Traces of the Individual in Prehistory

Flintknappers and the Distribution of Projectile Points in the Eastern Tonto Basin, Arizona

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ABSTRACT

There is considerable and largely untapped potential in individual-scale research in the discipline of archaeology. Innovative methods described in this article were developed to identify the work of individual prehistoric flintknappers. Theoretically, the approach was informed by previous researchers' discussions of technological style and utilizes an individual- or nano-scale focus for that concept. New analytical methods were then used to investigate individual flintknappers' participation in the community organization of the prehistoric eastern Tonto Basin, Arizona. Specifically, small triangular stone projectile points (n = 149) collected from Roosevelt phase (A.D. 1275–1325) sites were analyzed to inform an assessment of the spatial distribution of individuals' handiwork in late prehistoric multi-site settlements. This research illustrates how improved individual-scale techniques may provide new insight on topics of considerable interest to archaeologists. For the Tonto Basin case, this project offers a new perspective on the integration of immigrants into local systems and the strength of community ties across natural barriers such as the Salt River during the Roosevelt phase.

En la disciplina arqueológica, la investigación dedicada al estudio del individuo es una escala en gran medida inexplorada, pero que goza de un potencial considerable. Los métodos innovadores, descritos en este artículo fueron desarrollados con el objetivo de identificar el trabajo individual de talladores prehistóricos. Desde un punto de vista teórico, esta aproximación tiene su base en las discusiones previas de investigadores acerca del estilo tecnológico que utilizan un enfoque individual o a nano-escala para estudiar ese concepto. Estos nuevos métodos analíticos se han utilizado para investigar la participación individual de los talladores en la organización de la comunidad prehistórica de la zona este de la Tonto Basin en Arizona. Específicamente, las pequeñas puntas de proyectil de forma triangular (n = 149) que se recolectaron en sitios de la fase Roosevelt (1275–1325 d.C.) fueron analizadas con el fin de estimar la distribución espacial de la producción de individuos en múltiples asentamientos prehistóricos tardíos. Esta investigación demuestra como la mejora de las técnicas a escala individual puede proveer una nueva visión en aquellos temas que sean de gran interés para los arqueólogos. En el caso de la Tonto Basin, este proyecto ofrece una nueva perspectiva sobre la integración de inmigrantes en los sistemas locales y sobre la fortaleza de los lazos comunitarios más allá de las barreras naturales, como el Río Salado, durante la fase Roosevelt.

Individual-scale analyses are a promising but underutilized approach to a better understanding of a variety of topics in archaeology, particularly for issues related to economic or political organization in prehistoric societies. However, basic methods for studying the material traces of individuals remain underdeveloped for many artifact classes. As archaeologists begin to adopt techniques for identifying the work of individual craftsmen, analytical methods must be adapted to apply individual-scale data to topics of broader interest in the discipline. The innovative methods described in this article build on earlier projectile point analyses (e.g., Whittaker 1987) to demonstrate that the handiwork of individuals—real or analytical—may be recognizable in noisy, real-world archaeological contexts. Importantly, that data can be fruitfully interpreted in the context of interesting and relevant research questions.

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An example research project was undertaken to investigate the span and structure of community organization in the eastern Tonto Basin in central Arizona (Figure 1) through the study of the spatial distribution of individuals' points within an ancient community. Data informing the assessment included nearly 150 stone projectile points crafted by flintknappers during the Roosevelt phase (ca. A.D. 1275–1325). The points were recovered by the Roosevelt Community Development Study (Desert Archaeology, Inc.) and the Roosevelt Platform Mound Study (Arizona State University, Office of Cultural Resource Management) excavations, known collectively as the Roosevelt Projects. Previous Tonto Basin studies (e.g., Simon and Jacobs 2000) and others from around the Southwest United States (e.g., Adovasio and Gunn 1975; Crown 2007; Hill 1974; Huse 1976; Plog 1974; Van Keuren 1994a, 1994b, 1999) have studied associations among settlements and suggested that the individual scale should be useful for addressing a variety of questions about prehistoric communities. But to date none have employed evidence from lithic tools. The results of this research provided a unique glimpse into the arrangement of a prehistoric community. Furthermore, this project contributed to methods and scholarship of "the individual in prehistory" and studies of communities of practice and technology (Aldana et al. 2003; Hodder 2000; Knapp and van Dommelen 2008).

ARCHAEOLOGY OF THE INDIVIDUAL

Systematically identifying the handiwork of an individual artisan in prehistoric and historic contexts is not easy (Nassaney and Brandao 2009; White 2009). In the process of manufacture, an individual makes decisions and performs gestures that contribute to the final form of the object and to the range of variation expressed by the larger class (Aldana et al. 2003; Crown 2007; Huse 1976; Schneider and Fisk 1983). An analogy is modern handwriting: an individual's handwriting typically conforms to certain basic rules of composition and style, but is at the same time distinct from that of others (Aldana et al. 2003). According to Whittaker (1987), repetitive activities lead individuals toward consistency in these gestures through time (see also Gunn 1972, 1977; Van Keuren 1999).

