geographic Patterns section), so it is difficult to say how prevalent this strategy was.

Chronology

Historically, Coe[80] did not include fluted points in his original sequence for the North Carolina. Instead, Coe gave primacy to the Hardaway Complex which consisted of an ancestral-descendent relationship between three point types: Hardaway Blade, Hardaway-Dalton, and Hardaway Side Notched. Coe viewed the Hardaway Blade as having technological affinities to Clovis, noting that in some cases "they could be mistaken for

Clovis points"[80(p. 120)]. Others, however, have questioned this interpretation [81(p. 24), 82(pp. 62–63)]. Suffice it to say that some typological ambiguity remains with respect to the cultural-historical relationship of the Hardaway Blade[17(pp. 38–42)].

Still, Coe[80(p. 120)] did note the presence of three "Clovis-like" points recovered from the surface of the Hardaway site [see 16]. Today, however, scholars working in the state recognize that, like elsewhere in the Southeast, Clovis and other fluted point types predate Dalton points in the region[14–19,83].

Based upon its chronometric and stratigraphic priority elsewhere in North America[22,34,84(pp. 36–65), 85], Clovis is assumed to represent the earliest established point type in the state but the dating of Clovis and other fluted types in North Carolina is by no means precise[17(pp. 132–136)]. Presently, in North America, there are advocates for either a "short" chronology[85,86] of 13,050–12,750 cal BP or a "long" chronology[87,88] of ca 13,400–12,700 cal BP for the extent of Clovis. In the Southeast, however, Miller and Gingerich[2] use a tentative date range of 13,500–12,800 BP for Clovis. This date range assumes that the current earliest date for Clovis has yet to be found[89] and may predate the earliest date reported by Waters and Stafford[85] and Waters et al.[86] by a couple of centuries. Again, the relevance of this interval for North Carolina Clovis is difficult to say, but we assume it falls within a few centuries of 13,000 years ago.

Absolute dating for the other fluted point types in the state is also problematic [e.g., 1(p. 9), 17(pp. 132–136)]. Still, the Carolina Redstone point is morphologically similar to the deeply concave based fluted points known from the Midwest, Great Lakes, and the Northeast where they have been excavated and radiocarbon dated showing their post Clovis age and non-Clovis manner of fluting[90,91]. These types date immediately after Clovis, about 12,770 and 12,600 cal B.P., and likely are coeval with Redstones in the Carolinas. Perhaps the best known of these is the Gainey point named for its recovery at the Gainey site in Michigan. Ellis[91] has made a strong case for their consideration as a complex or phase-like cultural horizon, showing they are not made like Clovis points and date later than Clovis. Finally, Morrow has stated that "Redstone points are Gainey points that occur in the southeast"[40(p. 99)].

Assuming that Redstone and Cumberland types immediately post-date Clovis, then we might provide a rough age estimate for these deeply fluted and concave based points from ca. 12,800–12,550 BP bracketed between the end of Clovis and the beginning of Dalton [cf. 2] in North Carolina. Moreover, we also assume Hardaway-Dalton immediately post-dates Redstone perhaps dating from 12,550 to 11,400 B.P.[2, 17(p. 133)] terminating earlier than in the proposed for the Dalton "heartland" [see 92].

Regardless of the date ranges for North Carolina fluted points, we think the cultural-historical sequence of Clovis, Redstone, and Hardaway-Dalton is accurate. Hardaway-Dalton represents the earliest point type found in stratigraphic contexts in the state from the Hardaway[80,82] and Haw River[93] sites. Typologically, the Hardaway-Dalton is a North Carolina manifestation of the Dalton horizon elsewhere in the Southeast[22,24,81]. It is generally recognized that the shared technological traits of Clovis and Dalton including overall lanceolate shape, edge grinding, and flaking qualities suggest a historical relationship. Indeed, based upon his study of Dalton points from the Sloan site[24], Bradley[94(p. 57)] suggests "and in-situ technological development of Dalton points directly out of a Clovis technology." This interpretation is reinforced by the fact that both Clovis and Dalton tool kits also share many other tool forms, including well-made unifacial tools like end scrapers and side scrapers [e.g., 1,24,80,81].

Similarly, we see a historical link between Clovis and Hardaway Dalton in North Carolina; however, the presence of another fluted point type—Redstone—suggests that Dalton does not immediately succeed Clovis[17]. Rather, based on typological grounds, the Redstone type exhibits certain evolutionary changes in form that appear to bridge Clovis and Dalton. Redstones, for example, exhibit fluted faces like Clovis points but display a deeper basal concavity and steeple-shaped blades like Hardaway-Daltons. Clovis manifests itself as a lanceolate biface with a fluted base exhibiting a shallow concavity that evolves via the Redstone type into the Hardaway-Dalton type that is basally thinned or fluted exhibiting a relatively deeper basal concavity than Clovis with more flaring ears. Fluting apparently originates with Clovis, reaches its florescence with Redstone, and eventually declines with Hardaway-Dalton. The fuller facial fluting of Redstone is reminiscent of the full facial fluting on Folsom points in the Great Plains which are known to post-date Clovis [e.g., 95]. Fluting eventually diminishes as a trait to thin point bases and more developed ears emerge with Hardaway-Daltons. The de-emphasis of fluting on Hardaway-Daltons was likely a manifestation of the decline of fluting on Dalton points across the Southeast. In short, fluting on Dalton points became "a vestigial attribute of point technology" [96(p. 561)].

Fluted point breakage patterns

Fluted points vary in their condition which can be revealing with respect to point use (Supplemental Table S4). Several breakage patterns present on points are discussed here that are interpreted with respect to point function. Note also that certain attributes (e.g., breakage patterns) used in our analysis were not explicitly reported by Perkinson but were derived from the photographs and drawings in his reports.

Among Clovis points, approximately 55% (n = 146) points are complete. Another 18.5% (n = 49) are essentially whole but exhibit breaks at the ears, tip, or blade. That is, point tips and ears are the structurally weakest elements of the point (being unprotected by the haft) and we speculate that they likely broke during manufacture or use. Almost 9% (n = 23) represent bases only (lateral snaps). Another 2% (n = 6) are bases with a broken ear. In our sample, most such snaps occur at the furthest extent of lateral grinding, suggesting that breaks occurred during use while the point was secured in the haft. Another 7% (n = 18) of points exhibited lateral snaps several millimeters beyond the distal end of the haft, further up on the blade (again, some including broken ears). Lateral snaps are a common breakage pattern in fluted points and occur when a point is bent beyond its tensile strength and simply snaps[97,98(pp. 134–135), 99(p. 43)] which can happen during either manufacture or use[100(p. 197)]. (We acknowledge that such breakage could also occur after a point is lost or discarded, but the relatively even nature of surface weathering on the vast majority of these specimens suggests the breaks are old ones.) In short,

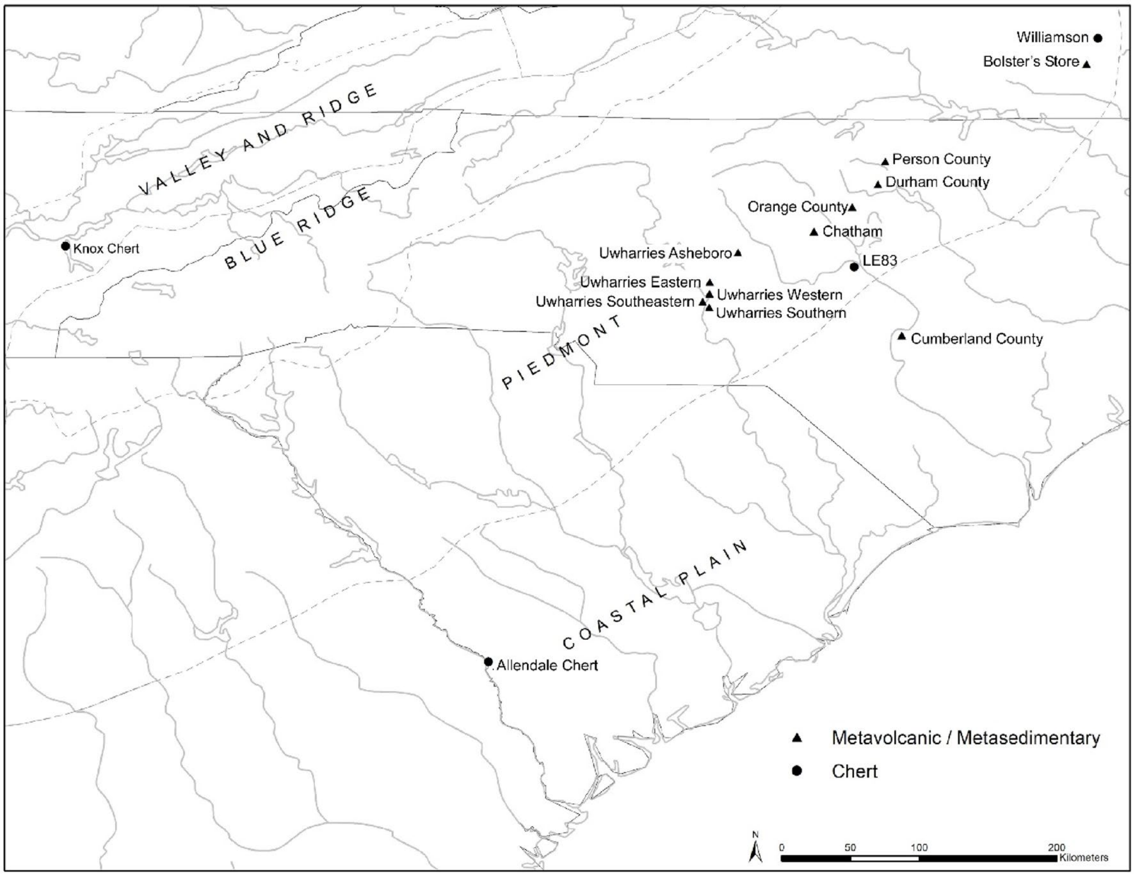

Fig. 9. Stone raw material sources in and around North Carolina (adapted from Daniel 2021).

