Points on Points: A Reply to Pollack et al.

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Abstract

Pollack et al. (2012) provide a critique of our recent paper Bradbury et al. (2011) on Fort Ancient triangular points. Here we re-examine our original hypotheses using newer data reported by Pollack et al. These additional data support our original contention that, while there are some diachronic trends evident in the Fort Ancient point types, these point types cannot be used either individually or at the assemblage level for assessing time. We stand by our original conclusion that it is time to cease using the Fort Ancient point typology as it is currently employed. We provide suggestions of how additional information may be derived from the examination of Fort Ancient triangular points.

The Pollack et al. response to our paper (Bradbury et al. 2011) is much appreciated, as it helps us clarify some of our arguments and gives us (and others) new data and new perspectives to consider. The points on which we disagree will hopefully stimulate more debate while the many points on which we agree should contribute to interpretations of triangular points in future studies in the Fort Ancient area. In this paper we examine critiques presented by Pollack et al. and re-evaluate our original hypotheses employing the newer data set that they provided. We fully agree with Pollack et al. that there is more to Fort Ancient triangular point variation than simple change through time. To our knowledge, no one had previously tested the main assumption of Railey's original typology. That is: point types can be used to measure finer increments of time within the Fort Ancient period. If we are interested in examining questions such as how or why point size/shape changes through time, we must first be able to tell time; thus the focus of our previous paper. Because our original paper just addressed the temporal issue, we will expand this discussion here in order to address Pollack et al.'s concerns with our 2011 paper. In addition, a large part of our disagreement is in the fundamental differences between typology vs. classification. We discuss these points in more detail below.

Background: Areas of Agreement and Disagreement

We are in complete agreement with Pollack et al. (2012:9) that "it is clear that a single triangular projectile point type alone cannot be used to date a Fort Ancient site occupation or component." Pollack et al. (2012:2) assert that "it simply was never the intent of the typology for individual projectile points to be used to date a site's occupation" and that "rather than looking at a particular point type, researchers should consider the spectrum of points recovered from a site component when attempting to interpret its age" (Pollack et al. 2012:10). However, this has been a point of contention in the past. For example, in his original paper, Railey (1992) never indicated that analysts should use assemblages of types in determining temporal association for a component nor did he indicate the need for larger sample sizes. Railey (1992:168) summarized his original Fort Ancient point study by stating the "analysis of the chipped stone artifacts focused on the identification of patterns that might contribute to the development of a Fort Ancient chronology for northeastern Kentucky. With the basics of the triangular projectile point sequence established for the study area, it should now be possible to identify the temporal placement of components lacking diagnostic ceramics, such as small hunting camps (e.g., Seeman and Munson 1980) or sites identified through surface reconnaissance." This suggested to us that one goal of the original analysis was to be able to date small sites based on the occurrence of just a few triangular points because few other materials were present at these sites. In fact, Henderson (1998) does just this. For example, Henderson (1998) uses triangular points to date non-village middle Fort Ancient sites. Further "in cases where a Fort Ancient occupation was represented only by a single triangular point, a middle Fort Ancient assignment was made only when the point was a Type 3: Coarsely serrated" (Henderson 1998:141). The corresponding table (Henderson 1998: Table 5-27) further indicates that several sites were placed in the middle Fort Ancient time frame based solely on the presence of *one* Type 3 point. Other examples could also be provided from other sources. What this suggested to us was that individual points were being used to date sites; therefore, we examined how well points could date a site.

Use of the typology has become common, and even expected, in studies of Fort Ancient sites with triangular points, regardless of sample size. This is why we felt a need to identify the problems we have had in using the typology and the potential loss of information that could result from its use in the future. Further, our paper did address the issue of using point assemblages rather than individual points to determine time (Bradbury et al. 2011:12-18). We determined that there were no consistent patterns in the assemblage level data that would allow one to determine time.

Beyond the question of single points as diagnostics, we are in agreement with Pollack et al. that there are changes in triangular point forms through time. Numerous studies have shown, for example, that a flared base (Type 2) is more common on points in the early part of Fort Ancient. It is also obvious that any of the temporal types (Types 2-6) can occur at any time during Fort Ancient. All the sites with large enough samples for comparison have multiple types (see Pollack et al. Table 1). While they believe the trends in the different triangular forms allow for the use of the dominant form to tell age, we believe this is not a reliable method of dating sites to such narrow spans of time, a point that we discuss in more detail below.

Pollack et al. re-emphasize the importance of studying small triangular points to learn about broader changes in Fort Ancient culture. As an example they hypothesize that serrations on Type 3 Triangles may be related to efficiency in taking larger game such as bear and elk. Certainly questions like these are of interest in the examination of Fort Ancient points. Examining faunal remains in finer detail and determining their association with various Fort Ancient points will provide answers to such questions. We look forward to this and other examinations of Fort Ancient points. We are in full agreement that it is important to employ small triangular points in examining broader changes in Fort Ancient culture. We only addressed this briefly in our original article because the focus was not on the question of what was driving the changes. The focus was on how best to quantify the changes and determine if changes were predictable based on age. We are in complete agreement that many factors can influence point form, and there is not a simple evolution through time. In order to determine what is changing through time, we must first be able to determine time.

Typology vs. Classification

Although we agree with Pollack et al. on a number of points they make, our area of greatest departure is on how to go about the task of examining variation in points. In short, there are several reasons why a typology cannot address the finer temporal questions that are being asked of it. First, the typology oversimplifies the variation expressed by triangular points. Second, the types are not defined well enough to allow consistent classification by independent analysts. Third, the typology does not adequately account for other factors influencing point form that might not be constant across time and space. Finally, even if the types are accepted as valid morphological forms, their predictive value does not rise to the standard of valid and reliable (cf. Ramenofsky and Steffen 1998).

Concerning the first issue, we contend that the types suppress too much of the variation in point form. In the new data presented by Pollack et al., they include only those points that match one of the temporally sensitive types (Types 2-6). This can result in a significant loss of information about variety in an assemblage. In the case of Elk Fork, for example, this approach requires elimination of two thirds of the sample. After the sample is reduced to only those points that fit within one (and only one) of the idealized forms, the sample size shrinks from 90 to 32 (21 of these are Type 2). Some of the ones eliminated were classic older forms, including Levanna and Hamilton. However, some were indeterminate fragments of smaller points that still retained time-sensitive attributes, according to the typology (e.g., incurvate bases). Some of the points dropped from consideration matched the criteria, both metric and non-metric, for more than one of the Railey types. It is true that Type 2 was the most common type, but to characterize the assemblage as dominated by Type 2 oversimplifies the wide range of variation and the degree of conformity to the typology. If the attributes that the types are based on have temporal significance, we should be able to get some information from nearly all of the points. Also, limiting the analysis to just those points that match one of the idealized types can reduce the sample size, and thus reduce the number of assemblages that can be used for regional comparisons.