Other researchers have defined the concept of technological style, or "a way of doing things" (Hegmon 1998; Hegmon et al. 2000; Lechtman 1977; Lemonnier 1993). Authors exploring technological styles in archaeological contexts have emphasized traditions at the group or community scale (e.g., Dietler and Herbich's [1989] concept of "micro-styles"). The current project is aimed at exploring an individual- or nano-scale technological style: patterned traces that emerge from the manufacture of an artifact through conscious or unconscious decisions and gestures of the craftsperson (Aldana et al. 2003). In flintknapping, the exact position of the artifact in the knapper's hand and the directions in which force is applied may be quite specific to the individual. Resulting patterns of flake scars therefore comprise a kind of signature, as demonstrated by experimental flintknapping projects in the 1970s and 1980s (Gunn 1977; Whittaker 1987) and replicated on a smaller scale in the author's own earlier study (Watts 2001).

This body of experimental work (Gunn 1977; Whittaker 1987) suggests that the morphology of scars produced by pressure flaking is less subject to conscious control and variation on the part of the knapper than other formal characteristics such as outline or notch placement. In seeking to recognize the signatures of artisans crafting these objects, this project focused on systematically documenting and summarizing the morphology of such flake scars. Nonetheless, flintknapping is fraught with potential error, and even the most experienced knappers are confronted with correcting minor mistakes or flaws in raw materials, and these hazards impact the consistency with which these signatures can be applied to projectile points (Aldana et al. 2003). In previous studies, particularly by John Whittaker (1984, 1987) during his work with experimental and Grasshopper Pueblo projectile points, it was recognized that relatively simple averages of angle measures could identify individual knappers—at least in limited contexts. The methods described below are broadly consistent with those earlier efforts but rely on more sophisticated and accurate measures of flake scar patterns, made possible by image analysis of the artifacts.

The emphasis of the research project described in this article was not experimental. Because the methods described below have not been systematically tested on a large collection of modern knappers' points, a complementary effort is currently being undertaken to more accurately assess the precision with which these methods sort the work of many individuals. While the experimental effort will contribute to establishing how far these methods may be reasonably extended in archaeological research, there nonetheless will remain some question as to how validly any experiments model prehistoric behavior. Importantly, because of these uncertainties and limitations, the emphasis of the results discussed below shifts away from actual individuals and moves instead to analytical individuals associated with nano-scale technological styles (Redman 1977).

PROJECTILE POINTS AND FLINTKNAPPERS IN THE PREHISTORIC TONTO BASIN

In the early 1990s, the Roosevelt Projects unearthed millions of artifacts, including a large number of projectile points. These points were bifacially worked, typically triangular and small, and stylistically consistent with types seen across much of the Southwest during the thirteenth and fourteenth centuries A.D. Presumably, these artifacts were arrow tips used by the Tonto Basin residents primarily for hunting and warfare related activities (Loendorf 2010; Sliva 1997). Previous analyses of these projectile points focused on their macro-morphology and the raw materials used in making them. Approaches to analyzing these artifacts have emphasized their classification according to a taxonomy derived mostly from artifact outline (Lindeman 1995), or alternately an attribute-based analysis of formal and morphological characteristics (Rice 1994). The current project instead focused on small-scale characteristics of the projectile points related to individual variation in the production process (Gunn 1972, 1977; Hill and Gunn 1977; Whittaker 1987).

Stone tips are a small, relatively inexpensive portion of bow and arrow technology, not typically intended for use in the exact location where manufactured. Arrows and stone tips probably moved around a prehistoric community in a variety of ways: as gifts or exchange, through loss and recovery, and use as weap-

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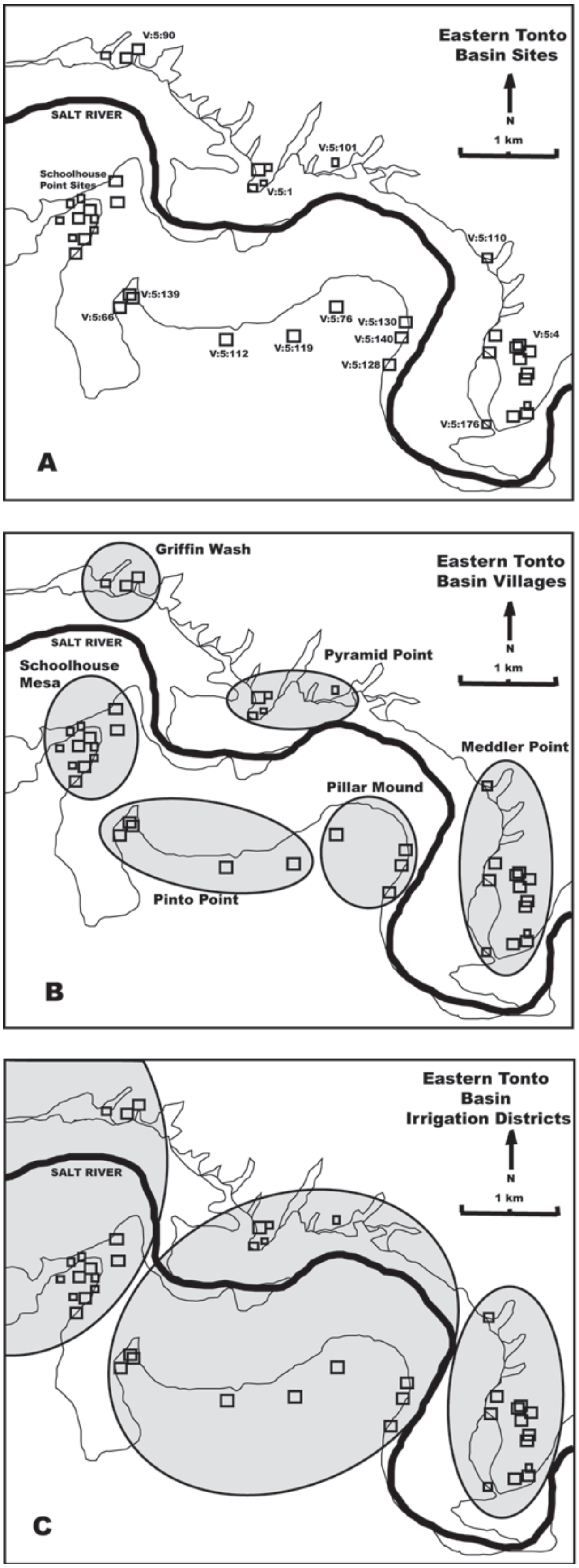