Region	Area (%)	Expected**	Observed***
Coastal plain	45	115	89
Piedmont	45	115	136
Mountains	10	26	30
$x^2 = 10.51$, $df = 2$, $p < .01$			

Table 5. Frequency distribution of Clovis points by region. Total n = 255 as 11 points occur in counties that straddle the Piedmont and Coastal Plain and their exact location is unknown. Expected values obtained by multiplying regional area percentage by point totals. Observed values are point totals per region.

almost basal breakage patterns are consistent with points being levered in hafts, presumably either as knives in butchering activities or as projectile point per se in hunting or both.

Another type of damage recorded on North Carolina fluted points in our survey are impact fractures. Impact fractures (3.8%) were observed on 9 blades and a remnant impact fracture observed on the base of 1 other Clovis point. These are “small to medium-sized flakes originating at the tip of the point and extending along the face of the blade toward the base”[101(p. 90)]. These fractures resulted from forceful impact with a dense material such as bone and are often seen as damage associated with hunting, either from hand-thrusted or thrown spears (or both) [102(pp. 153,173)] although they also can “occur as a result of plunging the point into a carcass during its use as a knife”[101(p. 90)]. The degree to which these data speak to the recent debate regarding the efficacy of Clovis points primarily serving as knives[103,104] or weapon tips in hunting[105] is difficult to say, but impact fractures remain a persistent presence on North American fluted points [see 30(pp. 72–73), 101(p. 90), 105(p. 5), 106(pp. 50–51)]. Thus, it may be the case that North Carolina Clovis points were multifunctional in nature—an interpretation made of Clovis points elsewhere in North America[107(p. 279), 108].

Four remaining Clovis specimens include four point tips (1.5%). Tips are undoubtedly underrepresented in the collection, given there are several times as many bases represented (which once held tips) in the sample. But this is understandable, given the manner in which points are recognized and collected. The four examples in our sample were only recognized as Clovis due to the fluting remnant visible on at least one face of the artifact.

Absent that diagnostic feature, Clovis point tips might go undetected in collections, assuming they are even recognized and collected in the field.

Finally, another 10 (3.8%) points are lumped into a "fresh break" category. These points exhibit relatively fresh breaks on various parts of a point as evidenced by the presence of an unweathered surface on the break that contrasts with the weathering covering the rest of the artifact surface. As such, these breaks are likely post-depositional in nature. Thus, the frequency of whole points in the sample may actually be higher than it appears, as these breaks likely happened after the points had been discarded or lost.

Similar breakage patterns are seen in Redstone and Cumberland types (Supplemental Table S4). A plurality of Redstone points are whole (n = 34, 38.2%), including one interesting example of a rebased tip. Another 31.4% (n = 28) exhibit tip or ear breakage. As with Clovis points, lateral snaps are common in our sample. Approximately 12% (n = 11) bases (one of which exhibits a broken ear). Another point exhibits a snap just beyond the distal end of the haft. Impact fractures are present on only 3.3% of all points (n = 3). Point tips, identified based on the full facial fluting remnant, are represented by 4 (4.5%) examples. Fresh breaks along an ear or blade are present on another 8 points (5.6%). Cumberland points are predominantly whole (n = 6) along with two point bases, one of which has a freshly broken ear.

Stone raw materials

Stone raw material use was also investigated which bears on the issue of Paleoamerican settlement adaptations. Stone types were identified relative to our understanding of the geologic occurrence of stone in and around North Carolina. A variety of stone types are listed in Supplemental Table S5. For analytical clarity, they are lumped into three broad categories—metavolcanic stone, chert, and quartz—based upon their presumed source locations (Fig. 9). While knappable stone sources occur across the state, they do not occur in abundance everywhere. The best-known sources of tool stone in North Carolina are the metavolcanic and metasedimentary sources found in the Carolina Terrane (formerly Carolina Slate Belt) in the eastern Piedmont, specifically in the Uwharrie Mountain region, where over two dozen quarries of this stone have been mapped and examined petrologically[17,82,109,110] Metavolcanic stone of the Carolina Terrane includes flows, porphyries, tuffs, and breccias—although metavolcanic flows seem to predominate. Generically, much of this stone is often labeled "rhyolite" in the archaeological literature[111(p. 12)]. What we refer to as Uwharrie rhyolite includes several rhyolitic flow and tuff sources located in the Uwharrie Mountains of Stanly, Montgomery, and Randolph counties. The most notable of these quarries is Morrow Mountain located at the southern tip of the mountain range in Morrow Mountain State Park. Morrow Mountain rhyolite is an aphyric, often flow-banded dark gray cryptocrystalline rhyodacite with a homogeneous fine-grained texture. Moreover, Morrow Mountain has been identified as the primary source of the stone in the Hardaway assemblage[82,109]. Several examples of fluted points recorded in this survey were likely made from Morrow Mountain rhyolite.

Not surprisingly, *metavolcanic stone* dominates raw material types (Supplemental Table S5). This type includes varieties of metamorphosed igneous and metamorphosed sedimentary stone. We have lumped both groups into *metavolcanic stone* because of their presumed source in the eastern Piedmont. Moreover, distinguishing between these two categories can be difficult in hand specimen, particularly with weathered specimens. Regarding the Perkinson[7,8] data, we have included his rhyolite, tuff, and slate categories under *metavolcanic stone*. In particular, this category also includes the "green silicified slate" described by Perkinson which may represent the distinctive highly siliceous stone that resembles a green chert in hand specimen but is more likely a type of metamorphosed stone. This material is often referred to as a "vitric tuff"[112(p. 428)] in the literature. Alternatively, apparent examples of a dark green siliceous stone has been found in the Early Archaic artifacts at the Hardaway site that has been petrologically identified as a metasiltstone[82(pp. 45–46)]. Whatever its classification, this stone is of particular interest as it was the predominant raw material in the Pasquotank assemblage mentioned above and the apparent raw material of several fluted points in this survey. Unfortunately, its geologic source remains unknown but the petrologic analysis of material from Hardaway suggests it is similar to argillite which is a major lithologic unit in the Uwharrie region[113]. Thus, it is not inconceivable that a quarry is located somewhere near the Uwharrie Mountains. On the other hand, the apparent rhyolite-like qualities of a green siliceous stone from the Bolster's Store quarry located a few kilometers south of the famous Williamson chert quarries just north of the Nottoway River in Virginia implicate it as a possible source location too[114(p. 33)].

Chert is a composite category that represents several highly siliceous cryptocrystalline materials of various colors often exhibiting a waxy or lustrous surface. Based on color and texture, the cherts in the assemblage appear to have originated from a variety of sources. And since no artifact-quality chert appears to occur in North Carolina, many if not most of the points manufactured from these raw materials probably originated from outside the state [see 17(pp. 26–29)]. One exception to this, however, may be some distinctive dark colored lustrous

Region	Area (%)	Expected	Observed
Piedmont	45	36.9	52
Coastal plain	45	36.9	23
Mountains	10	8.2	7
$x^2 = 11.6$, $df = 2$, $p < .01$			

Table 6. Frequency distribution of Redstone points by region. Total n = 82 as 7 points occur in counties that straddle the Piedmont and Coastal Plain and their exact location is unknown. Expected values obtained by multiplying regional area percentage by point totals. Observed values are point totals per region.