In terms of definitions of the types, we agree that “an analyst’s particular research needs and questions help determine which attributes they record and whether they privilege one attribute over another” (Pollack et al. 2012). We believe the “privilege” can be greatly reduced, however, by focusing on attributes that can be consistently observed or measured, rather than deciding on a case-by-case basis which attributes carry more weight in assigning a point to one type or another. It is not simply a matter of lumping or splitting. An incurvate or excurvate base, for example, can easily be observed and even measured by holding a ruler to the base. The typology cannot be applied consistently by different analysts unless it is based on measurements or observations that can be independently replicated.

As for problems of analytical bias, and behavioral factors that might influence point forms and classifications, Pollack et al. (2012:2) say “… attending to these factors is an issue in any projectile point classification.” While we believe this statement is generally true, there are some important differences between the small triangular point typology and most other hafted biface typologies. The Railey typology attempts to make much finer distinctions, both morphological and temporal, based on fewer attributes. Most hafted biface types are not used to define such narrow time ranges (as little as three or four generations), and most are not defined by such subtle differences in the curvature of the blade margins. An incurvate blade can become recurved or excurvate if a broken tip is resharpened. This leaves only the base to identify the original form. Most hafted bifaces have separate haft elements that can be stemmed or notched in various ways and not influenced by resharpening. Regardless of resharpening, most other hafted bifaces have more attributes (and combinations) on which to base a type. Finally, unlike most other typologies, all types in the Fort Ancient typology are present in all subperiods. Different types are just more common at different times.

A few examples can be presented to illustrate these problems. In his original descriptions, Railey (1992) notes: Type 4 point margins are *usually* excurvate, and bases are convex, straight or (rarely) concave; Type 5 exhibit straight lateral margins that *range* from nearly parallel to basally expanding and bases are *usually* straight or very slightly convex; and, Type 6 exhibit concave basal margins, excurvate *or* straight lateral margins, and narrow to medium basal widths (emphasis added). None of the types are defined by mutually exclusive attributes; therefore, different analysts can examine the same point assemblage and come up with different frequencies of types for the same assemblage.

In contrast to typology, classification can be used to define mutually exclusive classes. Classification is the “*creation of units of meaning by means of stipulating the redundancies* (classes)” (Dunnell 1971:44, emphasis in original). As Dunnell (1971:45) explains: “a class can be conceived of a conceptual box created by its boundaries. The boundaries are established by stating the criteria which are required, the necessary and sufficient conditions, to be included within the box or class. Only those items that are the same are grouped together. Classes are mutually exclusive.” As long as we can operationalize the dimensions that define the classes, two different analysts should be able to achieve the same results. Here, dimensions are “a set of attributes or features which cannot, either logically or actually, co-occur…*a set of mutually exclusive alternate features*” (Dunnell 1971:71, emphasis in original). In the classification of Fort Ancient triangular points, for example, we define a base shape dimension that is comprised of three mutually exclusive features: excurvate, incurvate, straight. A similar dimension can be set up for blade shape using these same three features. Shape can be determined by holding a straight edge to the base or blade. The triangular point classes are then defined by the intersection of these attributes. For example: excurvate base-excurvate blade; excurvate base, straight blade; and so on. Only those specimens that exhibit an excurvate base and an excurvate blade are included in the class: excurvate base-excurvate blade.

Examining Assemblages of Points as Indicators of Time

Given the above discussion, one might ask: if single points cannot be used to date sites, and multiple types are present in all of the larger assemblages, how do you know when you have enough of a particular type to determine the temporal affiliation of the assemblage? In the case of frequency data, simple majorities cannot be used as reliable indicators of site age. The data in Pollack et al. (2012: Table 1) show some obvious temporal trends. For example, Type 2 Triangles are more common in early Fort Ancient components, and Type 6 Triangles show even greater consistency in late Fort Ancient components. Several sites, however, lack a majority type (greater than 50 percent), and for some, the most common type in the sample is inconsistent with the date of occupation as determined by other means. With the obvious trends and the obvious inconsistencies, we need an objective means of weighing the trends against the inconsistencies. Looking back on these larger samples, how well would the point types have predicted the time of occupation? We assess these questions below.

Pollack et al. (2012: Table 1) provide point data from 24 Fort Ancient components in Kentucky. All of these assemblages contain at least 15 points each. For this analysis we have assumed that the temporal assignments provided by Pollack et al. are correct and that the components do not represent multiple time periods (though see below and Bradbury et al. 2011:12-15). The data in Pollack et al. (2012: Table 1) were examined using discriminant function analysis (DFA) to assess the hypothesis that assemblages of points can be used to determine an age for a component. DFA is a multivariate statistical method that attempts to maximize the differences between known groups (in this case, temporal assignment) as a way to classify unknown cases or as a method for checking how well classes have been defined (Baxter 1994:185–218; Fatti et al. 1982; Johnson and Wichern 1992:493–572; Klecka 1980). A cross-validation method was used here to assess the ability of the method to correctly classify temporal association. The cross-validation method provides a less biased estimate of correct classifications because it precludes a particular assemblage from being used to classify itself (SAS Institute Inc. 1989:688). If Pollack et al.’s hypothesis that assemblages of points can be used to assess time is correct there should be very high correct classification rates in the analysis. The percentage data from Pollack et al. (2012: Table 1) was used in the analysis with component as the class variable. It should be noted that one variable (point type) has to be dropped from the analysis. This is due to the use of percentages that all add up to 100 percent for each component. Any one variable can be predicted by knowing the other variables; thus the final variable is not needed. While the dropped variable is not directly considered in the analysis, it is indirectly considered because it was used in constructing the original percentage data.