ons in hunting or conflict. It would be naïve to assume that every projectile point collected during the Roosevelt Projects was dropped in place by a prehistoric knapper, especially given their use as tips of arrows. But in the case of the small Tonto Basin communities, it is reasonable to suggest relatively few degrees of separation from the knapper to the discard of the projectile point. The knapper, a friend (enemy?), or family member may have transported a point some distance before discarding it. Minimally, the spatial distribution of an analytical individual's projectile points indicates a relationship or interaction, even if indirect, between the artifacts and the person who made them.

Individual-scale data are relevant to understanding how the multi-site community of the Roosevelt phase eastern Tonto Basin was organized. A specific research goal of the Roosevelt Projects was to investigate the social and political organization of communities associated with the construction of platform mounds in the Basin (see chapters in Dean 2000). Individual flintknappers were probably involved in the economic, political, and ritual organization of these communities at multiple levels (Simon and Jacobs 2000); circulation of their handiwork (arrows or tips) may serve as a proxy for the interconnectedness of these social networks at different spatial scales.

For the purposes of this project, it was assumed that the bulk of the Roosevelt phase eastern Tonto Basin residential compounds were occupied contemporaneously. There may be reasons to doubt this assumption (cf. Doelle 2000; Gregory 1995), but for the spatial and temporal scales of interest in this project, it was of minimal concern because individual artisans may have contributed projectile points to sequentially occupied sites in the area. Note that the residential compounds that make up most of the sites in this sample were probably occupied by a small number of households, and, even taken altogether, they do not represent a substantial population. For the Roosevelt phase sites north of the Salt River, Doelle (2000:87) estimated a total of 36 households and perhaps 216 people. The south side of the Salt River may have had a slightly larger population, but the scale was similar to the north.

The Roosevelt phase eastern Tonto Basin settlement system has been subdivided by archaeologists in several different ways. Three of these approaches are particularly relevant to the current project. All agree that organization in the eastern Tonto Basin involved multiple settlements, though the scale of units addressed varies according to researchers (important, though, is that a sense of fluidity and multi-level organization underlies all of them). Lindauer (2000) described a series of dispersed village-sized communities, each centered on a larger compound (usually with a platform mound) and several associated residential compounds (see also Simon and Jacobs 2000) (Figure 1b). Alternately, Wood (2000) identified three irrigation districts within the eastern Tonto Basin (Figure 1c). Finally, Elson et al. (2000) argued for what they refer to as the eastern Tonto Basin local system, essentially a large multi-site community encompassing all of the village-sized clusters defined by Lindauer (2000). An individual's emphasis on local, irrigation-district, or system-wide interactions would be relevant to questions about

FIGURE 1. (a) Roosevelt phase sites; (b) platform mound-centered village clusters; and (c) irrigation districts in the eastern Tonto Basin, Arizona.