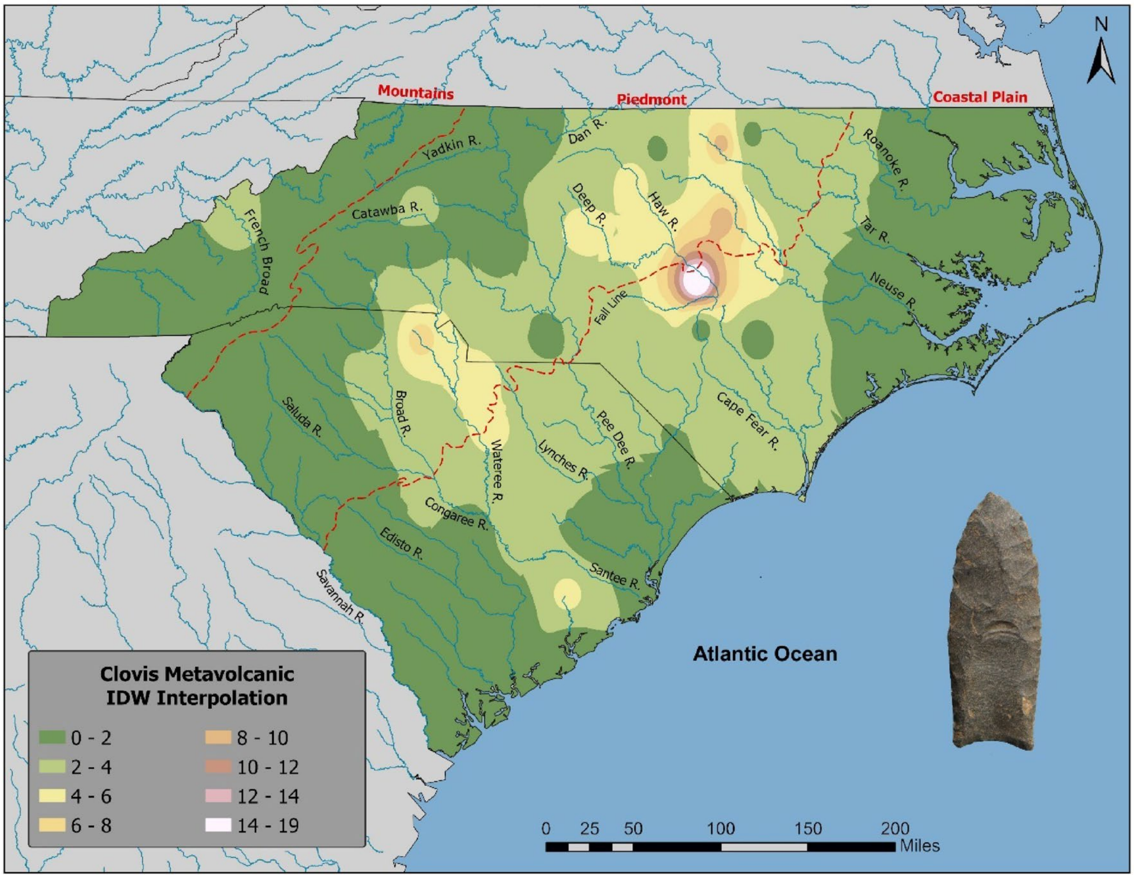

Fig. 10. Distribution of metavolcanic Clovis points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map made using ESRI ArcGIS Pro© Version 3.1.3.

(blue-black) cherts in the assemblage whose source areas are tentatively proposed to lie in the Ridge and Valley province. Sometimes referred to as "Knox" chert, this raw material occurs in nodular and tabular forms along the lower Little Tennessee River and its tributaries in East Tennessee[115]. Other highly siliceous raw materials that are likely nonlocal include chalcedony and jasper. It should be emphasized, however, that the raw materials identified as chert, chalcedony, and jasper listed in Table 5 are by no means geologically precise. In fact, some of the honey-brown siliceous stone points in the assemblage identified as jasper are macroscopically not unlike some examples of the earth tone Allendale cherts from the Savannah River of South Carolina[116]. In any case, whatever the sources of these cryptocrystalline stone are, they are distinctive enough in hand specimen to distinguish them from metavolcanic stone and likely include a variety of stone types that also originated outside the state.

The remaining stone types are relatively minor amounts of quartz, quartzite, orthoquartzite, and quartz crystal. The exact sources of these materials are unknown, but they would have been available in any region of the state primarily as "float" in soils or in cobble form in river gravels [17(p. 24)]. Quartz, of course, is technically a mineral and is the element that provides a conchoidal fracture to all the various stone types discussed here. Specimens of milky white quartz predominate among this group and appear to exhibit a flaking quality that is quite variable. Quartzite too exhibits a variable flaking quality[17(pp. 29–30)]. The glassy texture of quartz crystal, on the other hand, appears to have had an excellent conchoidal fracture. It exhibits a colorless, transparent quality like glass. It's use as a raw material was probably limited by its availability and "package size." Some crystals, for example, are quite small and would not appear to be of sufficient size to make points, but some crystals observed in private collections weigh several pounds and would have exhibited the necessary mass to serve as a source[17(p. 24)].

Finally, a residual category referred to as *indeterminate* includes three points whose surface was so weathered it precluded confident raw material identification. It is likely, however, that these were some type of metavolcanic stone.

Interesting patterns, then, begin to emerge when comparing raw material distributions by type and region. Metavolcanic stone dominates in both Clovis (49.2%) and Redstone (70.8%) types. And, while both Clovis and Redstone points have virtually identical percentages of the highly siliceous materials of cherts, chalcedony, and jasper (ca. 27%), quartz and related materials were apparently avoided as raw materials by Redstone point makers. While low sample size for Cumberland points makes only tentative statements about raw material use possible, it is interesting that chert (75%) dominates over metavolcanic stone (25%). Of the six chert Cumberland points

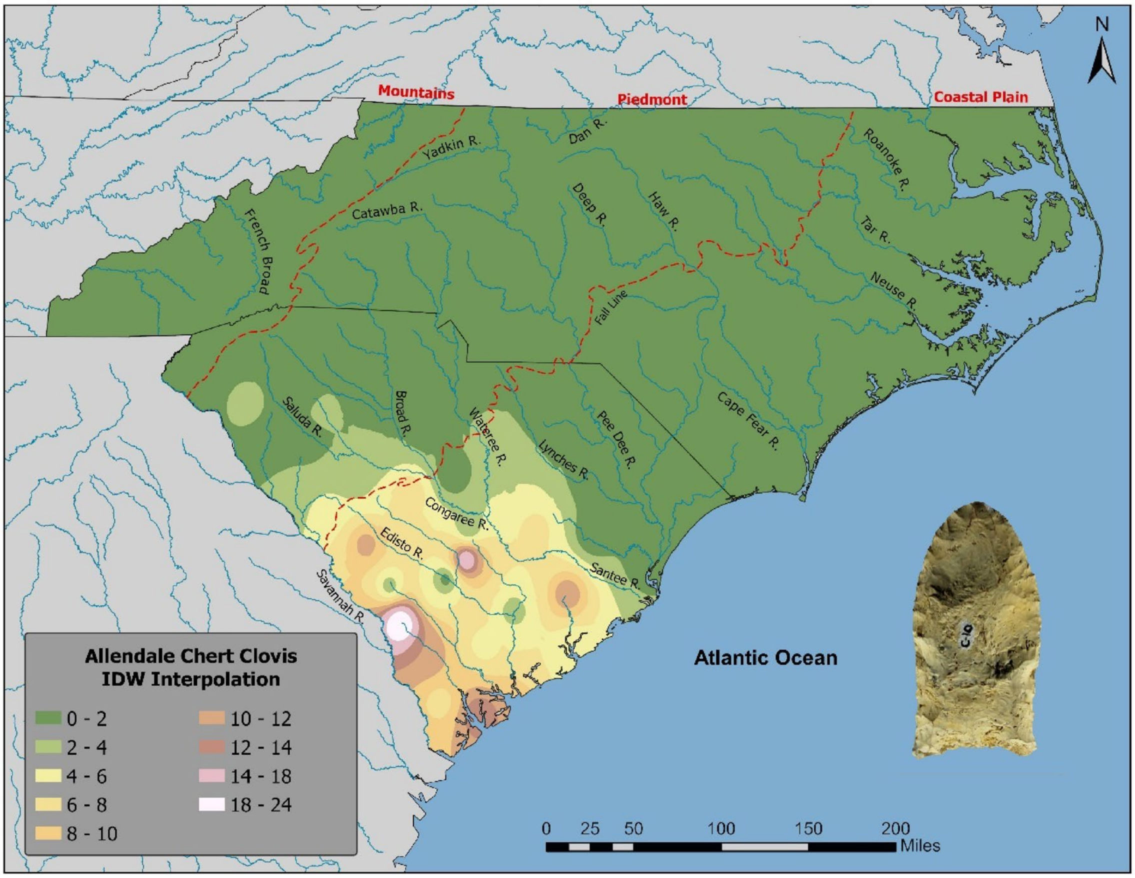

Fig. 11. Distribution of Allendale chert Clovis points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map made using ESRI ArcGIS Pro© Version 3.1.3.

in the assemblage, four were recovered in the Mountains consistent with the likely Ridge and Valley origin of the stone. As with Redstone points, it is also worth noting that quartz was avoided as a raw material by Cumberland point makers.