The cross-validation results for the current analysis indicate a 75 percent correct classification rate in classifying the components based on assemblages of points (Table 1). Miss-classifications are informative. All three of the Early Fort Ancient sites are miss-classified as late Early – early Middle Fort Ancient and 40 percent of the late Early – early Middle Fort Ancient are classified as Early Fort Ancient. Of the Middle Fort Ancient components, 14.3 percent are classified as late Early – early Middle Fort Ancient. All of the early Late Fort Ancient and late Late Fort Ancient are classified correctly. This can be seen graphically in Figure 1.

As noted above, one type was excluded from the analysis. In this case, Type 6 was dropped from the analysis by SPSS because it added nothing to the analysis in light of the other variables (point types) already in the analysis. Examining the ANOVA tests on each of the types (Table 2) indicates that Type 2.1 and Type 3.1 are not useful in distinguishing between the temporal periods; therefore, the analysis was rerun. Type 2.1 and Type 3.1 were excluded from this analysis and Type 6 was included in the analysis. The correct classification rate rose to 79 percent. One less late Early – early Middle component was miss classified. The remaining components were classified as indicated in the original analysis. In summary, some discriminating power was seen in the analysis. Late Fort Ancient components were correctly classified by examining assemblages of points recovered. However, none of the early Fort Ancient components were correctly classified. Further, late Early-early Middle Fort Ancient and Middle Fort Ancient components also show a number of miss-classifications.

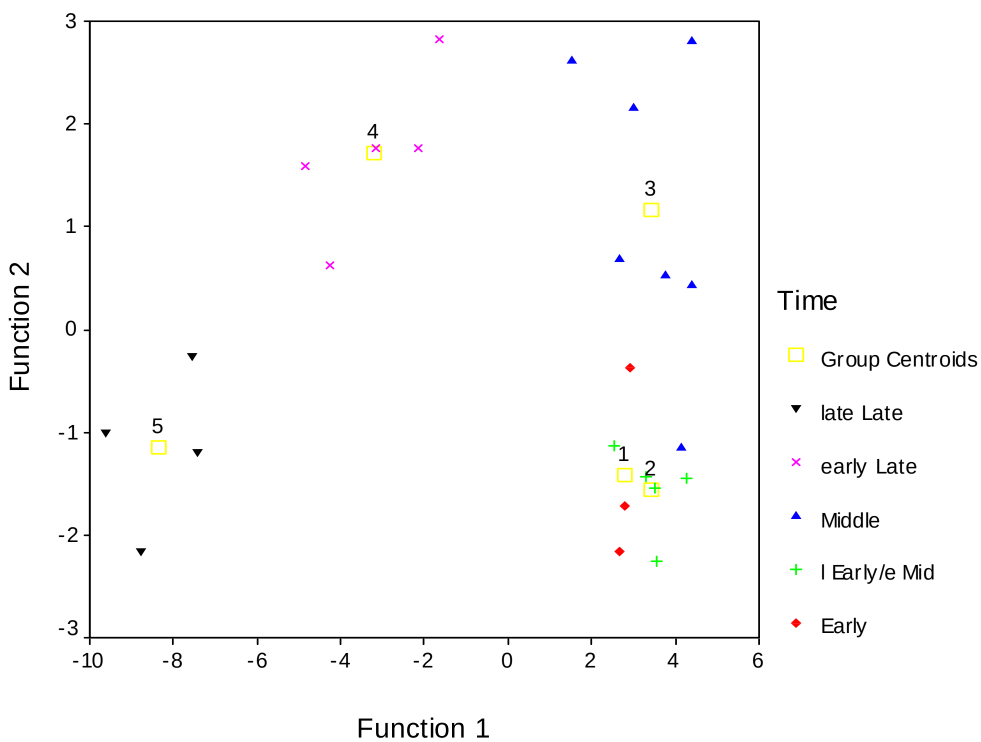

Figure 1. Function 1 vs. Function 2 for the DFA.

Table 1. Cross-validation Summary for DFA of Point Assemblages.

	Predicted Group Membership				
Actual Group Membership	Early	Late Early- Early Middle	Middle	Early Late	Late Late
Early	0%	100%	0%	0%	0%
Late Early- Early Middle	40%	60%	0%	0%	0%
Middle	0%	14.3%	85.7%	0%	0%
Early Late	0%	0%	0%	100.0	0%
Late Late	0%	0%	0%	0%	100%

Table 2. Tests of Equality of Group Means.

	Wilks' Lambda	F	df1	df2	Sig.
Type 2	.211	17.791	4	19	.000
Type 2.1	.835	.939	4	19	.463
Type 3	.414	6.725	4	19	.002
Type 3.1	.784	1.310	4	19	.302
Type 4	.524	4.315	4	19	.012
Type 5	.438	6.096	4	19	.002
Type 6	.121	34.564	4	19	.000

Further examinations of temporal trends in Fort Ancient point assemblages can be accomplished using correspondence analysis (CA). CA has been used by a number of researchers for the seriation of ceramics using either ceramic types or ceramic attributes (e.g., Duff 1996; Mainfort 2005; McNutt 2005; Smith and Neiman 2007). An in-depth discussion of CA for archaeological data can be found in Bolviken et al. (1982). Further information on the use of CA can be found in Clausen (1998), and additional archaeological application can be found in Shennan (1988) and Baxter (1994). A summary of the CA method is presented here.

CA is a descriptive/exploratory technique designed to analyze frequency data. As “Relationships between cases, those between variables, and those between variables and cases, may all be analyzed together and represented in the same scattergram or series of scattergrams produced by plotting pairs of orthogonal axes” (Shennan 1988:284). The outcome of such analyses “is first and foremost joint plots of the representations of units [components] and variables [point types] in various two-dimensional subspace” (Bolviken et al. 1982:44). In the case of the triangular point data, the plot obtained from CA can display both components and point types on the same plot; therefore, it is possible to see which of the types has most influenced the components (Bolviken et al. 1982). Further, it can be determined what types commonly occur together. In short, CA is a data reduction method that allows one to summarize data variability in a smaller subset of variables. These can then be plotted in a scatter plot to graphically depict similarities/differences between the components in terms of the point types represented. With respect to seriation, Smith and Neiman (2007) show that CA plots often display an “arched” shape on Dimensions 1 and 2 if the second dimension is a quadratic function of the first dimension. This occurs when the classic battleship curve is represented in the data. Plotting assemblages on the two axes can be used to order assemblages with respect to time (also see Duff 1996 for a similar application and O’Brien and Lyman 1999 for an in depth discussion of the seriation method). In these cases, a temporal dimension can be seen on Axis 1, and possibly Axis 2. In some cases, the arch may not be seen. This happens in cases where the temporal gradient is not long enough to contain both the increase and decrease within types (Smith and Neiman 2007:63) or there is little to no temporal information in the data. If there are temporal trends in assemblages of Fort

Ancient point types, then the classic arched plot should be observed.