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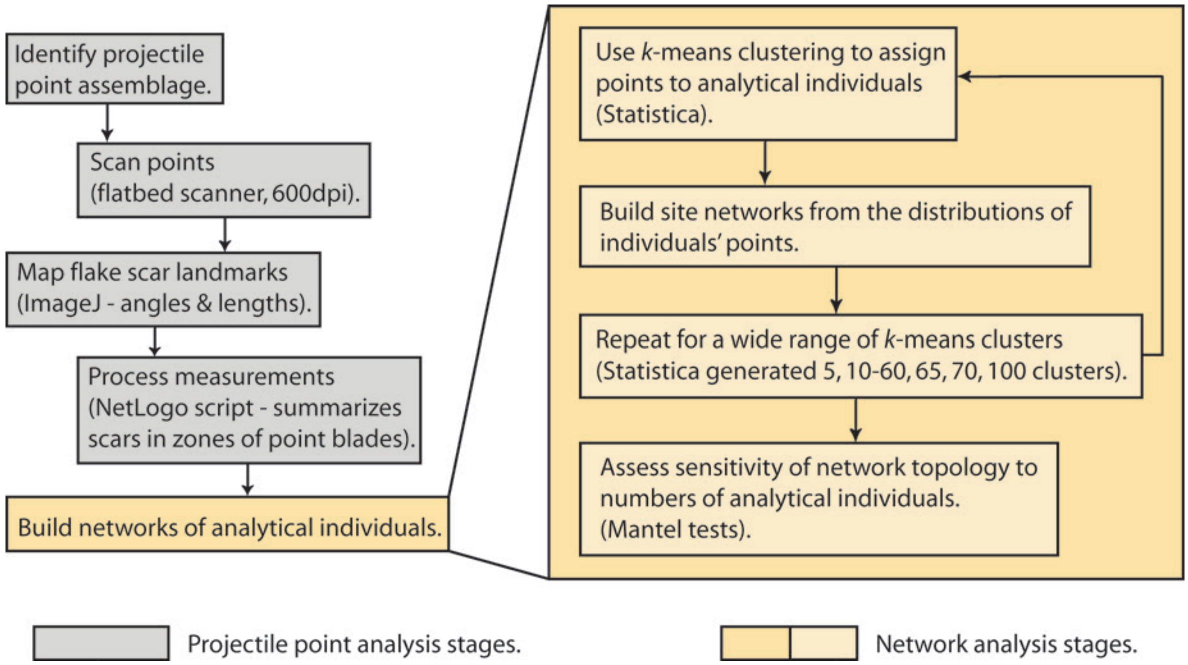

FIGURE 2. Workflow of projectile point analysis.

the scale or span of prehistoric social or political organization in the eastern Tonto Basin.

Methods

While generally straightforward, the process of finding, analyzing, and interpreting a relatively large collection of projectile points at the fine scale described in this article may be more easily explained when clearly broken down into its component stages. Those stages are described in detail in subsections below, and the overall workflow for the analysis is diagrammed in Figure 2.

Sample of Eastern Tonto Basin Projectile Points. All available projectile points from the Roosevelt Projects meeting a few basic criteria were included in the analysis. Intact, nearly complete, or broken but complete points from non-mortuary Roosevelt phase contexts were selected and analyzed. Early queries of the Archaeological Research Institute (ARI) databases suggested that nearly 350 projectile points in the collection met these criteria, but inspection of the points revealed that nearly 200 of these points were unsuitable for this analysis, mainly because 1) they were fragmentary but had not been coded as such, or 2) they were bifacially worked pieces, such as drill bits or large knives, rather than arrow tips. The points used in this analysis were typically 1.5–3 cm long and crafted from two broadly defined raw material types, with 62 percent cryptocrystalline silicates and 38 percent obsidian. Projectile point specimen numbers, contexts, and images of the points will be made available upon request. Full contextual information is available in the publications prepared by the Roosevelt Projects (Lindauer 1995, 1997; Elson et al. 1994). The sample comes from 24 recorded archaeological sites in the eastern Tonto Basin, though the Schoolhouse Mesa and Pinto Creek assemblages contributed a disproportionate number of points (Table 1).

The methods (described below) adopted for this research required a measurement or reasonably accurate estimate of the length of the projectile point and location of the tip and base. Projectile point fragments less than about 70 percent complete could not consistently be measured and analyzed, and so those cases were not included in the analysis. In some cases, where the tip of a triangular point was broken off, the length of the piece could be approximated from the taper of the blade and used in the analysis. A similarly shaped projectile point lacking a base could not be used. These important broken points would be a valuable addition to this analysis, as it is reasonable to hypothesize that these cases may represent more normal life histories than the still-useful intact pieces. Future modifications to these methods may allow for use of projectile point fragments.

Flake Scar Morphology on Projectile Points. In an effort to build on previous studies related to individual variation in flintknapping, much of the current project was devoted to developing an efficient and accurate program for measuring and summarizing characteristics of flake-scar patterning on a biface.[1] A home-office flatbed scanner was used to generate digital images of both faces of each lithic tool; details of flake scars were apparent at resolution settings of 600 dpi. The scanned images were imported into the ImageJ image analysis application (Rasband 2005) in order to map the scars and obtain the needed measurements. Formal characteristics such as maximum length and width were noted, but the focus of this effort was on recording major flake scars.

Spatial coordinates for each flake scar were collected using ImageJ by mouse-clicking four landmarks for every scar: the two ends of the long axis, and two ends of the perpendicular axis (Figure 3). As each scar was recorded, ImageJ generated a sequential list of coordinate *x-y* pairs. The smaller projectile points typically required approximately 200 *x-y* coordinates (100

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TABLE 1. Counts of Projectile Points Collected from Tonto Basin Sites.

Village Cluster	Number of Sites	Projectile Points
Pinto Point	4	57
Pillar/Livingston	3	6
Schoolhouse Mesa	11	56
Pyramid Point	2	7
Griffin Wash	1	9
Meddler Point	3	14
Totals	24	149

per face, representing 25 scars) to capture the spatial layout of flake scars on the face of the point, while larger specimens sometimes required over 400 coordinates. The effort required a moderate amount of time—approximately 10 to 20 minutes per projectile point.

