Chapter 12: A geometric morphometrics-based assessment of the number of point types on the Southern High Plains during Plainview times

by

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Introduction

The Plainview type occurs during the Late Paleoindian period (ca. 11,900-10,000 calendar years before present [calBP]). This period is widely considered to be a watershed in the prehistory of North America because of the development of the first regionally distinct cultures (e.g. Anderson 1990; Anderson and Faught 2000; Meltzer 1988, 1993, 2002). This "cultural diversification hypothesis" is based on a putative increase in the number of point types compared to the preceding Early Paleoindian period (13,350-11,900 calBP; Holliday 2000; Holliday et al. 1999; Taylor et al. 1996). Thus, the hypothesis is only as good as the estimate of the number of point types in the two time periods. With this in mind, we decided to investigate point richness in the period from ca. 11,900 to ca. 10,500 calBP, which brackets the Plainview type (Holliday et al. 1999). Our study focuses on a region that has a rich Paleoindian archaeological record, namely the Southern High Plains of Texas and New Mexico.

The Southern High Plains region appears to follow the general continental pattern of an increase in the number of point types between the Early and Late Paleoindian periods. The Early Paleoindian period in the region has two sequential types, Clovis and Folsom, with little temporal overlap (Collard et al. 2010). The Late Paleoindian period is generally considered to have had several different types, and during the time of interest here — 11,900–10,500 calBP — it is widely accepted that there were at least three contemporaneous and distinct lanceolate point types: Plainview, Milnesand, and Lubbock. However, the types' contemporaneity and distinctiveness may be misleading because of two well-known problems (Hofman 1989; Johnson and Holliday 1997; Wheat 1972). One is that the best-known Late Paleoindian type in the region, Plainview, is ambiguously defined. The Plainview type was created on the basis of points recovered at the site of Plainview in the Texas Panhandle (Krieger 1947; Sellards et al. 1947). Subsequently, most unfluted, lanceolate points discovered in the region were classified as Plainview without regard to how similar or different they were from the original type specimens. This expanded the range of variation for the type so far that it has been argued to be a catch-all category by a number of researchers (e.g. Frison 1996; Hartwell 1995; Irwin 1971; Irwin-Williams et al. 1973; Johnson and Holliday 1980; Kelly 1982; Kerr 2000; Knudson 1983; Wheat 1972).

The other problem is that the Milnesand and Lubbock types were created for points from single sites without rigorous comparative analysis. The Milnesand type was named by Sellards (1955) based on specimens from the Milnesand locality in northeastern New Mexico, where points were found in association with bison bones. The Lubbock type was named for a set of points found among bison bones at Lubbock Lake, Texas (Knudson et al. 1998). In both cases, investigators suggested that the points were different enough from Plainview to warrant the recognition of a new type but did not demonstrate empirically that such was the case (Knudson et al. 1998; Sellards 1955). Thus, it is possible that the number of point types in the Southern High Plains region in Plainview times is higher or lower than the three commonly accepted types.

The study reported here builds on the work of Buchanan et al. (2007), who undertook a quantitative analysis of Plainviewlike assemblages from the region, including points from Plainview, Milnesand, and Lubbock Lake. Buchanan et al. used 10 interlandmark distances to determine if groups of points could be discriminated. Multivariate statistical tests showed that most of the variation in assemblages could be subsumed under the Plainview type, as all but one assemblage were indistinguishable from the Plainview assemblage. The single assemblage that was significantly different was from Lubbock Lake. Buchanan et al. concluded that two types of lanceolate points were produced on the Southern High Plains during Plainview times: Plainview and Lubbock. As such, their study supported the cultural-diversification hypothesis but challenged the idea that there were three lanceolate point types on the Southern High Plains during the Late Paleoindian period.

Here we revisit the question addressed by Buchanan et al. (2007) with a more powerful set of analytical techniques, geometric morphometrics (GM). GM uses coordinate data rather than the interlandmark distances commonly employed in lithic analyses and allows patterns of variation in shape to be investigated within a well-understood statistical framework that yields easily interpreted numerical and visual results (Adams et al. 2004; Bookstein 1991; Bookstein et al. 1985; Dryden and Mardia 1998). It has been used to analyze stone-tool shape in a number of recent studies, including Archer and Braun (2010), Buchanan and Collard (2010), Buchanan et al. (2011, 2014), Cardillo (2010), Charlin and González-José (2012), Costa (2010), Lycett and von Cramon-Taubadel (2013), Lycett et al. (2010), Thulman (2012), and Wang et al. (2012).