Geographic patterns

Here we describe broad spatial patterns in the data. Moreover, we comment on this distribution in relation to prior spatial patterns noted in the data[14,15,18–20] focusing on the density and distribution of fluted points across the state, and how previous interpretations are enhanced by the current sample of points. The county serves as the basic provenience unit since it is almost always known and recorded by collectors. Moreover, using county as the basic provenience unit is consistent with that used in PIDBA. Several prior studies have used the county as the spatial unit of analysis with good results [e.g., 31,117–119]—and for good reason. The county in which a point was recovered is almost always known, while more precise location information is not available. This is particularly true in the earlier fluted point studies in North Carolina[7,8]. Moreover, other similar studies have shown that using the county as a basic spatial unit of analysis does not result in a significant loss of spatial information given the statewide scope of fluted point surveys[30,31,106]. In short, using county level data has the advantage of avoiding any potential undue effects that might result from the use of uneven provenience data.

A total of 373 points are present in 73 of North Carolina's 100 counties (excluding two points for which no county provenience is known)—a 48.0% increase over the 252 specimens previously reported[18]. The current tally results in a mean score of 5.1 ± 6.6 points per county; however, this statistical average is somewhat misleading as suggested by the fact that the standard deviation is greater than the mean. This is likely due to the influence of nine counties with counts of 10 or more points. Harnett County, in particular, has 49 points. In this case, the median of 3 and mode of 1 (with 18 counties) may represent more meaningful average scores with 27 counties reporting no fluted points. The overall density of all Paleoamerican points across the state is almost 30 points per 10,000 km^2.

Yet, North Carolina Clovis point densities are not distributed equally physiographically. Looking at Clovis points (Table 5), for example, given the comparable area between the Piedmont and Coastal Plain, one would expect that similar frequencies of points (n = 115) would occur in the Piedmont and Coastal Plain, yet this is not the case. While the Piedmont contains greater frequencies of points (n = 136) than expected for a region that size, the Coastal Plain contains fewer points (n = 89) than expected. Moreover, it is likely that the abundance of fluted points in the Piedmont reflects some prehistoric reality since, as discussed above, the majority of points

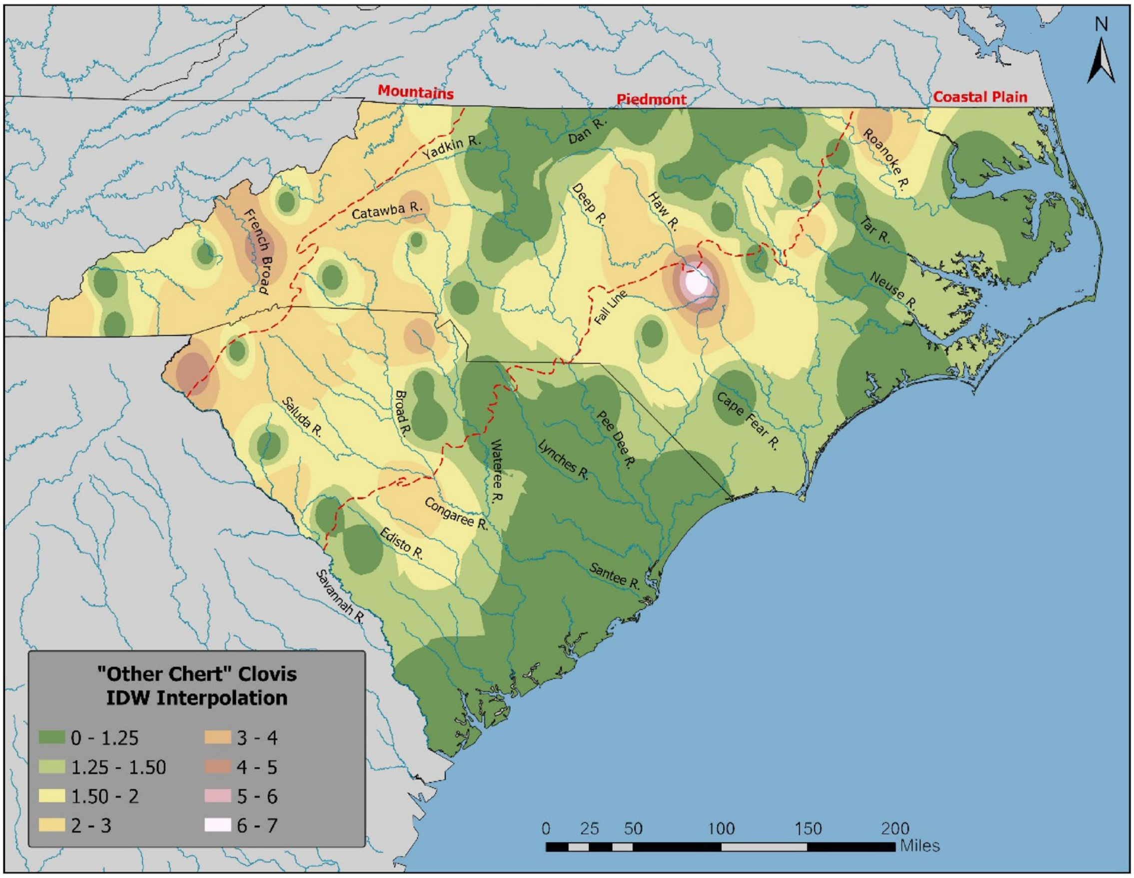

Fig. 12. Distribution of "other chert" Clovis points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map created using ESRI ArcGIS Pro© Version 3.1.3.

identified in the survey were made from metavolcanic stone, the best-known source areas of which are located in the Uwharrie Mountains in the central Piedmont. Given the well-known correlation between fluted point densities and high quality toolstone sources noted elsewhere in the Southeast [e.g., 120,121] it is conceivable that the Piedmont was more intensely utilized by Clovis groups than the Coastal Plain.

Using county as a spatial location, Clovis points are found in ca 70 of North Carolina's 100 counties. Modally, there are mostly 3 points or less per county, but some counties have double digit counts. Specifically, this includes Harnett (36), Wake (n = 14), Granville (n = 12), and Alamance (n = 11) counties. These four counties include a nearly contiguous concentration of counties with points that cover the central and eastern Piedmont and Fall Line. Gaps are also present in the point distribution that tend to highlight the Piedmont cluster. That is, points are generally absent from a corridor of counties spanning the western Piedmont and northern Mountains. This concentration is also marked by a sharp decrease in point frequencies—usually one or two points per county—in the Coastal Plain.

Previously, points were noticeably rare in the North Carolina Coastal Plain[19], and despite increasing point totals in the survey, the Coastal Plain region retains the lowest density of Paleoamerican points in the state (Table 5). It may be of some significance that the Coastal Plain counties that points are recovered from tend to parallel major river valleys such as the Cape Fear (in Hoke, Cumberland, Bladen, and Sampson counties), the Neuse and Tar (in Wayne, Greene, Edgecombe, Pitt, and Beaufort counties), and the Chowan (in Gates, Chowan, and Pasquotank counties) (more on this below).

Turning to the Mountains concentration, we see that it covers a much smaller area than the Piedmont concentration describe above. Yet, the density of points from this region suggests it may have been as intensely occupied as the Piedmont (Table 5). Of course, what this distribution illustrates is the problem often encountered when using modern state boundaries to examine fluted point distributions [see 30(p. 51)]. It is highly unlikely that Paleoamerican land use coincided with current political borders. This assumption is reinforced in this case by the apparent high frequencies of fluted points present in counties across the state line in eastern Tennessee[6]. In effect, the mountain concentration in North Carolina is probably just a portion of a larger cluster centered in the southern Appalachians. In any case, the Mountain region counties in North Carolina where points were recovered are associated with two major drainages: the French Broad River (Madison, Buncombe, Yancey, Haywood, and Transylvania counties) and the Hiwassee River (Cherokee, Graham, and Clay counties.)

Of course, the potential for bias looms large in a study like this and we should be cautious regarding the degree to which we assume fluted point distributions accurately reflect prehistoric landscape use. For example,