Since the face of any given projectile point may have many flake scars (typically 15 to 40), it was necessary to develop a means of summarizing the scars captured with ImageJ in such a way that different projectile points could be compared. Following in the footsteps of numerous colleagues who have used automated computer methods to assist in organizing and summarizing large amounts of data, a NetLogo (Wilensky 1999) script was written to process the raw flake scar maps and transform them into data relevant to the signatures of individual flintknappers. The code used in this step, and other scripts from throughout the rest of the analysis, will be made available upon request.

The script first imported a text file with the coordinates of the relevant landmarks on the projectile point. Each side of the biface was loaded as a separate file, but the faces were shortly reunited by the software. The projectile point was aligned vertically, with the center of the base of the point located at the origin (middle of the display window) and the tip oriented toward the top of the screen. Rejoining of opposite faces followed a

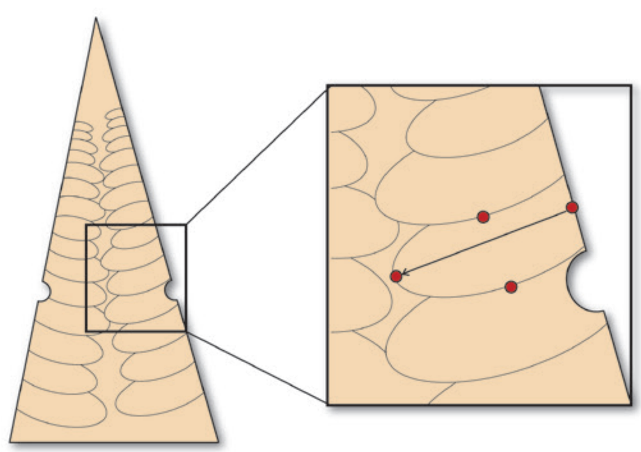

FIGURE 3. Flake scar landmarks recorded for this analysis.

routine that worked well for this collection of projectile points, but may not be applicable for all assemblages. Specifically, one face almost always had scars that were much longer than the opposite face. In most cases, this is fairly easily explained by observing the cross section of the point: flakes produced during pressure flaking "like" to travel on more convex surfaces and tend to run further compared to flatter surfaces (Andrefsky 1986, 1998; Whittaker 1994). Part of a knapper's signature includes the decisions made during the reduction sequence of a flake tool that should show slight but consistently different handling of faces depending on their convexity. For the purposes of this project, the script oriented the point so that the face with longer scars was oriented to the top of the screen. The face with shorter scars was rotated 180 degrees, with the tip at the bottom of the screen. Figure 4 provides a screen shot of this stage.

Once loaded and correctly oriented, the NetLogo script divided up the perimeter of the point into zones for measuring flake scar attributes. These zones corresponded to different areas of the blade (e.g., near the base, or near the tip) in a generally consistent manner for the small projectile points in the collection. As seen in Figure 5, the zones were defined by angles originating from the center of the base of the point. Near the base, a 30-degree arc defined that zone. Progressively smaller angles were used to define zones closer and closer to the tip. Specifically, another 30 degrees captured much of the midsection of the blade, 20 degrees captured an area just below the tip, and the last 10 degrees captured a zone right near the tip. This pattern of five zones was repeated for each quadrant.

Scars from each of the zones of the projectile point image were measured for length and heading (flake scar angle). Typically, on the small projectile points used for this research, between two and five scars were measured within each zone, often with relatively fewer near the base. As mentioned above, in most cases a total of 15 to 40 scars were measured for each face of the point. For each of the zones, the scar measurements for angle and length were averaged, offering a simple but meaningful summary of how flakes were removed from that portion of the blade. The NetLogo script saved the zone averages for angle length and width as a set of 20 variables for each projectile point in a delimited text file, resulting in a data table with each row representing one of the 149 points. These measures are the data that summarize the scar morphology on the faces of the projectile points, capturing the knappers' signatures.

Identifying Tonto Basin Knappers and Social Networks. An important aspect of this study was transforming projectile point data from 24 archaeological sites in the eastern Tonto Basin into social networks that revealed patterns of community organization. The basic approach to building those social networks may be best illustrated in an example. If a single knapper contributed six points to the collection used here, each found on a different site, that would provide evidence of links between those concrete spatial locations. Overlaying the networks from multiple analytical individuals would indicate which sites shared more connections—and perhaps illustrate patterns in the scale and organization of interactions between sites, villages, or irrigation districts in the project area. The following paragraphs describe in detail the methods used to convert measurements from projectile points to knapper social networks in the Basin.