We focused on the outline shape of points because most of the differences among Paleoindian point types relate to plan shape (Buchanan et al. 2007; Knudson et al. 1998). We used a multivariate significance test to evaluate the differences between points from the Plainview type-site and points from five other important assemblages from the same time period on the Southern High Plains. We reasoned that identifying a significant difference between the points from the Plainview site and points from any of the other assemblages would support the existence of multiple Late Paleoindian point types, whereas finding no such differences would indicate the presence of a single Late Paleoindian point type. The former finding would be consistent with the cultural-diversification hypothesis, whereas the latter would not.

Materials and Methods

Sample

Our sample comprised 143 complete, previously typed specimens (Table 12.1). Because we are revisiting Buchanan et al.'s (2007) study, we used as many of the same points as we could but had to exclude 47 incomplete points. The specimens came from six sites: Plainview, Ryan’s, Ted Williamson, Warnica-Wilson, Lubbock Lake, and Milnesand. These sites are located in the central portion of the Southern High Plains, between 33°N and 35°N latitude, and 101°W and 103.5°W longitude (Figure 3.1).

The Plainview site (41HA1) was discovered when quarry operations near the town of Plainview, Texas, uncovered the remains of ≥100 bison in Running Water Draw (Holliday 1997; Sellards et al. 1947; Speer 1983, this volume). Sellards et al. (1947) suggested that the Plainview bone bed was the result of a single-event stampede kill, but subsequent analyses based on tooth eruption and wear patterns have indicated that the bone bed represents at least two kills at different times of the year (Johnson 1989). Ten complete points and fragments of at least 18 others have been recovered from the bone bed (Knudson 1983, this volume). All of the points have been assigned to the Plainview type (Krieger 1947). In the present study, we digitized the 10 complete points.

The Ryan’s site (41LU72) is near Shallowater, Texas, at the edge of a small playa basin (Hartwell 1995). The assemblage is a cache of points, preforms, tools, and flakes, the majority of which came from two potholes. Thirteen of the 14 points recovered from the cache have been identified as Plainview; the remaining point is thought to be a reworked Clovis point

(Hartwell 1995). The 11 complete Plainview points were included in the sample used in the present study.

The Ted Williamson site is located in the Lea–Yoakum dune field of Roosevelt County, New Mexico. The site yielded numerous points within a dune blowout. However, no evidence of an animal kill was found (Johnson et al. 1986). All the points recovered have been assigned to the Plainview type (Buchanan et al. 1996). We used 54 specimens from the Ted Williamson site.

The Warnica-Wilson site (aka the Bethel site) is in Roosevelt County, New Mexico (Reutter 1996). The assemblage includes points from the surface of a campsite and from the area immediately surrounding the site. All the points have been assigned to Plainview. We used 25 of them in our study.

The Lubbock Lake site (41LU1) is located in a meander of Yellowhouse Draw north of the city of Lubbock, Texas (Johnson 1987). Excavations of feature FA5-17 uncovered stone tools among the remains of at least four disarticulated bison in substratum 2s (Knudson et al. 1998). The five points recovered from FA5-17 have been argued to be morphologically distinct from several incomplete Plainview points recovered from a nearby bone bed (FA6-11) as well as from Plainview points in the wider region. They were have been assigned to a new type, the Lubbock point (Johnson 1987; Knudson et al. 1998). We included the four complete points from the Lubbock Lake site in our study.

The Milnesand site is located less than 500 m from the Ted Williamson site (Sellards 1955; Warnica and Williamson 1968) and in a similar topographic and stratigraphic setting. At Milnesand a bison kill containing the remains of at least 33 individuals was found (Hill 2002; Holliday 1997). Sellards (1955) carried out excavations at Milnesand in 1953. The landowner collected additional material from the surface of the site in the decade following the excavations (Warnica and Williamson 1968). The points from the site have been argued to represent a new type, Milnesand (Sellards 1955; Warnica and Williamson 1968). We analyzed 39 complete points from the Milnesand site—eight from Sellards' (1955) excavations and 31 from the collection of the landowner, Ted Williamson.