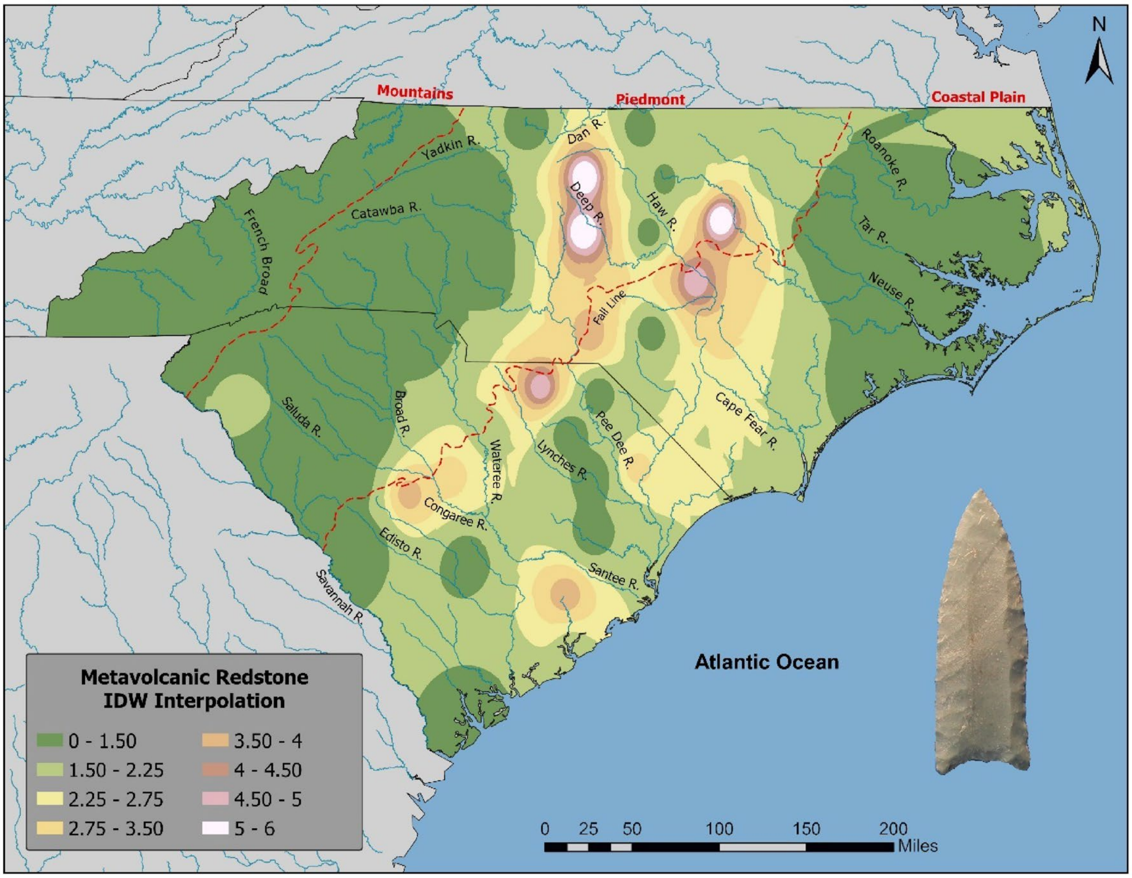

Fig. 13. Distribution of metavolcanic Redstone points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map created using ESRI ArcGIS Pro© Version 3.1.3.

factors such as collector habits, modern population density, and surface exposure variability due to landcover or geomorphology are all factors that have been noted as potential sources of biases in fluted point distributional databases [e.g., 122–125].

However, Miller[31(pp. 709–710)] has found that, at least in the Southeastern US, potential recovery biases of Clovis points related to modern population density and development as well as open or cultivated land appear to be negligible. Moreover, the pattern of counties with high frequencies of Clovis points are near sources of raw material that often lie near the intersection of a physiographic section and a major river. Miller suggested two potential hypotheses for this pattern. First, because these locations were easy to relocate in a forested environment, they were ideal locations for recurring aggregation like that practiced by ethnographically known hunter-gatherer populations. Alternatively, these locations could simply represent areas of high stone tool discard rates due to the readily available occurrences of knappable stone.

Still, two potential factors may be affecting our ability to recover fluted materials on the North Carolina Coastal Plain. Perhaps the most obvious of these factors is sea level change. Sea level rise since the early Holocene has inundated a significant portion of the coastline, rendering any potential Paleoamerican occupations on the continental shelf, which over 10,000 years ago was a portion of the coastal plain, essentially invisible. A second factor may also be attributed to geological processes. The relative absence of points in the Coastal Plain as compared to the Piedmont may, in part, reflect the deeper and less eroded soils of the former. Piedmont soils, for instance, have undergone a high degree of erosion since the nineteenth century[126]. Thus, greater soil exposure would favor a greater chance of artifact recovery in the Piedmont versus the Coastal Plain. One might argue, however, that this fact is minimized by the great degree of archaeological work that has taken place on the Coastal Plain in the last two decades. Indeed, it is tempting to argue that the lower frequencies of Clovis points may be real given that this region has probably seen the most archaeological attention due to compliance needs—both survey and excavation—of any area in the state[83(p. 226)].

Turning to North Carolina Redstone point densities, they also exhibit a concentration in the Piedmont akin to Clovis point distributions. As in the Clovis case, one would expect that similar frequencies of Redstone points (n = 37) would occur in the Piedmont and Coastal Plain, yet this is not the case (Table 6). While the North Carolina Piedmont contains greater frequencies of points (n = 52) than expected for a region that size, the Coastal Plain contains fewer points (n = 23) than expected. Although overall occurrences per county are lower than Clovis, those counties with the highest point frequencies tend to occur in the eastern Piedmont as did Clovis including Harnett (n = 11), Randolph (n = 7), Wake (n = 6), Granville (n = 4), and Richmond (n = 4). The

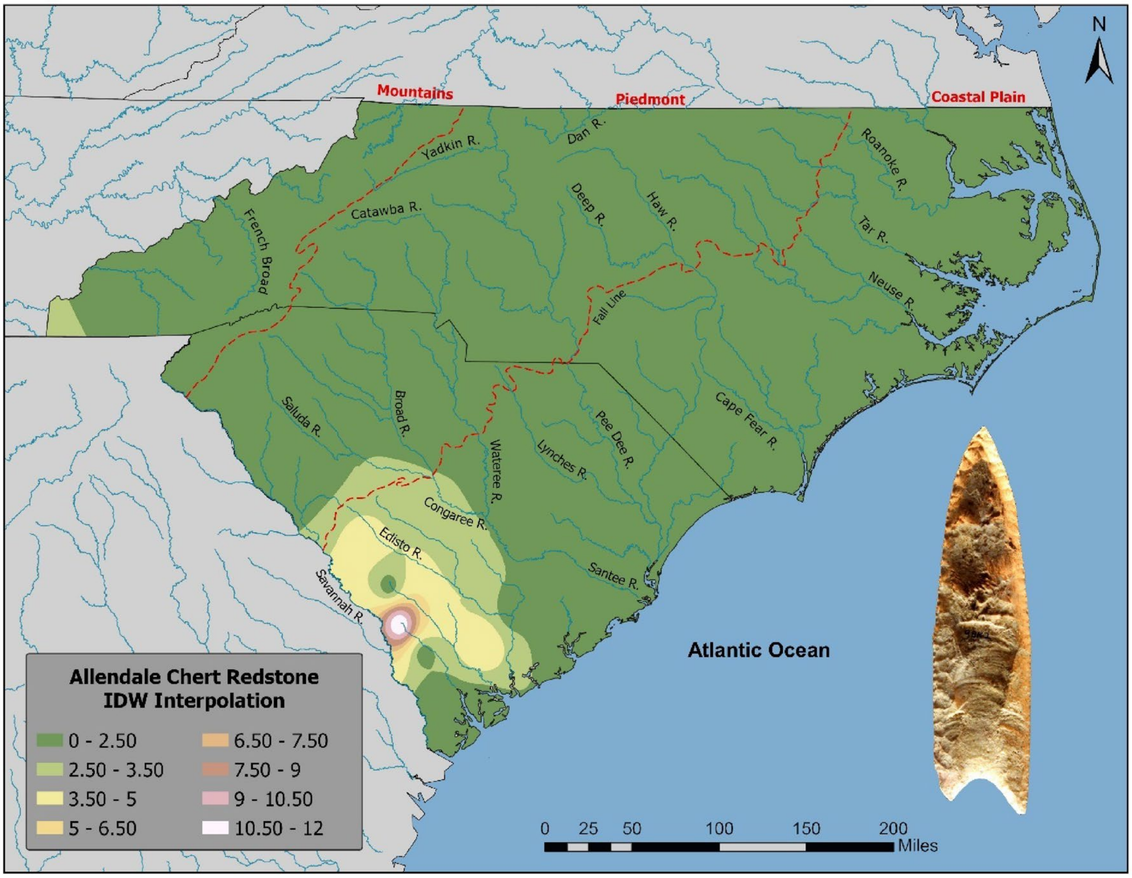

Fig. 14. Distribution of Allendale chert Redstone points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map created using ESRI ArcGIS Pro© Version 3.1.3.

Mountains contain Redstone frequencies (n = 7) only slightly lower than expected (n = 8). In short, we interpret this overall pattern similarly to the Clovis pattern: a Redstone settlement territory focused on the Piedmont, albeit more focused on the Fall Line as discussed further below.

In an attempt to gain a broader view of these data, we looked at the spatial distribution of Clovis and Redstone points by raw material across both North Carolina and South Carolina using a series of geographic information system (ArcGIS) derived interpolation maps employing inverse distance weighted (IDW) interpolation for both point types using county centroids as spatial locations. Because of the lack of precise provenience locations for most points, we don't have enough data to reliably model spatial autocorrelation, and we use IDW as a quick, intuitive method for visualizing what might be considered a preliminary view. IDW can be used when your sample points are unevenly distributed, as long as one is cautious about (1) sparse areas (which may produce unreliable estimates), and (2) avoiding over-interpretation in regions with no nearby data. Point frequencies by county are listed in Supplemental Tables S6–S7. Several interesting patterns emerge from these data. First, metavolcanic Clovis points (Fig. 10) in both states show a heavy Piedmont and Fall Line focus centered on the Uwharrie rhyolite sources in North Carolina and perhaps some metavolcanic sources along the northern Wateree River in York and Lancaster counties, South Carolina[127]. Lesser frequencies of metavolcanic Clovis points do occur in portions of the upper Coastal Plain that tend to parallel some of the major river valleys in the region. It may be the case that when occupation of the Coastal Plain occurred, it happened via movement from the Piedmont along river valleys or along interstream divides between major drainages. Potential evidence of such movement is found in a recent study by Moore and Irwin[128] that addressed Archaic settlement mobility in the North Carolina Sandhills and found evidence that supported the notion of large-scale cross-drainage (i.e., interriverine) mobility. In particular, networks of upland divides were postulated to represent conveyance corridors between sources of high-quality stone featuring aggregation loci where drainage divides intersect, and the establishment of base camps along major interriverine game trails likely occurred.

