CHAPTER 12

A Geometric Morphometrics-Based Assessment of Point Types on the Southern High Plains during Plainview Times

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The Plainview type occurred during the Late Paleoindian period (ca. 12,100–10,000 cal yrs BP). 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 as compared to the preceding Early Paleoindian period (13,350–11,900 cal yrs BP; Holliday 2000a; 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 ~12,100 to ~11,300 cal yrs BP, which brackets the dating of the Plainview type (Holliday et al. 1999; Chapter 3). 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—12,100 to 11,300 cal yrs BP—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 (Chapters 1, 2; Krieger 1947a; 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 catchall category by a number of researchers (e.g., Chapters 2, 8; Frison 1996; Hartwell 1995; Irwin 1971a; Irwin-Williams et al. 1973; Johnson and Holliday 1980; Kelly 1982; Kerr 2000; Knudson 1983a; 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 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 Plainview-like 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. Thus, 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 it 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 (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 between 101°W and 103.5°W longitude (see 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 (Chapter 1, 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 (Chapter 1, this volume; Johnson 1989). Ten complete points and fragments of at least 18 others have been recovered from the bone bed (Chapter 2, this volume; Knudson 1983a). All of the points have been assigned to the Plainview type (Krieger 1947a). In the present study we digitized the 10 complete points.

TABLE 12.1. Assemblages Examined in This Study, with Previous Type Designations, Number of Points in the Assemblages, and Number of Points Used in the Analysis.

Assemblage	Previously Assigned Type Designation	Number of Points in the Assemblage	Number of Points in the Analysis
Plainview	Plainview	20	10
Ryan's	Plainview	14	11
Ted Williamson	Plainview	148	54
Warnica–Wilson	Plainview	44	25
Lubbock Lake	Lubbock	5	4
Milnesand	Milnesand	92	39
Total		323	143

The Ryan's site (41LU72) is near Shallowater, Texas, at the edge of a small playa basin (Chapter 3, this volume; 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 (Chapter 3). 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 in our study.

The Warnica-Wilson site (aka the Bethel site) is also in Roosevelt County, New Mexico (Chapter 3; Reutter 1996). The assemblage includes points from the surface of a camp site 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 (Chapter 3; Johnson, ed. 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 assigned to a new type, Lubbock (Johnson, ed. 1987; Knudson et al. 1998). We included the four complete points in our study.

The Milnesand site is located less than 500 m from the Ted Williamson site (Chapter 3; 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, 8 from Sellards's (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 (following 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

FIGURE 12.1. Digital image of a Plainview point with the locations of 23 landmarks marked along the point outline. The lines superimposed on the point image were produced using the MakeFan program.

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 the 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 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

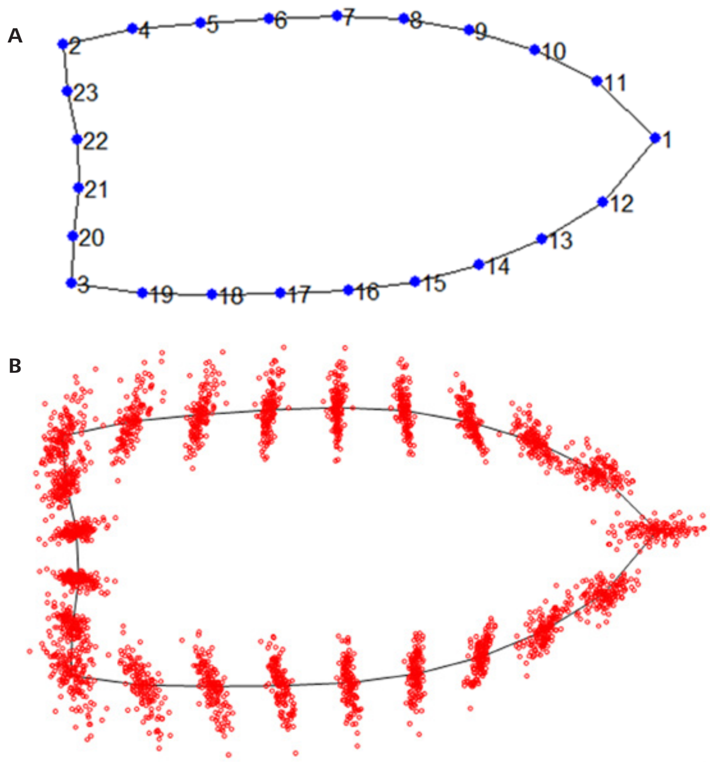

FIGURE 12.2. Results of the superimposition method using the generalized orthogonal least-squares Procrustes procedure: (*A*) consensus configuration of 143 point landmark configurations; (*B*) variation in point landmark configurations after being translated, scaled, and rotated.