Data acquisition and analysis

As noted earlier, we obtained shape data using GM. Detailed descriptions of GM can be found in Adams et al. (2004), Bookstein (1991), Bookstein et al. (1985), Dryden and Mardia (1998), Rohlf and Bookstein (1990), and Slice (2005, 2007). Briefly, a GM analysis begins by standardizing landmark configurations so that they are directly comparable. This is usually accomplished with a superimposition method called Generalized Procrustes Analysis (GPA). GPA iteratively minimizes the sum of the squared distances among landmarks of each configuration by translating (shifting the configurations together in a fixed direction), rotating ("spinning" the configurations around a fixed point), and scaling the configurations. Scaling is accomplished by dividing the coordinates of each configuration by its centroid size, which is defined as the square root of the sum of the squared distances between the geometric center of the configuration and the landmarks (Bookstein 1991). The remaining differences in landmark position, which are called the "Procrustes residuals," represent the shape differences among the configurations.

After GPA is completed, partial warp scores and the uniform components can be derived from the Procrustes residuals. Partial warp scores are an orthogonal rotation of the full set of the Procrustes residuals, and as such are eigenvectors of the bending-energy matrix that describe local deformation along a coordinate axis. The uniform components express global information on deformation. The first uniform component accounts for variation along the *x*-axis of a configuration, and the second uniform component accounts for variation along the *y*-axis. Together, the partial warps and uniform components represent all information about the shape of specimens (Rohlf et al. 1996; Slice 2005). The partial warps and uniform components are in shape space, and in order to carry out conventional multivariate statistical analyses they have to be projected to tangent Euclidean space (Kendall 1984; Rohlf 1998; Slice 2001).

Here, shape data were obtained from the points following the steps outlined in Buchanan et al. (2011, 2014). First, digital images of the points were acquired. The images were then digitized by placing landmarks around the points using tpsDig2 shareware (Rohlf 2008). We used 3 landmarks and 20 semilandmarks to capture point shape. Two landmarks were located at the base of the point and were defined by the junctions of the base and the blade edges of the point. A third landmark was located at the tip. Line segments with equally spaced perpendicular lines were used to place the semilandmarks along the blade edges and the base. These “combs” were superimposed on each image using the MakeFan6 shareware program (www.canisius.edu/~sheets/morphsoft.html). The 23 landmarks digitized for each artifact are shown in Figure 12.1. The program tpsSuper (Rohlf 2008) was used to carry out the Generalized Procrustes Analysis and to project the data to Euclidean space. A regression analysis was then carried out to check the fit between the specimens in shape space and the tangent Euclidean space. This test was carried out using tpsSmall (Rohlf 2008). The correlation between the two distances was strong and highly significant (slope = 0.997, correlation = 0.999), indicating that the projection was adequate.

Next, statistical analyses were conducted on the partial warps and uniform components. Because the number of shape variables was large (double the number of landmarks), principal components analysis was used to reduce the dataset to a smaller number of variables that reflect the major patterns of shape variation within a group of specimens. By convention, the principal components obtained in an analysis of GM shape data are referred to as "relative warps." We computed the relative warps with the program tpsRelw (Rohlf 2008).

Subsequently, for visual comparison we created bivariate plots showing the points' scores on the first two relative warps (principal components) for points from the Plainview site compared with points from each of the five other Late Paleoindian assemblages. This was carried out using the tpsRelw program. Next, we conducted significance tests of the differences in shape between the points from the Plainview site and points from each of the five other assemblages. This was accomplished with pairwise Hotelling's *T*-squared tests, which is a multivariate extension of Student's *t*-test (Hotelling 1931). Significance was determined using *p*-values derived from a permutation test that compared the observed difference between means with a distribution of pairwise mean differences from 1000 random permutations of the data. We used a permutation test to derive *p*-values because the sample did not approximate multivariate normality. Because we performed multiple tests, we modified the critical level used in evaluating the comparisons (Dudoit et al. 2003). We used Benjamini and Yekutieli's (2001) method to do this. The method employs the following equation to determine the critical value:

$$\alpha / \sum_{i=1}^{k} (1/i)$$

where *k* is the number of hypothesis tests conducted. Narum (2006) has shown that Benjamini and Yekutieli's (2001) method optimizes the reduction of both type-I and type-II error rates relative to several other methods. We used MorphoJ 1.03d (Klingenberg 2011) to conduct the pairwise Hotelling's *T*-squared tests.