For the current analysis, the categories module in SPSS, Version 10 was used to calculate the CA. By default, SPSS standardizes the data by removing the row and column means; thus, both the rows and columns are centered. The current analysis was by row principal normalization. In row principal normalization, the distances between row points are approximations of the distances in the correspondence table according to the selected distance measure (chi-square in the current analysis). Row principal normalization allows an examination of similarities or differences between the various point assemblages from the components. The data for CA consists of counts, in the current example point types, for each component. Pollack et al. (2012: Table 1) provide data set of 24 Fort Ancient components. The percentage data from this table were converted back to count data (Table 3) for the CA conducted here. While it would have been preferable to consult the original sources for the data, many of the sources used to construct the table are unpublished data or found in limited distribution media (e.g., site reports, MA thesis); therefore, not readily available for examination. Point totals for each of the components were the same for our data as that of Pollack et al. indicating that the data are consistent.

Three dimensions were retained in the CA and account for 80.6 percent of the inertia of the original data (Table 4). Scores for the rows and columns can be found in Table 5. Dimension 1 (44.1 percent of inertia) contrasts Type 6 points with Type 2.1 and Type 3. High scores on this dimension indicate components with high percentages of Type 6 points. Dimension 2 (20.1 percent of inertia) contrasts Type 2.1 and Type 3.1 points with the rest of the types. High percentages of Type 2.1 and 3.1 in a component will result in low scores on Dimension 2. Dimension 3 (15.7 percent of inertia) contrasts Type 2.1, Type 3, and Type 3.1 with Type 2 points. Low scores on Dimension 3 are associated with high percentages of Type 2 points in a component. The resulting scatter plots are depicted in Figures 2 and 3. A temporal dimension is indicated in both plots, though more noticeable in the plot of Dimension 1 vs. Dimension 2.

The plot of Dimension 1 vs. Dimension 2 (together accounting for 68.9 percent of the inertia) is of the most interest for the examination of temporal data within point types and is the focus of this discussion. The arch shape in the plot suggests some temporal dimension to the graph. This can be seen more clearly by replacing the site names with the temporal designations (Figure 4). Late Fort Ancient components plot in the upper right of the graph. High percentages of Type 6 points are associated with late Late Fort Ancient sites. Early Late Fort Ancient sites are associated with high percentages of Type 5 points. In addition, Type 4 and Type 6 points are also recovered in relatively high amounts. Types 2, 2.1, 3, and 3.1 are rare in the late assemblages. These results confirm Pollack et al's (2012:9) hypotheses that: Type 6 points are more common late in the sequence; Types 4 and 5 are also popular late in the sequence; and low percentages of type 2, 2.1, 3, and 3.1 points occur during Late Fort Ancient. Contra Pollack et al., the early to middle portion of the Fort Ancient is much more complex and cannot be defined by point assemblages. This is indicated by the overlap of Early, late Early-early Middle, and Middle Fort Ancient assemblages in the graph. It is also of note that the total inertia of Type 4 and Type 3 are low in the analysis suggesting that they do not contribute much in terms of temporal information. This may also be influenced by their relatively low frequencies in the assemblages. Additional data are needed to confirm or reject this hypothesis.

We further note that had the graph evidenced the classic arch shape indicating a temporal dimension to this dimension, then the components could have been ordered to provide a finer resolution of chronological ordering of the components (e.g., Duff 1996; Smith and Neiman 2007). Because the plot indicates that the types are measuring more than just a temporal dimension, such an analysis is not possible.

The results of the CA confirm the results of the DFA above. That is, the data indicate a relationship between time period and point form. However, not all of the data provide indications of time. The Late Fort Ancient can be clearly separated from other assemblages by examining the entire point assemblage, assuming that large quantities of points are recovered (i.e., > 15 in the current example). The early to middle portions of the Fort Ancient are much more complex and temporal indicators are not provided by the point assemblages. Elsewhere, Seeman and Munson (1980) and Shott (2003) have examined small triangular point trends. Both papers indicated some issues with using triangular points for examining finer temporal trends. In the Illinois Valley case, Shott (2003) concluded that changes were complex and continuous, and could not be viewed as a succession of discrete types. We see a similar situation with the Fort Ancient point data. We also note that all of the types can be found at sites throughout the Fort Ancient temporal sequence. The recovery of, for example, a few Type 2 points within components dominated by Type 6 points could mean that the component is late Late Fort Ancient, or that a smaller early Fort Ancient component is represented at the site. The typology cannot be used to determine which of these two hypotheses is correct.

Above, we assumed that the components used in the analysis do in fact represent single components. However, the dates from several of the sites suggest that this may not be the case. For example: Muir (1010+/-80, 980+/-60, 890+/-70, 790+/-60, 1010+/-60, 780+/-50 [Sharp and Turnbow 1987]); Carpenter Farm (700+/-60, 590+/-60, 540+/-60 [Pollack and Hockensmith 1992]); Florence (15Hr22: 470+/-50, 600+/-50, 680+/-50 [Sharp and Pollack 1992]); all have dates that suggest multiple Fort Ancient components. To test this hypothesis, the dates from these three sites were calibrated using OxCal 4.1 (Ramsey 2009). The IntCal09.14c calibration dataset, Northern Hemisphere terrestrial sample (Reimer et al. 2009) was used in calibrating the dates. Graphical representations of these dates can be seen in Figures 5 to 7. Multiple components are suggested for all three of these sites. It is also of note that the dates were derived from wood charcoal, and in some cases, using multiple timbers, rather than using annual plants (e.g., nutshell, maize, seeds). These dating issues may be part of the reason that the types do not predict time well, a point that we brought up in our original paper (Bradbury et al. 2011:12-15).

Table 3. Point Type Data for CA. Original data from Pollack et al. (2012: Table 1).