TABLE 12.2. Variances at Each Landmark for Aligned Specimens.

Landmark	Location	S^2x	S^2y	S^2
1	Tip	0.00039	0.00004	0.00043
2	Base	0.00013	0.00040	0.00052
3	Base	0.00015	0.00038	0.00053
4	Base	0.00009	0.00044	0.00053
5	Base	0.00005	0.00040	0.00046
6	Base	0.00003	0.00039	0.00041
7	Blade	0.00001	0.00037	0.00038
8	Blade	0.00001	0.00031	0.00033
9	Blade	0.00004	0.00022	0.00026
10	Blade	0.00010	0.00015	0.00025
11	Blade	0.00021	0.00008	0.00029
12	Blade	0.00020	0.00010	0.00030
13	Blade	0.00009	0.00016	0.00025
14	Blade	0.00003	0.00023	0.00026
15	Blade	0.00001	0.00030	0.00032
16	Blade	0.00002	0.00036	0.00038
17	Base	0.00004	0.00038	0.00042
18	Base	0.00007	0.00041	0.00048
19	Base	0.00011	0.00041	0.00052
20	Base	0.00007	0.00015	0.00022
21	Base	0.00012	0.00002	0.00015
22	Base	0.00012	0.00002	0.00015
23	Base	0.00007	0.00015	0.00022

Note: Locations of numbered landmarks are shown in Figure 12.3.

components analysis was used to reduce the data set 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 pair-wise 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 pair-wise 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 pair-wise 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 percent 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 (Figures 12.3A, 12.3B, 12.3C, 12.3E).

Table 12.3 summarizes 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.