Lastly, we characterized the shape differences between the sample from the Plainview site and the samples that were found to be significantly different from it in the Hotelling's *T*-squared tests. To do this, we created deformation grids to visualize the differences using MorphoJ 1.03d (Klingenberg 2011). The grid was warped to indicate the differences between average assemblage point shapes.

Results

The top panel of Figure 12.2 shows the consensus configuration derived from the GPA. This configuration of landmarks represents the average shape of the 143 Late Paleoindian points in the sample. As expected, the average point has a lanceolate-shaped blade and a slightly concave base. The bottom panel of Figure 12.2 shows the variation in the point landmark configurations. This figure and Table 12.2 indicate that the basal landmarks are more variable relative to the landmark variation around the blade and tip. The basal landmarks (numbers 2 and 3) and the landmarks demarcating the outer basal edges (numbers 4,5,6,17,18, and 19) have the highest variability among the set of landmarks.

The first two relative warps account for 87.6% of the total shape variation. We used bivariate plots of points from the Plainview site against each of the other assemblages in Figure 12.3. In these plots convex hulls are used to define the variation encompassing each point assemblage. The convex hulls surrounding the Plainview and Lubbock points appear to be the most separate (Figure 12.3D), whereas there is considerable overlap in the convex hulls for the other comparisons (Figure 12.3A, 12.3B, 12.3C, 12.3E).

Table 12.3 summarizes the results of the significance tests in which the points from the Plainview site were iteratively compared to the points from each of the other sites. It shows that only the points from the Lubbock site are significantly different from the points from the Plainview site (Table 12.3).

The difference in mean shapes between the points from Plainview and Lubbock is illustrated in Figure 12.4. Plainview points are distinguished from Lubbock points primarily by having a wider base and a deeper basal concavity.

Discussion

Our results are consistent with those obtained by Buchanan et al. (2007). To reiterate, their analyses supported the existence of two lanceolate point types on the Southern High Plains during Plainview times — Plainview and Lubbock. In the present study, we found that five of the six point assemblages we examined were indistinguishable from the assemblage of points from the Plainview site. The assemblage that differed significantly from the Plainview assemblage was the one from Lubbock. Thus, our study also supports the existence of two lanceolate point types on the Southern High Plains during the Late Paleoindian period, and indicates that those point types are Plainview and Lubbock.

An important implication of Buchanan et al.'s (2007) results and the results we obtained in the study reported here concerns the Milnesand type. Sellards described points from

Milnesand in the mid-1950s (Sellards 1955) and suggested that the type differed from the Plainview type in basal shape. Specifically, he argued that Milnesand points have square bases, whereas Plainview points have concave bases, although even visual inspection of the collection of points from Milnesand show that 20-30% of the points exhibit concave bases. The results of Buchanan et al.’s (2007) study and those of the present study are inconsistent with the idea that the points from Milnesand are different from the points from Plainview. Moreover, our data show that if there are any differences in shape, they are in the blade edges and tip rather than in the base (Figure 12.5).

Holliday et al. (Chapter 3 this volume) also argue that the basal shape of points from the Milnesand assemblage differ from Plainview, again with the latter having concave bases and the former having straight bases. We should note that differences in the results of our study and that of Holliday et al. could be a consequence of several factors, including differences in the samples analyzed and methods used. Our sample for Milnesand is larger than the one used by Holliday et al. (39 vs. 27 points), whereas the sample we have from Plainview is smaller than the one used by Holliday et al. (10 vs. 15 points). For our analyses the methods we used (geometric morphometrics) control for size variation in the points being examined, therefore, the differences in the two sets of results might also be driven by point size.

One could argue, we suppose, that the Milnesand assemblage includes points from both the Plainview and Milnesand types that were mixed through either post-depositional processes or some cultural process that entailed an aggregation of groups using the two distinct styles (Buchanan et al. 1996). At this point, however, we have no evidence to support those possibilities and suggest that the prudent course of action is to subsume Milnesand within the Plainview type until such evidence is presented that warrants separation.