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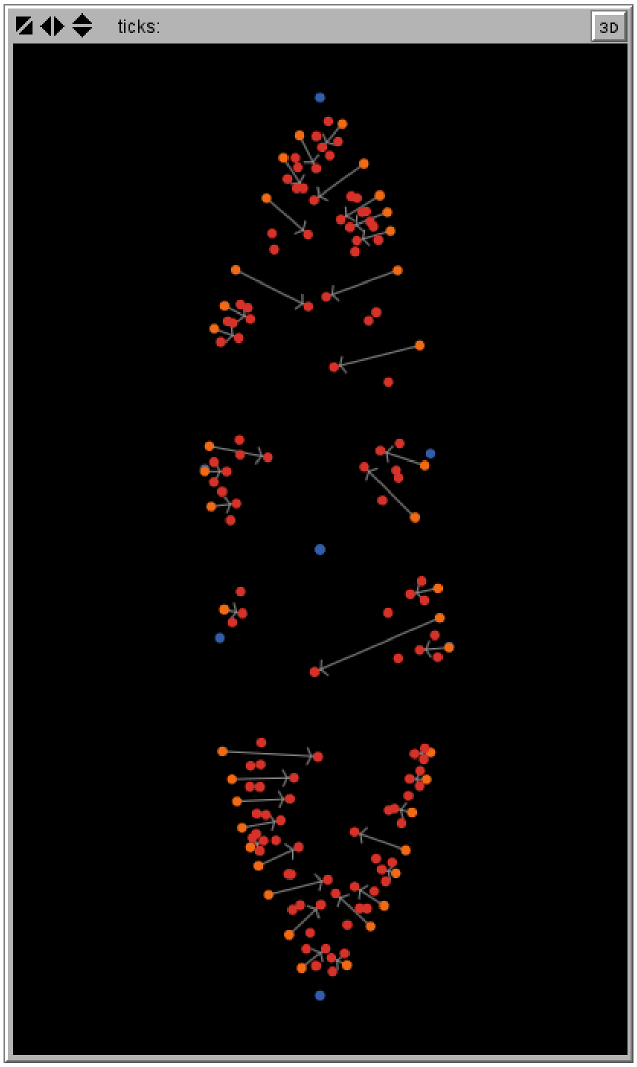

FIGURE 4. Screen shot of NetLogo window showing the complete projectile point.

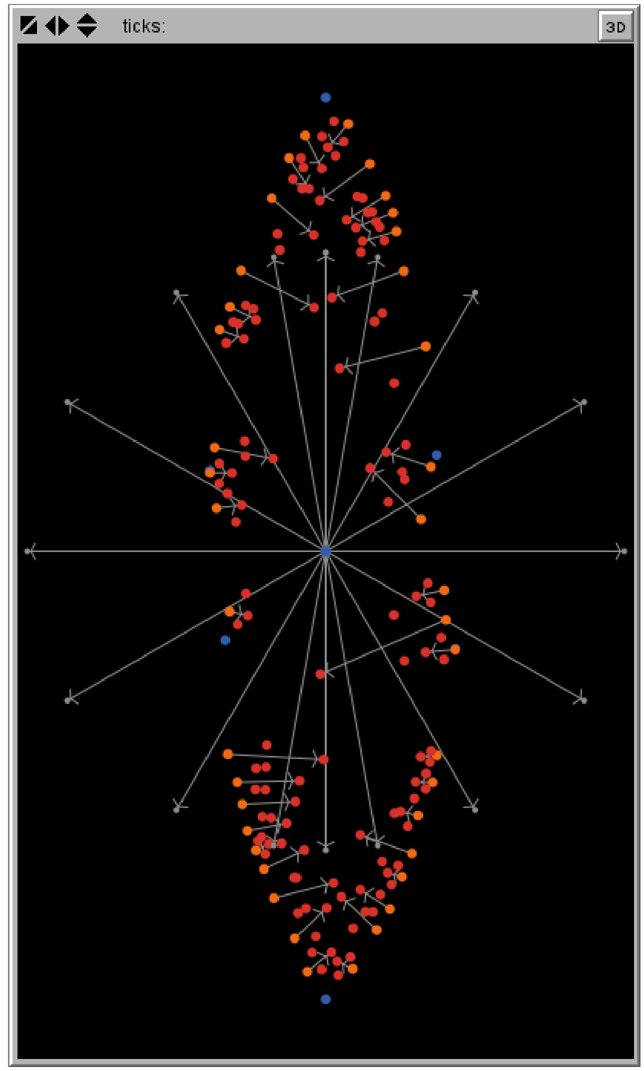

FIGURE 5. Screen shot of NetLogo window showing scar recording zones.

After summarizing flake scar morphology for each projectile point, the next phase of the project was to take the projectile points and assign them to an analytical individual—but not, strictly speaking, an actual individual. While knapping an arrow point is the result of dozens of gestures that in some fashion may be unique to the maker, there are many things that can go awry during the process, and there only so many ways to knap a 2-cm triangular point. It would have been irresponsible in this context to subject the 149 projectile points to a hierarchical cluster analysis; hierarchical methods would have formed clusters, but determination of a clustering distance would have been arbitrary. The focus of this research was instead to determine whether the number of knappers represented in the collection, whether 10 or 50, significantly affected an assessment of the topology and span of social networks in the eastern Tonto Basin. In other words, the number of craftspersons potentially represented in the collection of points was used as a parameter and varied to assess its influence on social and political networks. The emphasis on the analytical individual (or nano-style), as opposed to actual individuals, is broadly consistent with other attempts by archaeologists struggling with fine-scale research topics like the example described here (e.g., Redman 1977).