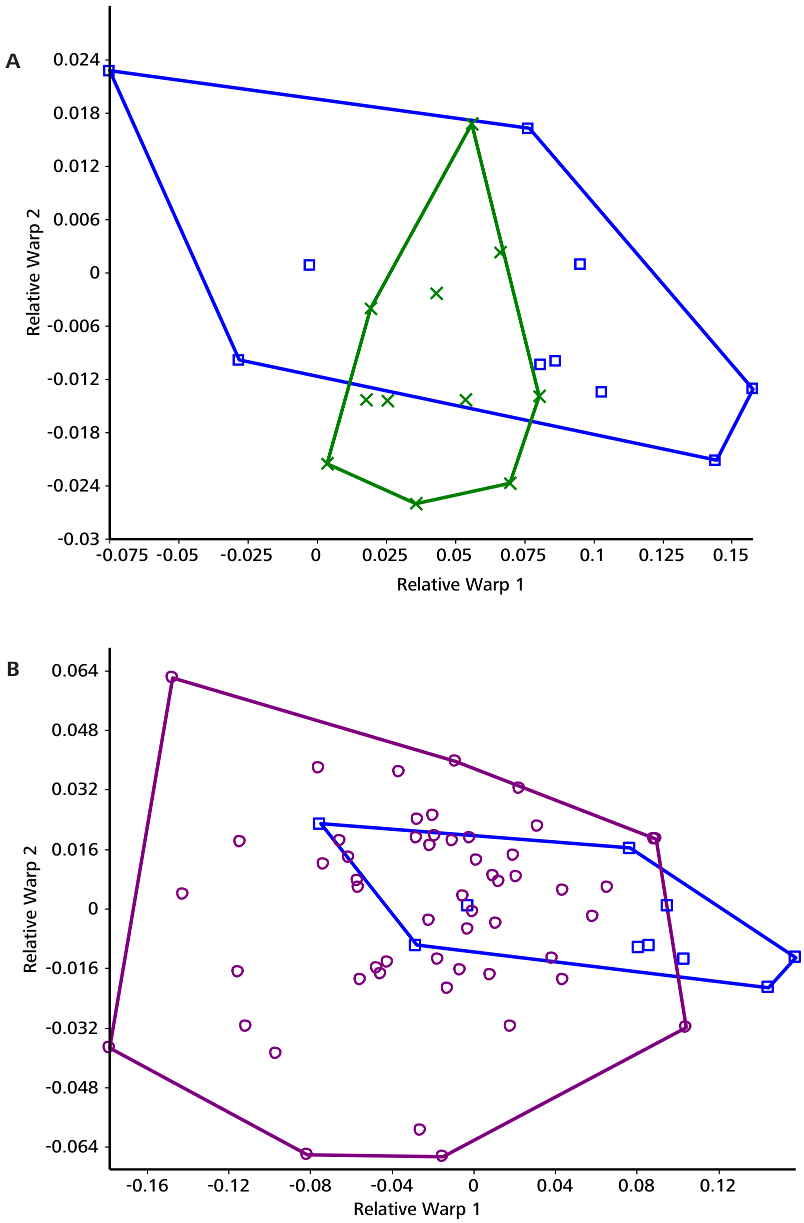

FIGURE 12.3. Bivariate plots of relative warp 1 against relative warp 2 for the Plainview type points (blue squares) and each of the other point assemblages: (*A*) Plainview and the Ryan's assemblage (*green x's*); (*B*) Plainview and the Ted Williamson assemblage (*purple circles*); (*C*) Plainview and the Warnica-Wilson assemblage (*gray diamonds*); (*D*) Plainview and the Lubbock Lake assemblage (*purple stars*); (*E*) Plainview and the Milnesand assemblage (*red crosses*).

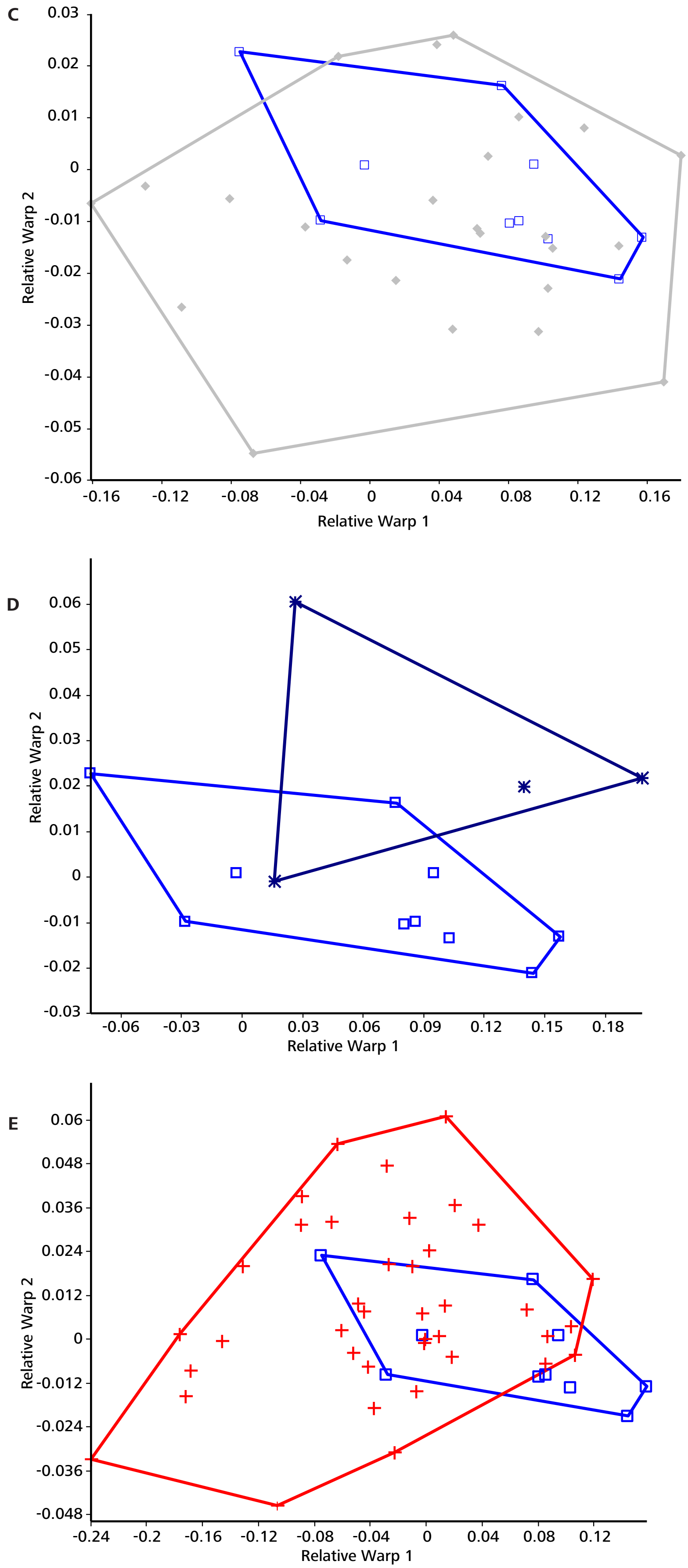
C
Relative Warp 2
Relative Warp 1
D
Relative Warp 2
Relative Warp 1
E
Relative Warp 2
Relative Warp 1

TABLE 12.3. Pair-Wise Discrimination Results of the Type Plainview Assemblage with the Other Late Paleoindian Point Assemblages.