Site	Time (Fort Ancient)	Type 2	Type 2.1	Type 3	Type 3.1	Type 4	Type 5	Type 6	Total
Elk Fork	Early	21*	0	2	0	2	2	5	32
Dry Run	Early	21	1	1	0	0	19	0	42
Muir	Early	21	11	0	8	0	6	0	46
Bedinger	late Early/early Middle	47	0	0	0	2	18	2	69
Cox	late Early/early Middle	12	0	0	0	0	5	0	17
Dry Branch Creek	late Early/early Middle	17	0	0	0	0	10	2	29
Kentuckiana Farm	late Early/early Middle	11	9	3	1	2	10	0	36
Van Meter	late Early/early Middle	13	0	0	0	0	6	1	20
Guilford	Middle	9	0	3	0	0	6	0	18
Broaddus	Middle	40	0	10	0	3	41	0	94
Kenny	Middle	43	0	3	0	1	17	1	65
Singer	Middle	9	3	5	2	0	7	0	26
Carpenter Farm	Middle	3	0	3	0	0	11	0	17
Fox Farm	Middle	13	0	23	0	4	15	0	55
Florence	Middle	4	1	5	1	1	5	0	17
Capital View	early Late	5	0	1	0	5	46	8	65
Sweet Lick Knob	early Late	3	1	3	1	4	46	1	59
Fox Farm	early Late	3	0	5	0	7	13	12	40
New Field	early Late	0	0	1	0	8	58	18	85
Petersburg	early Late	4	0	1	0	4	16	1	26
Augusta	late Late	0	0	0	0	3	8	9	20
Goolman	late Late	0	0	0	0	0	26	81	107
Larkin	late Late	2	0	2	0	6	13	32	55
Bently	late Late	0	0	0	0	17	9	26	52

*It should be noted that only 21 of the 90 triangular points at Elk Fork were Type 2. For this reanalysis we use the 21 of 32 presented in the Pollack et al. critique, as they eliminated all points from consideration that did not exclusively match Type 2, 3, 4, 5, or 6.

Table 4. Summary Data for CA of Point Types.

Dimension	Singular Value	Inertia	Proportion of Inertia		Confidence Singular Value		
			Accounted for	Cumulative	Standard Deviation	Correlation 2	Correlation 3
1	0.73884	0.545885	0.440939	0.440939	0.015531	0.250685	0.209731
2	0.507479	0.257534	0.208024	0.648963	0.041793		0.101327
3	0.441312	0.194756	0.157314	0.806277	0.025972		
4	0.376292	0.141596	0.114374	0.920651			
5	0.269225	0.072482	0.058547	0.979199			
6	0.160475	0.025752	0.020801	1			
Total		1.238005	1	1			

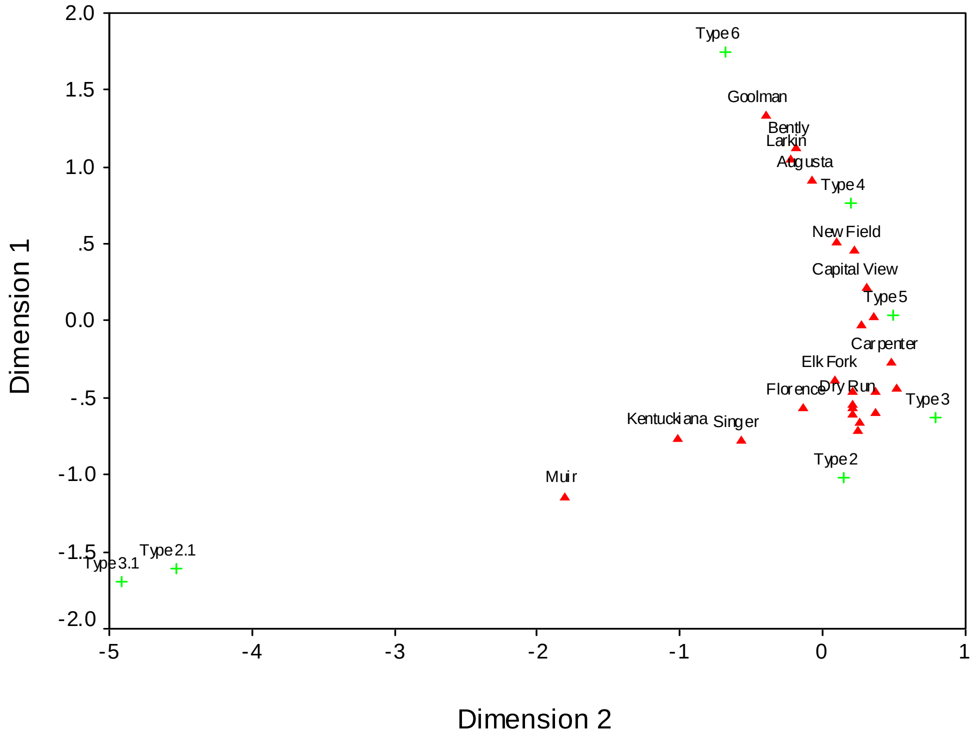

Figure 2. Dimension 1 vs. Dimension 2 in the CA of point types.

Table 5. Row and Column Points for CA of Fort Ancient Points.