Second, Allandale chert Clovis points (Fig. 11) show a distribution centered on the Allendale quarries along the Savannah River[116] with a broad distribution that extends over most of the South Carolina Coastal Plain south of the Congaree and Santee Rivers. Taken together, these two distributions clearly reflect the influence of the respective raw material sources in each state. Given this raw material spatial distribution, we are intrigued by the possibility that this pattern might represent the geographic ranges of two macrobands centered on their respective toolstone sources: the Uwharrie Mountains metavolcanic stone sources to the north and the Allendale Coastal Plain chert sources to the south—previously referred to as the "Uwharrie Clovis Marcoband" and "Allendale

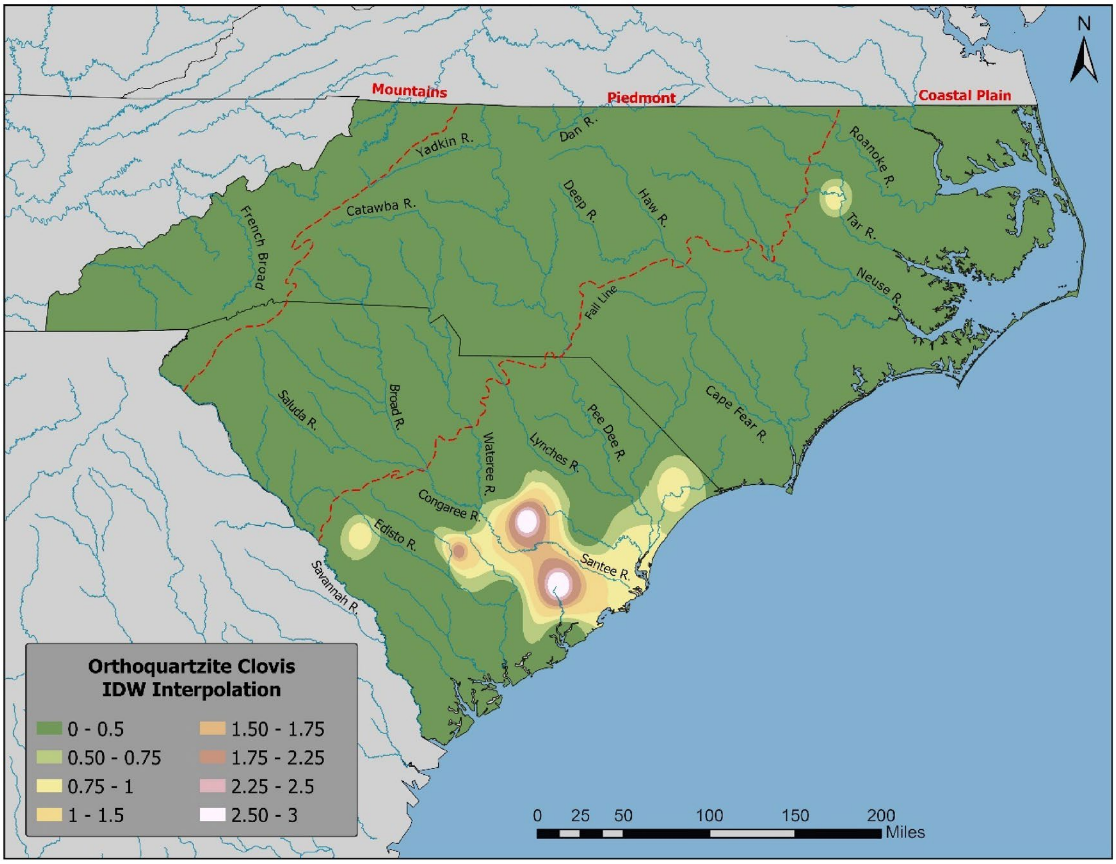

Fig. 15. Distribution of orthoquartzite Clovis points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map created using ESRI ArcGIS Pro© Version 3.1.3.

Clovis Macroband," respectively[19,20,129] The current data reinforce this pattern and suggests two contemporary and adjacent macrobands centered on distinct major toolstone sources spanning a distance of some 300 km. The areas where these macrobands converge along the Congaree and Saluda Rivers are hypothesized as an aggregation area between these groups that would have facilitated trade and exchange of mates necessary for social alliances and maintenance of genetic diversity.

To examine this possible boundary, a distributional study was conducted of Clovis points by raw material found within 20 km of the Congaree and Santee Rivers[130], producing a sample of 38 Clovis points. Of these, 28 or 74.8% were exotic to this area with 19 coming from the Savannah River region and 9 from probable Uwharrie sources. Only 8 points were made from orthoquartzite, a definite local sedimentary material. This suggests that Clovis groups coming from the different provinces brought their tools with them rather than residing in these river valleys for extended periods of time and using local toolstone. Accordingly, this zone is likely a place of interaction between the two macrobands or an aggregation zone rather than an aggregation site per se.

The geographic distribution of the category "Other Chert" was also examined for Clovis points (Fig. 12). As discussed previously, in North Carolina this category represents a composite raw material classification that, based on color and texture, likely includes cherts that appear to have originated from a variety of sources outside the state. In South Carolina, this category includes non-Allendale cherts that also likely originated from outside South Carolina. Interestingly, the largest concentration of this category is focused on the western portions of both states suggesting influences from the Mountain region. As noted above, this Mountain concentration in the Carolinas is probably just a portion of a larger cluster centered in the southern Appalachians. Moreover, there is a distinct gap in point frequencies between the Mountain concentration along the western Piedmont that separates the Mountain concentration from another concentration of chert points in the central Piedmont. This concentration of chert Clovis points in the central Piedmont overlaps the distribution of Clovis metavolcanic stone points. Assuming these points were not made from Allendale chert, then they presumably reflect some interaction with Clovis populations to the north or west. Finally, a smaller Clovis chert concentration is present along the Roanoke River in the northeastern Coastal Plain that may reflect influences from chert sources in Virginia such as the famous Williamson sources[131].

Turning to the Redstone distribution, both metavolcanic and Allendale chert Redstone distributions exhibit a geographic footprint similar to Clovis points (Figs. 13 and 14) albeit in reduced frequencies.

In particular, metavolcanic Redstone points reveal a striking distribution exhibiting several small clusters along the Fall Line in both states suggesting a significant geographic constriction of the range previously occupied

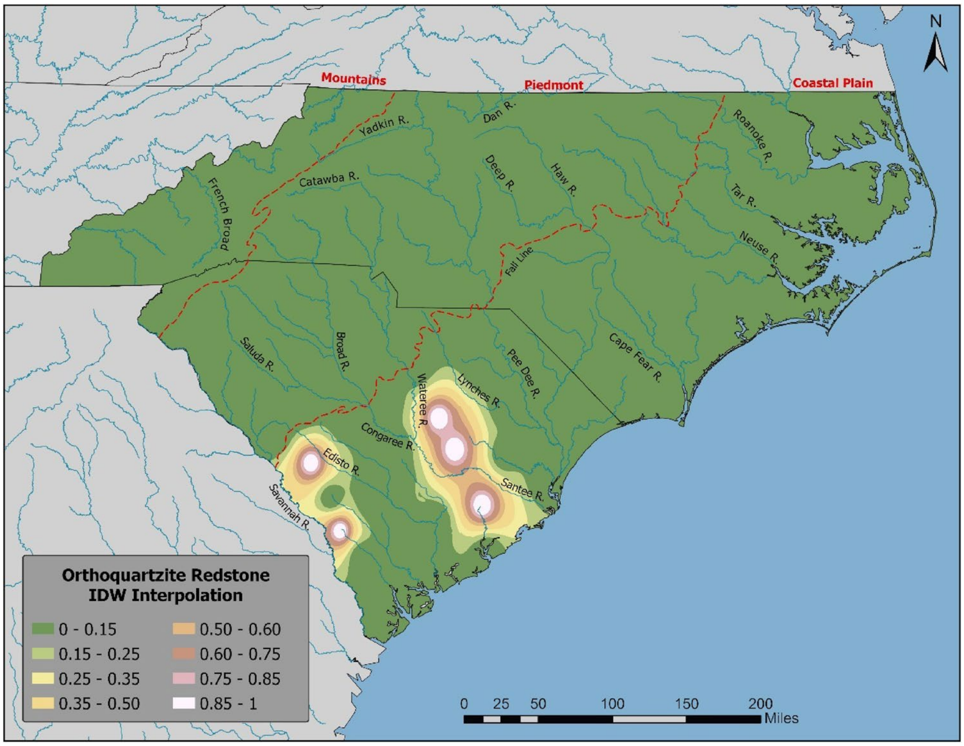

Fig. 16. Distribution of orthoquartzite Redstone points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map created using ESRI ArcGIS Pro© Version 3.1.3.

by Clovis, although the distribution of metavolcanic points crosses the Congaree and Santee Rivers, unlike the Clovis metavolcanic pattern. With respect to point frequencies, ratios of Clovis to Redstone points in North and South Carolina indicate ~3 to 4 Clovis points for every 1 Redstone[18,43]. These data have been interpreted to indicate a possible reduction in the human population immediately post-Clovis during the early centuries of the Younger Dryas (ca. 12,800–12,600 cal BP) and before the development of Dalton[130,132,133]. This inference is supported by a summed probability analysis (SPA) of radiocarbon dates showing a decline in the frequency of human-occupied sites, post-Clovis abandonment of large stone quarries, and a decline in the number of post-Clovis Redstone points from this time[134].