Site	Plainview
Ryan's	0.5310
Ted Williamson	0.1090
Warnica–Wilson	0.6590
Lubbock Lake	0.0020[a]
Milnesand	0.5240

Note: The cells show *p*-values based on 1000 permutations for Hotelling's *T*-squared tests.
[a] Significant at the critical level of $p = .02041$ based on Benjamini and Yekutieli's (2001) method for controlling the false-discovery rate.

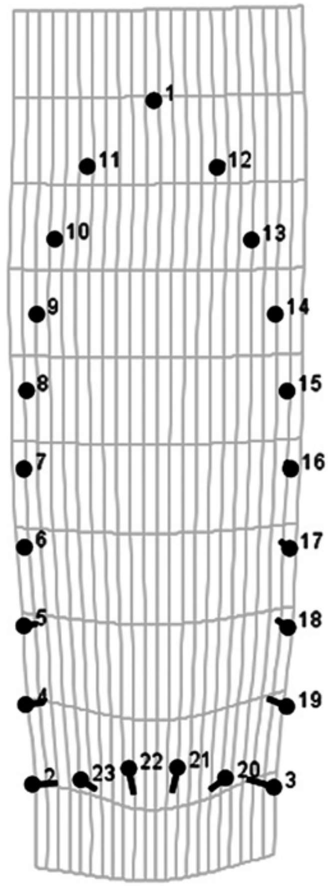

FIGURE 12.4. Deformation grid for the significant pair-wise comparison of mean point shape for the Plainview and Lubbock Lake assemblages. The grid is warped to indicate the differences between average assemblage point shapes. Landmarks are numbered, with circles showing the average landmark configuration for the first assemblage and lines indicating the direction and magnitude of difference.

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 the results obtained by Buchanan et al. (2007) and the results we obtained in the study reported here is that the points from the Milnesand site should be assigned to the Plainview point type. This stands in contrast to the conclusion reached by Sellards (1955). Sellards argued that the Milnesand points represent a different type from Plainview points because Milnesand points have square bases whereas Plainview points have concave ones. Holliday and coworkers (Chapter 3 this volume) agree with Sellards. They also argue that points from the Milnesand assemblage have straight bases whereas Plainview points have concave bases.

There are two obvious potential explanations for this discrepancy. One is that our analysis examined overall outline whereas Sellards and Holliday and colleagues concentrated on the base. The other is that the discrepancy is due to differences in methods. To test between these possibilities, we conducted an additional set of comparisons in which we used only the 14 landmarks associated with the base. These comparisons were carried out in exactly the same way as the comparisons using the complete set of landmarks. The results of the new analyses were consistent with the first set of results. They also indicated that the Milnesand points are not different from the Plainview points (p = .024; the B-Y corrected alpha level is 0.0219). This suggests that the discrepancy is not a consequence of our study having focused on overall outline whereas those of Sellards and Holliday et al. focused on the base. This in turn implies that the discrepancy is due to differences in methods. The most obvious such difference is that we used more landmarks than Sellards and Holliday and colleagues, and therefore captured overlap they missed. This explanation is supported by the fact that when we visually inspected the Milnesand points, we found that 20–30 percent of them have a concave base rather than the square/straight base claimed by Sellards and Holliday and coworkers.

One could argue, we suppose, that the Milnesand assemblage includes points from both the Plainview and Milnesand types and that they were mixed through either postdepositional 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 (~13,350 to ~12,830 cal yrs BP), Clovis was the only point type on the Southern High Plains (Collard et al. 2010). From ~12,830 cal yrs BP until the end of the Early Paleoindian period, ~11,900 cal yrs BP (Collard et al. 2010), the only point type was Folsom (although some researchers advocate for a second type during Folsom times, which they call "Midland" [Judge 1970], while others argue that Midland is an unfluted variety of Folsom [Amick 1995]).

The single assemblage containing Lubbock points at Lubbock Lake was recovered within 50 m of another assemblage containing Plainview points, and the two assemblages have yielded overlapping radiocarbon dates of about 11,500 cal yrs BP (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 adaptation 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 than 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 (1947a) 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 to 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) research 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

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