	Mass	Score in Dimension			Inertia	Contribution Of Point to Inertia of Dimension			Contribution Of Dimension to Inertia of Point			
Row		1	2	3		1	2	3	1	2	3	Total
Elk Fork	0.029304	-0.38479	0.082358	-0.71929	0.024282	0.007948	0.000772	0.077848	0.178687	0.008186	0.624395	0.811268
Dry Run	0.038462	-0.54603	0.206824	-0.23339	0.018485	0.021007	0.006388	0.010757	0.620349	0.089004	0.113335	0.822687
Muir	0.042125	-1.14052	-1.80646	0.176365	0.199815	0.100379	0.53377	0.006728	0.27423	0.687959	0.006557	0.968746
Bedinger	0.063187	-0.61152	0.214392	-0.65764	0.055675	0.043286	0.011277	0.140317	0.424419	0.052166	0.490844	0.967429
Cox	0.015568	-0.70815	0.248284	-0.66939	0.016134	0.014301	0.003726	0.035817	0.48386	0.05948	0.432339	0.975679
Dry Branch	0.026557	-0.46403	0.208809	-0.53955	0.015594	0.010475	0.004496	0.039695	0.3667	0.074254	0.495772	0.936727
Kentuckiana	0.032967	-0.761	-1.01055	0.440224	0.078732	0.034974	0.130727	0.032805	0.242489	0.427611	0.081148	0.751248
Van Meter	0.018315	-0.56373	0.208998	-0.63372	0.014368	0.010662	0.003106	0.037767	0.405098	0.055681	0.511931	0.97271
Guilford	0.016484	-0.60141	0.368113	-0.11105	0.010352	0.010922	0.008673	0.001044	0.575957	0.215778	0.019638	0.811373
Broaddus	0.086081	-0.45983	0.366886	-0.02488	0.03014	0.033343	0.044992	0.000274	0.603902	0.384438	0.001768	0.990108
Kenny	0.059524	-0.6545	0.254571	-0.55736	0.047998	0.046711	0.014979	0.094946	0.531247	0.080369	0.385255	0.996872
Singer	0.02381	-0.77955	-0.56645	0.380358	0.029795	0.026506	0.029664	0.017687	0.485627	0.256408	0.115611	0.857647
Carpenter	0.015568	-0.26671	0.482717	0.511355	0.010882	0.002029	0.014086	0.020902	0.101769	0.333364	0.374093	0.809226
Fox Farm (Mid)	0.050366	-0.43729	0.511447	0.656469	0.109431	0.017643	0.051157	0.11145	0.088011	0.120393	0.198348	0.406752
Florence	0.015568	-0.5629	-0.13377	0.636202	0.019472	0.009036	0.001082	0.032354	0.253326	0.014306	0.323595	0.591226
Capital View	0.059524	0.211107	0.303324	0.379126	0.031315	0.00486	0.021265	0.043931	0.084711	0.174882	0.273211	0.532803
Sweet Lick	0.054029	-0.03023	0.272978	0.641946	0.041436	9.05E-05	0.015633	0.114323	0.001192	0.097165	0.537341	0.635698
Fox Farm (Late)	0.03663	0.514062	0.100078	0.264425	0.018994	0.017732	0.001425	0.013151	0.509615	0.019315	0.134839	0.663769
New Field	0.077839	0.458714	0.219893	0.400026	0.04822	0.030004	0.014614	0.063956	0.339663	0.078052	0.25831	0.676025
Petersburg	0.02381	0.025747	0.360176	0.390359	0.011729	2.89E-05	0.011993	0.018629	0.001346	0.263339	0.309324	0.574009
Augusta	0.018315	0.914298	-0.07901	0.064787	0.016307	0.028047	0.000444	0.000395	0.938896	0.007012	0.004714	0.950623
Goolman	0.097985	1.330551	-0.39492	-0.39475	0.225441	0.317778	0.05934	0.078399	0.769468	0.067788	0.067728	0.904984
Larkin	0.050366	1.047605	-0.22345	-0.16005	0.061385	0.101259	0.009764	0.006625	0.900485	0.040966	0.021018	0.962469
Bently	0.047619	1.127932	-0.18929	0.028811	0.102026	0.11098	0.006625	0.000203	0.593796	0.016723	0.000387	0.610906
Column												
Type 2	0.275641	-1.01832	0.146704	-1.2262	0.239995	0.285836	0.005932	0.414443	0.650154	0.006366	0.336321	0.992841
Type 2.1	0.02381	-1.61153	-4.52804	1.597239	0.181043	0.061834	0.488171	0.060742	0.186444	0.694425	0.065343	0.946211
Type 3	0.065018	-0.62605	0.784414	1.678349	0.154654	0.025483	0.040006	0.183147	0.089949	0.06662	0.230638	0.387206
Type 3.1	0.011905	-1.69624	-4.91521	1.536443	0.114918	0.034253	0.287611	0.028103	0.162708	0.644542	0.047627	0.854878
Type 4	0.063187	0.76059	0.199945	0.859978	0.091397	0.036553	0.002526	0.046731	0.218321	0.007118	0.099577	0.325015
Type 5	0.378205	0.036276	0.492076	0.666963	0.103156	0.000498	0.091578	0.16824	0.002634	0.22863	0.317634	0.548898
Type 6	0.182234	1.745997	-0.67964	-0.73554	0.352842	0.555543	0.084175	0.098593	0.859484	0.061438	0.05442	0.975343

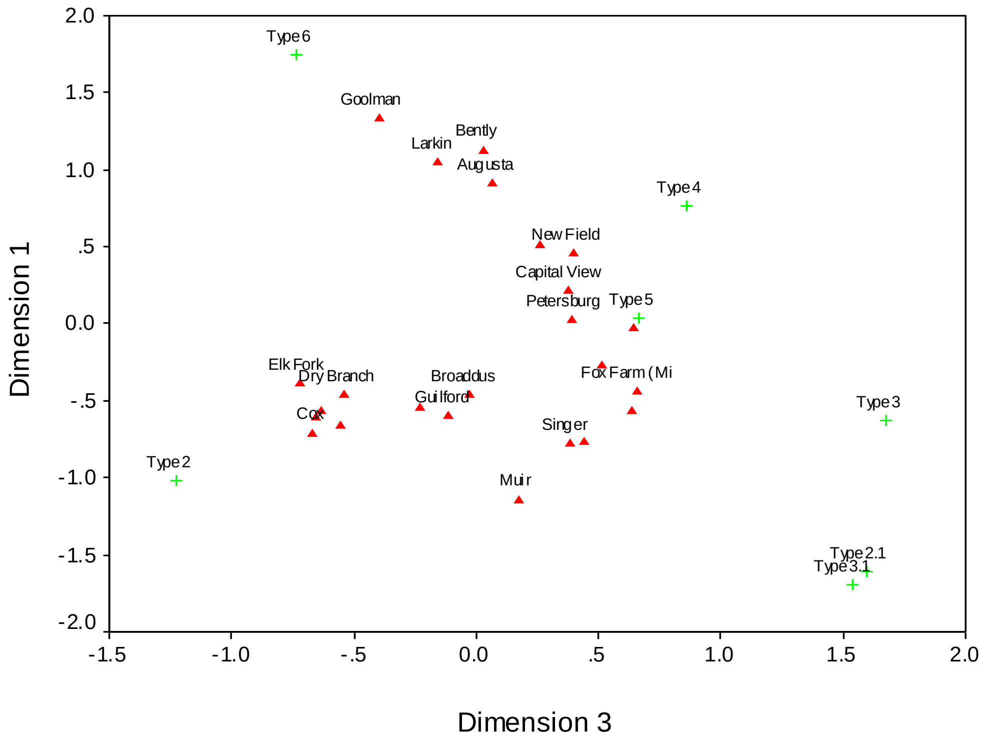

Figure 3. Dimension 1 vs. Dimension 2 in the CA of point types.