In a similar vein, we can speculate that the Redstone pattern of settlement in the Carolinas, focused primarily on the Fall Line ecotone, may represent a cultural adaptive response to the environmental pressures of Younger Dryas climate change, the extinction or extirpation of regional megafauna, and a decline or demographic shift in human population[43,133,135,136]. A sudden post-Clovis decrease in human populations would necessitate an adaptive response to maintain previously established kin-based social relationships. Fall Line locations provide obvious geographic landmarks for prehistoric aggregation (i.e., rapids and waterfalls with large rock outcrops), offer the easiest paths of least resistance for travel above the major swamps that form when rivers drop out of the Piedmont onto the Coastal Plain, and occupy a diverse environmental niche between the resources available in the Coastal Plain and Piedmont.

Spatial distributions of the remaining raw materials are also telling. Both Clovis and Redstone orthoquartzite point frequencies are small and virtually absent in North Carolina (Figs. 15 and 16). In South Carolina, orthoquartzite Clovis and Redstone points are confined to the Lower Coastal Plain in the southeast-central part of the state near their presumed source locations[130,132]. Apparently, orthoquartzite points were not transported far and were discarded locally. Quartz Clovis points are sparsely scattered across the Carolinas and likely represent the expedient use of "float" or cobble sources on an ad hoc basis (Fig. 17). The one exception to this is the concentration in Harnett County, North Carolina, where, as noted above, consistently high frequencies of metavolcanic, chert, and quartz points have been recovered, presumably related to its Fall Line location.

Quartz Redstone points are concentrated in the lower South Carolina Coastal Plain, albeit in low frequencies (Fig. 18).

"Other Chert" Redstone points also exhibit a relatively high occurrence in Harnett County (Fig. 19). A secondary concentration of "other chert" Redstone points in the northern Wateree and Broad rivers near the North Carolina border may reflect the use of chert sources further west.

In sum, the widespread distribution of Clovis and Redstone points across the region indicates that the Carolinas represented an important region of settlement during the Late Pleistocene and Early Holocene. In particular, the density and distribution of Paleoamerican points and their associated raw material types documents toolstone use centered on two major quarry sources in the Uwharrie region of North Carolina and Allendale region of South Carolina, respectively. We suggest that the spatial distributions of fluted points documented here are an

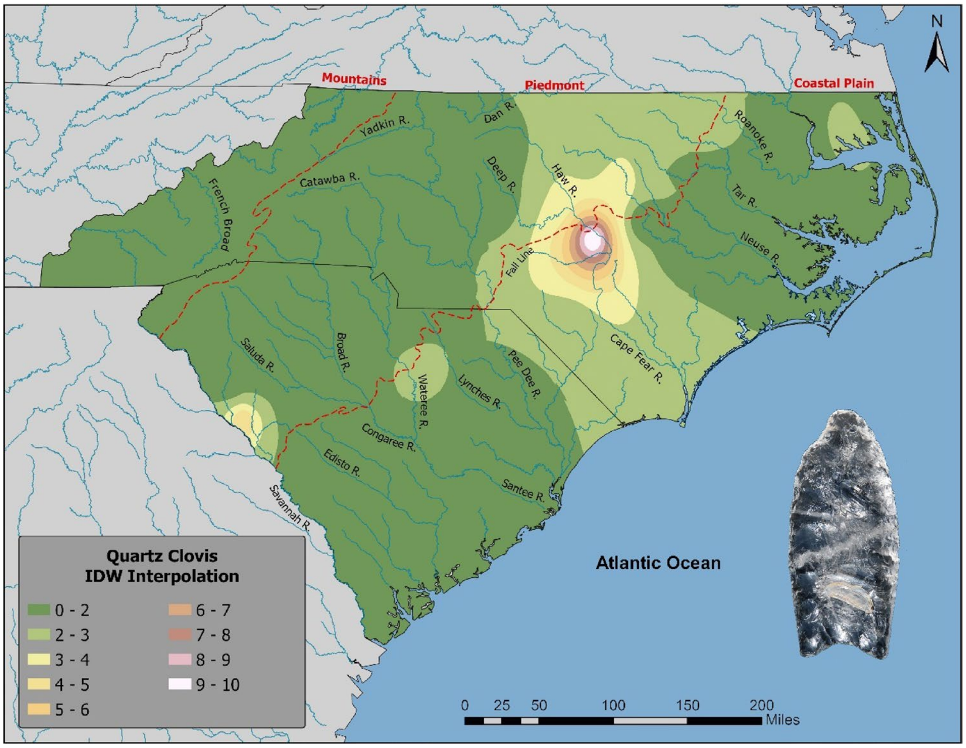

Fig. 17. Distribution of quartz Clovis points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map created using ESRI ArcGIS Pro© Version 3.1.3.

indication of where and how far Clovis and Redstone people traveled away from their respective quarries before having to return, essentially mapping portions of two macroband foraging ranges. The use of lesser quality but more widely available toolstone such as quartz and other stone types supplemented unplanned raw material needs. Moreover, these distributions also suggest that the Congaree—Saluda rivers represent a geographic boundary and interaction zone between the two regions, particularly during Clovis times. Finally, a difference in the density and distribution of Clovis and Redstone points suggests a more restricted settlement range for Redstone groups than Clovis, focused on the Fall Line. The Redstone distribution is consistent with an ecological response to a reduced and possibly stressed human population adapting to the early Younger Dryas climate event and to declines/changes in favored prey populations while attempting to maintain social connectedness within critical habitats along the Fall Line.

Discussion and conclusions

The data presented here go a long way towards filling a knowledge gap in Paleoamerican occupation in the Southeast. Our data demonstrates that North Carolina follows the general southeastern pattern with Clovis as the earliest recognizable manifestation but with the development of a presumed post-Clovis regionally specific point type, here Redstone, and eventually Hardaway-Dalton. Such data facilitate analyses of interesting questions about why there is post-Clovis regional variation in the region, in contrast to the relatively uniform development of post-Clovis point types in the Great Plains and Southwest. While Cumberland points are also present in North Carolina, they occur in low frequencies and most likely represent a post-Clovis type associated with the Appalachians.

The fundamental change and improvement typologically in the Southeast has been the recognition of the Redstone type. In the past, such points have often been misclassified as Clovis based on the elongated flute. Technologically, the typological distinction includes a fundamental change in fluting. Clovis flutes are typically struck with a percussor directly off the base often with one or more strikes, i.e., direct percussion. This results in shorter and wider flute scars. Redstones have a deeper basal concavity where an instrument was placed to precisely initiate a flute by the punch and drift technique or possibly by pressure using a crutch (see Supplemental Fig. S1). Direct percussion fluting would not have been possible without destroying the ears. This has been named the instrument-assisted method[43,137]. This is very similar to the Folsom fluting method using an intermediary instrument [cf. 44,45]. Fluting platforms are carefully created isolating the platform by pressure flaking platform release scars on either side to isolate the platform to about the same height or thickness of the biface preform.