To further explain, if we assume that there were 30 knappers (i.e., one knapper per 2 to 3 households in the system, given population estimates in Doelle 2000) who contributed sets of projectile points to the collection, with an average of 5 points each, the distribution of points would be an indicator of which sites were more strongly connected. If a similar analysis with an assumption of 20 or 40 knappers were to show significantly different social networks—indicating a high degree of sensitivity to the specific number of knappers— it would suggest that perhaps this method would be of limited use for assessing the scale and structure of networks in the eastern Tonto Basin. However, if the networks generated by different counts of knappers were relatively similar, there would be greater confidence that the method does offer some insight into prehistoric community organization.

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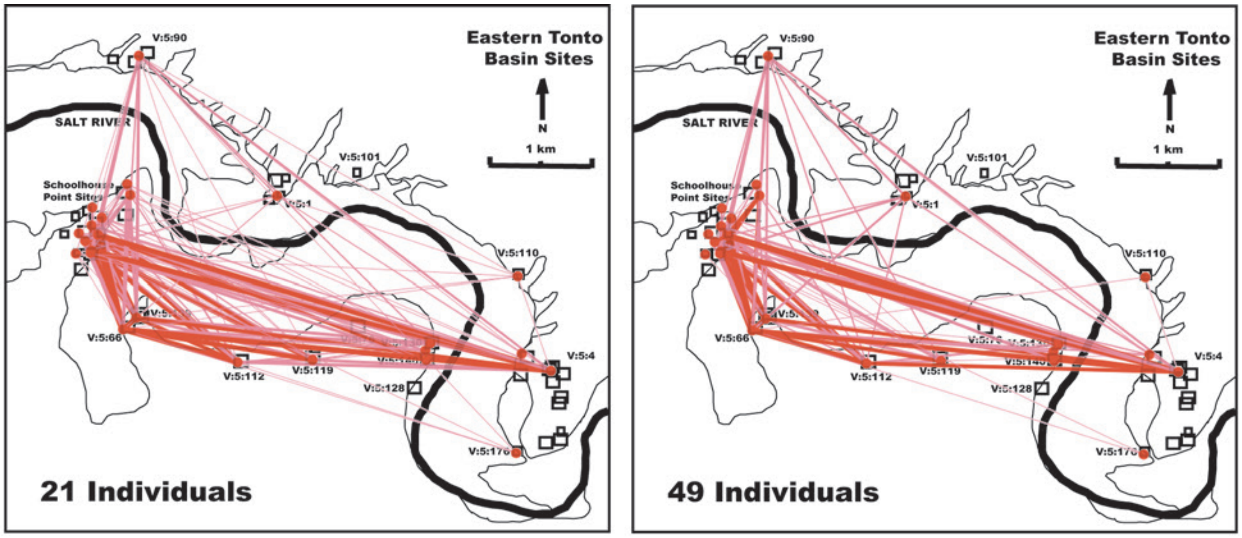

Figure 6. Eastern Tonto Basin networks for 21 and 49 clusters.

The flake scar data from the 149 projectile points were imported into Statistica (StatSoft, Inc. 2001) and subjected to non-hierarchical *k*-means cluster analysis (Bishop 1995) for a wide range of possible numbers of individual knappers. To demonstrate how the *k*-means analysis proceeded, first a specific number of analytical individuals was selected (e.g., 30 knappers), and the 149 projectile points were sorted by the *k*-means analysis into that predetermined number of clusters. A second NetLogo script used the *k*-means cluster assignments to define networks linking the 24 archaeological sites. The script first established a geographically accurate plot of site locations in the eastern Tonto Basin (adapted from published figures in Elson et al. 2000 and Lindauer 2000) and specified those locations as nodes for the networks. Next, the script interpreted a single knapper's *k*-means cluster of projectile points as a network, linking sites where points assigned to that analytical individual were collected. The remaining knappers' networks (e.g., the other 29) were also added to the graph. Sites with many links effectively had stronger overall connections. The strength of the link between sites was documented so that runs with few *k*-means clusters (i.e., analytical individuals) could then be compared to runs with many clusters. The networks generated were represented graphically, with the strength of the connection indicated by the thickness of the link between the two sites and links representing more than 20 connections shown in darker red (Figure 6).

The process described above was repeated for a large range of possible and reasonable values for the number of flintknappers that may have been active in the eastern Tonto Basin. The range of values is provided in Table 2. While observing the structure of the networks across this range provided a general sense of how the number of analytical individuals affected patterns of interaction in the eastern Tonto Basin, it was necessary to summarize the results of this process. A sample of the *k*-means runs was subject to further statistical analysis to assess whether knapper networks with fewer individuals were structurally similar or different from networks with larger numbers of individuals represented in the sample of projectile points. The sampled runs are listed in the second column of Table 2. The networks for the seven *k*-means runs were summarized and exported as 24-by-24 half-matrices for statistical analysis, with each matrix cell representing the strength of the connection between two sites.