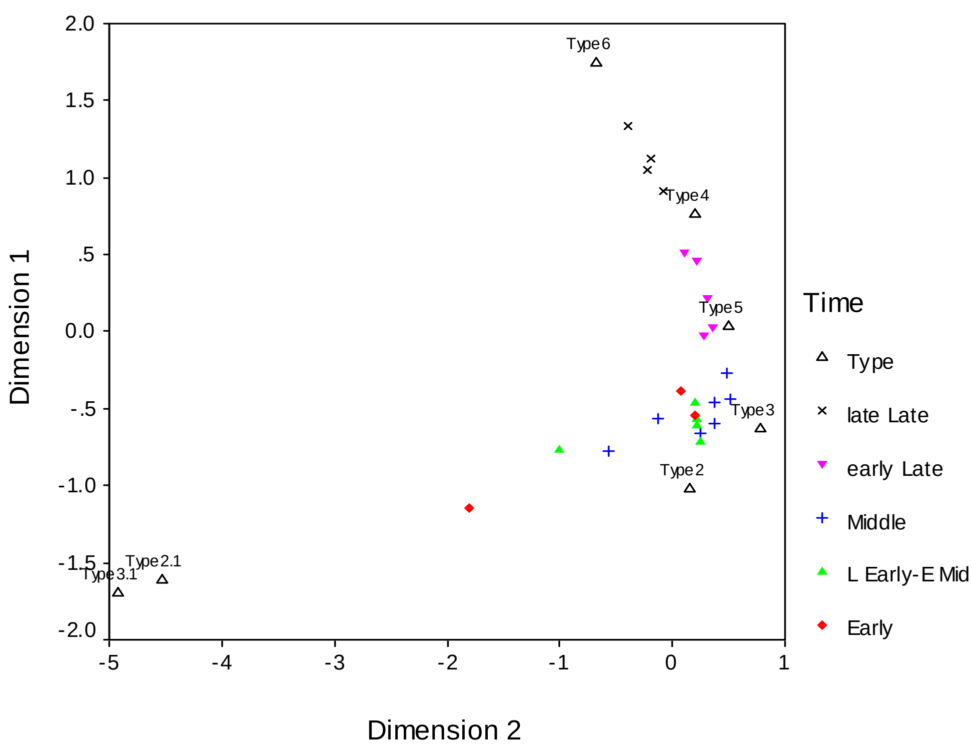

Figure 4. Dimension 1 vs. Dimension 2 in the CA of point types depicting temporal data.

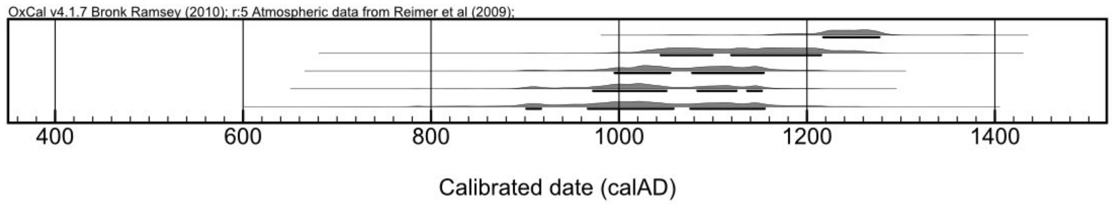

Figure 5. Calibrated dates from Muir.

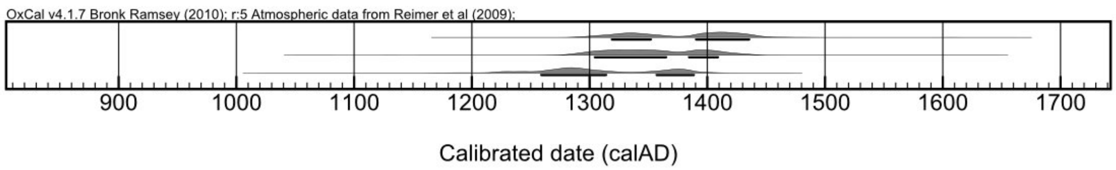

Figure 6. Calibrated dates from Carpenter Farm.

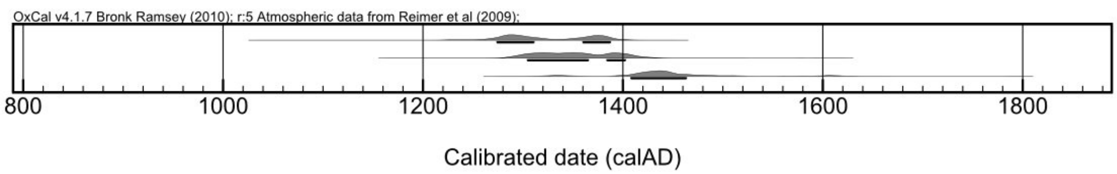

Figure 7. Calibrated dates from Florence.

Proposed Triangular Point Classification Revisited

The paradigmatic classification system that we suggested in our original paper (Bradbury et al. 2011: Table 8) can be used to further explore potential temporal and geographic variation in triangular points. Further, it may be possible to include Late Woodland triangular points in such an examination further extending the temporal dimension. Possible avenues of inquiry are using CA of the classes defined by the classification system we proposed. Plotting available radiocarbon dates into the CA plot would enable the results to be calibrated to time. Table 6 depicts how the data for such an examination might be set up. All possible combinations of Table 8 in our original paper are examined. Those classes with no members are of course removed from consideration. Like Pollack et al. suggest, we concur that these data need to be derived from secure contexts and that smaller datasets (less than 15 points) be excluded. We also note that additional attributes could be included if deemed important. For example, Pollack et al. (also see Bradbury and Richmond 2004) note the decrease in point size in the Late Fort Ancient, a trend that has been noted elsewhere at roughly the same time (e.g., Shott 1993). Certainly a size variable could be added to the paradigmatic classification that we have suggested.

Likewise, frequency data for each of the dimensions (base shape, blade shape, serration, basal flaring) could be subjected to a CA as above to map how each of these change through time. In addition, this would provide information on what attribute states co-occur. Further, assessing the classification system via CA of classes or attribute states could be used to order components as is commonly conducted for frequency seriation (e.g., O’Brien and Lyman

1999). Similar approaches have been used in the seriation of ceramic assemblages to order components in time (e.g., Duff 1996; Smith and Neiman 2007). If it can be shown that temporal information can be derived from the examination of classes or attributes, then frequency seriation can be used to put a series of Fort Ancient components in chronological order based on their point assemblages. As noted by O'Brien and Lyman (1999:137) "seriation is the only relative dating technique that allows time to be measured in anything approximately a continuum." A similar method could be applied to ceramic assemblages to derive finer resolution of time and could be used in conjunction with the point seriation.