Accompanying these changes in basal treatment and method of fluting are also changes between Clovis and Redstone blade and tip configurations. Clovis blades tend to be more excurvate on the margins and nearly rounded on the tips. Redstone tips are more pointed, and the blade margins are straighter. This suggests that Clovis points were better suited for piercing and cutting, while Redstones were more effective for piercing and

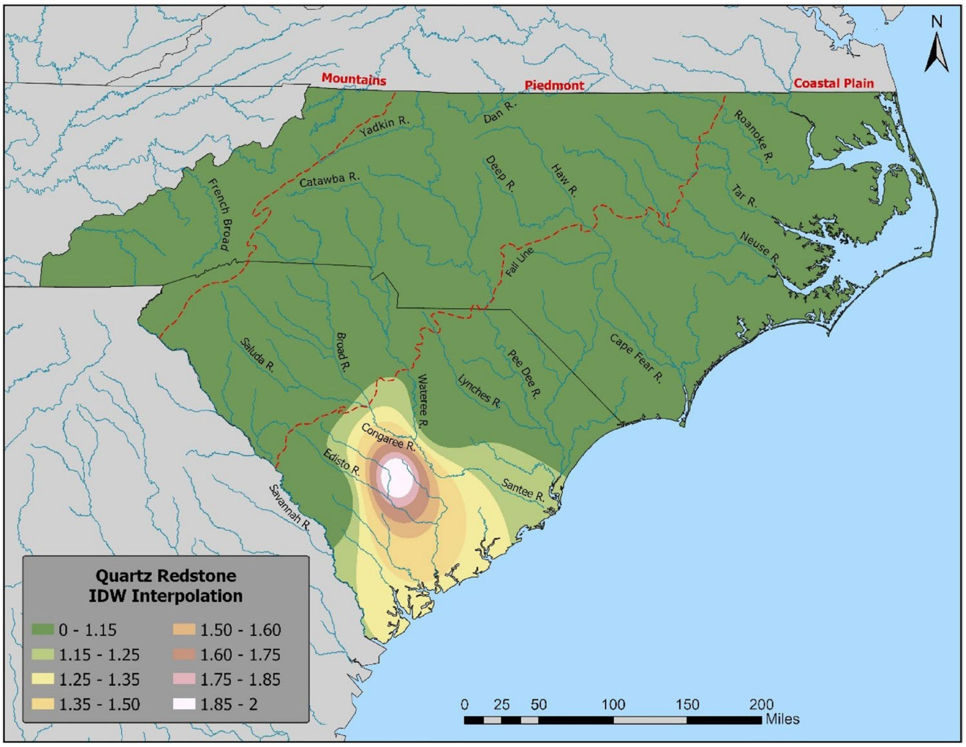

Fig. 18. Distribution of quartz Redstone points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map created using ESRI ArcGIS Pro© Version 3.1.3.

penetrating[43]. This distinction is consistent with Buchanan and Hamilton's[37] study using engineering principles that examined tradeoffs between penetration and robustness (i.e., durability) in a sample of 16 Paleoamerican point types that included both "Eastern Clovis" and Redstone types. Interestingly, their results found that "Eastern Clovis" tended to sacrifice penetration ability for durability while the Redstone type emphasized penetration versus durability[37(pp. 595–597)].

These changes in hunting armature are likely related to larger issues in human demography and changes in animal ecology perhaps associated with the Younger Dryas climate episode. The Younger Dryas saw a loss of several dozen genera of animals, including proboscideans, horse, and *Bison antiquus*, the latter evolving to modern Bison, with Clovis points known to be associated with these larger species[131]. Spears thrown by atlatls at a distance from the prey may have given way to handheld lances that were repeatedly thrust and withdrawn from the prey, akin to the stabbing function of a modern military bayonet, with its straight smooth blade margins. Thus, Redstone blade and tip morphologies with straight blade margins and minimal to nonexistent basal ears may be related to close-up thrusting episodes requiring ease of withdrawal such as needed for hunting bison herds and probably caribou herds further north, as proboscideans were likely gone by Redstone times. This inference is supported by LGM analysis showing that considerable effort was undertaken by Redstone makers to maintain the Redstone form (i.e., pointed tips with straight blade margins) during resharpening, unlike that seen in Clovis.

Recent immunological blood residue analysis of 120 Paleoamerican points from North and South Carolina provides the first direct evidence consistent with the hunting and butchery of extinct Proboscideans (mammoth and mastodon), the extinct North American horse (Equidae), and Bovidae (most likely *B. antiquus*) on early Paleoamerican artifacts in eastern North America. Although more testing will be needed to confirm, Proboscidean and Bovidae blood residues were found on Clovis points, while Redstone and other post-Clovis points lacked evidence of Proboscidean but had residue of Equidae and Bovidae. Based on these results, post-Clovis Redstone populations may have witnessed the regional extinction/extirpation of Proboscideans in the Carolinas during the early Younger Dryas or were adapting to a new environment lacking Proboscideans, but which still had abundant bison and Equidae. The morphology of the Redstone type may be an adaptation for thrusting lances and the hunting of smaller but potentially abundant herd animals like bison and horse. Future blood residue studies may provide evidence on the timing and demography of megafaunal collapse leading to eventual extinction[136].

Related to the onset of the Younger Dryas cooling is the geographic macro ecotonal location of the Carolinas. Looking at the Atlantic Slope north to south, the Carolinas are situated in what has been referred to as the Temperate zone with the colder Boreal zone north of North Carolina and the Subtropical Zone to the south, including portions of Georgia and Florida with the Temperate and Subtropical regions being ecotonal and species diverse[138]. Moreover, this diversity in the Southeast would have included an odd array of "disharmonious species" of animals living together, including those native to both cold weather and those of the warmer Subtropical zone,

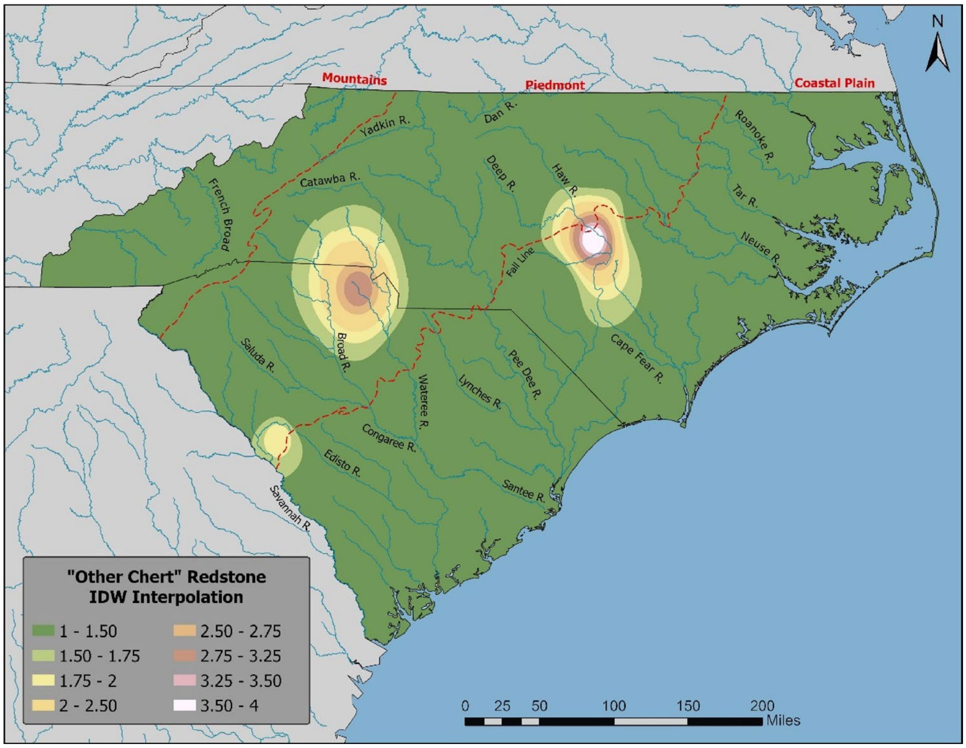

Fig. 19. Distribution of "other chert" Redstone points based on inverse distance weighted (IDW) interpolation using county centroids as spatial locations. Map created using ESRI ArcGIS Pro© Version 3.1.3.

offering unique resources to populations living there[129(pp. 261–262), 139]. Given these paleoenvironmental factors, the Carolinas might be regarded as a somewhat distinctive ecological setting to examine fluted point makers in North America where they arrived some 13,000 years ago and sustained themselves for a few centuries surviving and adapting to dramatic environmental and demographic changes.

One archaeological manifestation of this adaptation ca. 13,000 years ago can be seen in the point raw material distribution maps discussed above. The identification of tool stone types and their sources has progressed to where basic distance to geological source estimations can be made. Such studies in the Carolinas are advantaged due to the vast lithologic differences between Piedmont metavolcanic types and Coastal Plain marine fossiliferous cherts. As things stand now, we believe we have assembled a satellite view of the two fluted point macroband systems, allowing a view of their distributions over the complete Atlantic Slope minus what may exist under the Atlantic Ocean due to Holocene sea level rise.

Finally, the above presentation of North Carolina and South Carolina fluted points is a compilation of records of Paleoamerican points collected by numerous individuals and institutions over nearly 50 years in both states. Working responsibly with private collections has been critical to obtaining the data used here[17(pp. 158–175), 140, e.g., 141]. It is unlikely such a collaborative effort will be equaled anytime soon. Advances in Southeastern Paleoamerican studies are such that analysis of geographically extensive databases is now available to move analysis beyond studies of individual sites to the archaeological record of regionally mobile foragers.

Data availability

All data needed for the evaluation of this paper are present in the paper and/or Supplementary Information. Many of the fluted points studied in this paper are from private collections and are not available from the authors for inspection. Other fluted point artifacts are curated at the Department of Anthropology at East Carolina University and the Southeastern Paleoamerican Survey (SEPAS) at the University of South Carolina. Any additional data related to this paper may be requested from the corresponding author.

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