Buchanan et al.'s (2007) results and the results of the present study also have implications for the cultural-diversification hypothesis. Although both sets of results suggest that there is little support for the existence of the Milnesand type, the fact that they support the existence of two types in the Southern High Plains during Plainview times is consistent with the hypothesis. To reiterate, the hypothesis posits that the number of point types increased in the Late Paleoindian period relative to the preceding Early Paleoindian period. During the Early Paleoindian period, there is only ever a single point type in the Southern High Plains. Between 13,350 calBP and 12,830 calBP, the only point type is Clovis (Collard et al. 2010). From 12,830 calBP until the end of the Early

Paleoindian period, at 11,900 calBP (Collard et al. 2010), the only point type is Folsom. (It should be noted that while some researchers advocate for a second type during Folsom-times, which they call "Midland" [Judge 1970], other researchers argue that Midland is an unfluted variety of Folsom [Amick 1995].)

The single assemblage containing Lubbock points was recovered within 50 m of another assemblage containing Plainview points, and the two assemblages have yielded overlapping radiocarbon dates of about 11,500 calBP (Buchanan et al. 2007; Johnson 1987; Knudson et al. 1998). Consequently, the fact that we and Buchanan et al. (2007) have found evidence for two types co-occurring in the Late Paleoindian period supports the cultural-diversification hypothesis. Having said that, our findings suggest that there were fewer point types than is usually assumed. Thus, it appears that point-type richness increased on the Southern High Plains in the Late Paleoindian period but only to two types.

An obvious direction for future research is to address the causes of the increase in typological richness. The most obvious possibility is that typological diversification is a consequence of population growth and local adaptation to environments. However, local adaptation seems unlikely to be a driver of increasing typological richness on the Southern High Plains because the region is extremely homogeneous. It is a flat and nearly featureless grassland dissected only by the usually dry tributaries of the Red, Brazos, and Colorado rivers. On the face of it, this environmental homogeneity suggests it is unlikely that the two point types represent different cultural adaptations.

That local adaptation probably does not explain the existence of the contemporary types is further supported by the fact that the single assemblage containing Lubbock points was recovered in association with the remains of a bison (Johnson 1987; Knudson et al. 1998). Several Plainview assemblages, including one that is less than 50 m from the Lubbock assemblage, are also associated with bison remains (Johnson 1987; Knudson et al. 1998). Thus, it appears that the two point types were used for hunting the same species. Given this, it seems more likely that the two different point types are markers of group identity.

One way of testing this environmental adaption hypothesis would be to examine the functional equivalence of the different types with experiments designed to distinguish between adaptive and neutral traits. For example, our analyses revealed that Plainview points are wider and have deeper basal concavities compared to Lubbock points. To investigate how these shape differences affect the performance characteristics of the weapon system of which the points were a part, experimental work with replicas could be undertaken. No differences in the performance of these specific traits would suggest a stylistic rather than a functional origin.

Conclusions

The Plainview point type was described by Krieger (1947) more than 65 years ago based on an assemblage of points recovered from a large bison kill near the town of Plainview, Texas. The Plainview type is now widely considered to be a "wastebasket taxon" because various unfluted Late Paleoindian point forms have been uncritically assigned it. To compound this problem, two additional types found only at single sites, Milnesand and Lubbock, have been claimed to coexist with Plainview without rigorous comparative analysis. To address these problems, Buchanan et al. (2007) carried out quantitative comparative analyses and concluded that two different point types—Plainview and Lubbock—coexisted in the region. In the study reported here, we revisited Buchanan et al.'s (2007) study using more powerful techniques to analyze point shape in the region. We found that only the Plainview and Lubbock assemblages were significantly different from each other. This finding is consistent with the results of Buchanan et al.'s (2007) study. Together, the results of the two studies support the Late Paleoindian cultural-diversification hypothesis. However, they also suggest that the Milnesand type should be abandoned and that the points assigned to it should be reassigned to Plainview.

Acknowledgments

We thank Laura Nightengale of the Texas Archeological Research Laboratory, Austin, for access to the Plainview assemblage and portions of the Milnesand and Lubbock Lake assemblages collected by Sellards. The late Ted Williamson and his son, Ted Williamson, Jr., graciously permitted analysis of their personal collections of the Milnesand and Ted Williamson sites, as did James Warnica with the Warnica-Wilson assemblage and his surface collection from Roosevelt County, New Mexico. We also thank Eileen Johnson of the Museum of Texas Tech University for access to the Lubbock Lake and Ryan's collections. BB is supported by the University of Tulsa and MJO by the University of Missouri. MC's work is supported by the Social Sciences and Humanities Research Council, the Canada Research Chairs Program, the Canada Foundation for Innovation, the British Columbia Knowledge Development Fund, and Simon Fraser University.

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