As we noted above, one of the problems of typologies is the lack of mutually exclusive classes. Further, the criteria used to define the types are often not operationalized. For example, how coarse do the serrations need to be for a point to be classified as Type 3? In using the classification system that we propose, a straight edge can be placed against the base or blade of the point to aid in determining whether it is incurvate, excurvate, or straight. A size cut off could be used to determine coarse vs. fine serration.

The classes that would be derived from the classification system that we propose encompass the types originally defined by Railey (1992) and modified by Henderson (1998) and Carmean (2010). For example, Type 2 points are defined as having excurvate or straight bases, incurvate blades and/or markedly flared bases, and no serrations. In our classification system, several classes define these attribute states: excurvate base, incurvate blade, no serrations, flared base; straight base, incurvate blade, no serrations, flared base; excurvate base, incurvate blade, no serrations, base not flared; and straight base, incurvate blade, no serrations, base not flared. These finer distinctions allow for a more detailed examination of the temporal and geographic differences.

A paradigmatic classification would contain the information that the triangular point typology provides; however, the classification does not have the associated problem of vague criteria for determining each type. In addition, the classification provides more detailed information concerning the variation expressed by triangular points. Such information is lost by using the point typology. By examining the various attributes and dimensions it may be possible to: track the changes in these attributes through time; determine which attributes changed together; determine which attributes changed independently of one another; identify other criteria that may be related to these changes (e.g., changes in hunting patterns, changes in weapons systems); and finally, identify which changes are consistent across time and space within the Fort Ancient area. Such changes cannot be tracked as finely by the examination of point types by themselves.

Summary and Conclusions

The additional analyses conducted here expand on those in our earlier papers (Bradbury and Richmond 2004; Bradbury et al. 2011). These analyses have shown that there is wide variation in Fort Ancient points and that some of the variation is related to the time of occupation, but not in a *consistent* way, *temporally or geographically*. We do agree with Pollack et al. (2012) that there are changes in triangular point form through time. We seem to agree (at least partially) that smaller data sets cannot be trusted to represent broader trends in point variation. They note the importance of other factors that can influence point form (e.g., resharpening, different game, geography, raw material) and suggest we study triangular point variation to better understand these factors. We also think this is important, although it was not the focus of our original paper.

Pollack et al. acknowledge that different analysts can classify points differently depending on how much they "privilege" one attribute over another, but they believe that this is a problem in any point typology. We would argue that this is a much more serious problem in the Fort Ancient small triangular point typology because finer distinctions must be made to subdivide this simple form; the time frames it seeks to identify are very narrow; and perhaps most importantly, multiple types (both "early" and "late" forms) regularly occur at sites throughout the span of Fort Ancient. In order to record point variation more consistently, and to record data on small triangular points that do not fit within the current Fort Ancient typology, we proposed a system based on classification rather than typology.

Beyond the question of whether types can be recorded consistently by different analysts, the data presented by Pollack et al. (Table 1) includes some mismatches between the site age and the expected point type(s). For most sites it "works" and for some it does not. Without the benefit of hindsight, how do you know if a new assemblage is one of the ones that "works." To evaluate how well the point types predict site age, we used DFA and CA. The DFA indicated that there was a temporal component to the point variation, but the point types predicted site age only 75 percent of the time overall. For later sites, the rate of correct classification was higher, and for earlier sites it was lower. The CA corroborated these results and further indicated a relationship between late Fort Ancient sites and Type 6 points. In addition, there was more overlap in the percentages of each triangular type represented in earlier Fort Ancient components than later components. However, these points cannot be used to confirm a temporal component. Larger samples of points might provide some indications of the time of occupation, but they should not be used as the sole indicator of age.

We feel that we have demonstrated that the types do not adequately account for the full range of variation in Fort Ancient triangular points, and they do not *consistently* represent subperiods of Fort Ancient. The typology needs to be abandoned and replaced with a classification system based on *objective*, *mutually exclusive* attributes that can be recorded consistently by different analysts. We maintain that our original paper was an important first step towards achieving this goal.

Finally, we thank Pollack et al. (2012) for their critique of our original paper (Bradbury et al. 2011) as issues they raised enabled us to further refine our arguments. We hope that the analyses presented here will add to the understanding of variation in Fort Ancient points. We also look forward to future evaluations of the hypotheses presented here by others.

Table 6. Possible Structure of Examination of Triangular Point Variability.

Class	Component 1	Component 2	Component 3	Component 4	etc.
Incurvate base, incurvate blade, no serrations, flaring absent					
Incurvate base, incurvate blade, fine serrations, flaring absent					
Incurvate base, incurvate blade, coarse serrations, flaring absent					
Incurvate base, incurvate blade, fine serrations, flaring present					
Incurvate base, incurvate blade, coarse serrations, flaring present					
Incurvate base, incurvate blade, no serrations, flaring present					
Excurvate base, incurvate blade, no serrations, flaring absent					
Excurvate base, incurvate blade, fine serrations, flaring absent					
Excurvate base, incurvate blade, coarse serrations, flaring absent					
Excurvate base, incurvate blade, coarse serrations, flaring present					
Excurvate base, incurvate blade, coarse serrations, flaring present					
Excurvate base, incurvate blade, no serrations, flaring present					
Straight base, incurvate blade, no serrations, flaring absent					
Straight base, incurvate blade, fine serrations, flaring absent					
Straight base, incurvate blade, coarse serrations, flaring absent					
Straight base, incurvate blade, coarse serrations, flaring present					
Straight base, incurvate blade, coarse serrations, flaring present					
Straight base, incurvate blade, no serrations, flaring present					
Incurvate base, excurvate blade, no serrations, flaring absent					
Incurvate base, excurvate blade, fine serrations, flaring absent					
Incurvate base, excurvate blade, coarse serrations, flaring absent					
Incurvate base, excurvate blade, coarse serrations, flaring present					
Incurvate base, excurvate blade, coarse serrations, flaring present					
Incurvate base, excurvate blade, no serrations, flaring present					
Etc.					

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