Mantel tests were used to compare each of the seven sample networks to the other six, the outcome of which was conveniently summarized in a 7-by-7 half-matrix (Magurran 2004; Mantel 1967; Rosenberg and Anderson 2011; Sokal and Rohlf 1995). The Mantel correlation may be interpreted in the same way as any product-moment correlation coefficient: values close to 1.0 indicate a strong linear dependence between corresponding cells in the two compared network matrices. Values in Table 3 suggest that, for the most part, these networks were structurally quite similar across a relatively wide range of cluster counts. Only at the highest level (100 clusters) do the network correlations show a striking difference compared to the lower counts.

TABLE 2. Sampled *k*-means Cluster Counts That Were Statistically Evaluated.

Tested Numbers of Clusters	Sampled *k*-means Run in Range[a]
5	5
10–19	18
20–29	21
30–39	34
40–49	45
50–59	54
60	-
65	-
70	-
100	100

a. Sampling scheme explained in endnote 2.

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TABLE 3. Half-Matrix of Mantel Correlations.

	Networks Generated from the Shown Number of Clusters						
	5	18	21	34	45	54	100
5	-	-	-	-	-	-	-
18	.94293	-	-	-	-	-	-
21	.93146	.93855	-	-	-	-	-
34	.80772	.84947	.85514	-	-	-	-
45	.81902	.83905	.83713	.85572	-	-	-
54	.70134	.73054	.73699	.85635	.74014	-	-
100	.47588	.48569	.51239	.57608	.59873	.61891	-

Results

Once the 149 projectile points were sorted into the clusters of points attributed to analytical individuals, the results were used to inform an interpretation of the social networks of the knappers in the eastern Tonto Basin. The overall patterns of social networks and the structure of community interactions were surprisingly consistent regardless of the exact number of knappers represented in the collection.

Three clear patterns emerged from the knapper network analysis. The first was a consistent pattern of strong east-west links connecting separate villages (see Figure 6). Strong connections between relatively close neighbors on the south side of the river were not surprising, but the strength of connections between Schoolhouse Mesa and Meddler Point was an important result crosscutting the platform mound village and irrigation district scales (Lindauer 2000; Wood 2000). Secondly, connections on the north side of the river were generally sparse compared to the south side. This may partly be a function of fewer points collected from the north side and of the lower relative density of sites on that side of the river (depending on how sites are defined). The third pattern was somewhat more sensitive to the number of knappers. In several of the *k*-means runs, the Griffin Wash site (AZ V:5:90 [ASM]) was notably isolated from other sites in the system (see Figure 6). This was an interesting result, though not entirely unexpected, because that site has been identified by previous researchers as a probable site-unit intrusion of Puebloan immigrants from outside the basin (Clark 2001). These results are consistent with an interpretation that those immigrants were perhaps less integrated into the workings of the local system.

After all the clusters had been assigned by the methods outlined above, the original scanned projectile point images were reviewed to see if sets of points assigned to analytical individuals were intuitively satisfying (a sample group is shown in Figure 7). Observing raw material and projectile point outlines suggested that very few knappers strictly limited their options for raw materials in this sample. Many of the clusters had a high proportion of white cryptocrystalline silicates, mostly from a local source known as Windy Hill chert (Loendorf and Rice 2004; Rice 1994; Lindeman 1995). A minority of clusters had higher proportions of obsidian compared to other raw materials. The clusters often included projectile points of one or two morphological styles (see Figure 7) (cf. Loendorf 2010, different point types probably had different functions). The observed clusters indicate that it is likely that points knapped by an individual craftsperson crosscut traditional morphological characteristics. Clusters often showed impressive internal consistency in the shape of the points' bases, even though the measures employed in this approach specifically do not take into account the treatment of the projectile point base.

Discussion

Interpreting Knapper Social Networks. This research provided an opportunity for exploring the spatial structure of knapper interactions in their broader community. An important observation is that both the village and irrigation district organizational scales showed a pattern of knappers' projectile points frequently crossing unit boundaries. In short, the present results are consistent with an interpretation that the organizational scale relevant to most knappers in the eastern Tonto Basin was probably larger than the irrigation district.

The largest scale discussed in this research, the eastern Tonto Basin local system, does appear to have considerable relevance to the knappers within the community. Individual knappers probably participated in activities at all the major sites and many of the smaller sites in the local system. Even sites where relatively few projectile points were recovered during excavations appear to have maintained ties with other, sometimes spatially distant, sites in the eastern Tonto Basin. The major village centers at Meddler Point, Pyramid Point, Griffin Wash, Schoolhouse Mesa, and Pinto Creek Point were all interconnected (see Figure 6) to a greater or lesser extent. An interesting exception is the Livingston (Pillar) mound (AZ V:5:76 [ASM]), an unusually sparse site from which very few points were collected (and none used in this analysis), despite its thorough excavation.

The Salt River does not appear to have significantly impeded the integration of knappers from either side of that natural barrier. Strong ties between Meddler Point and several sites on opposite sides of the Salt River were observed, regardless of the exact number of individual knappers represented in the collection (see Figure 6). Likewise, lesser natural impediments, such as Pinto Creek, appear to have been easily negotiated by the Tonto Basin knappers, as shown by the density of links typically maintained between the Pinto Point and Schoolhouse Mesa sites.

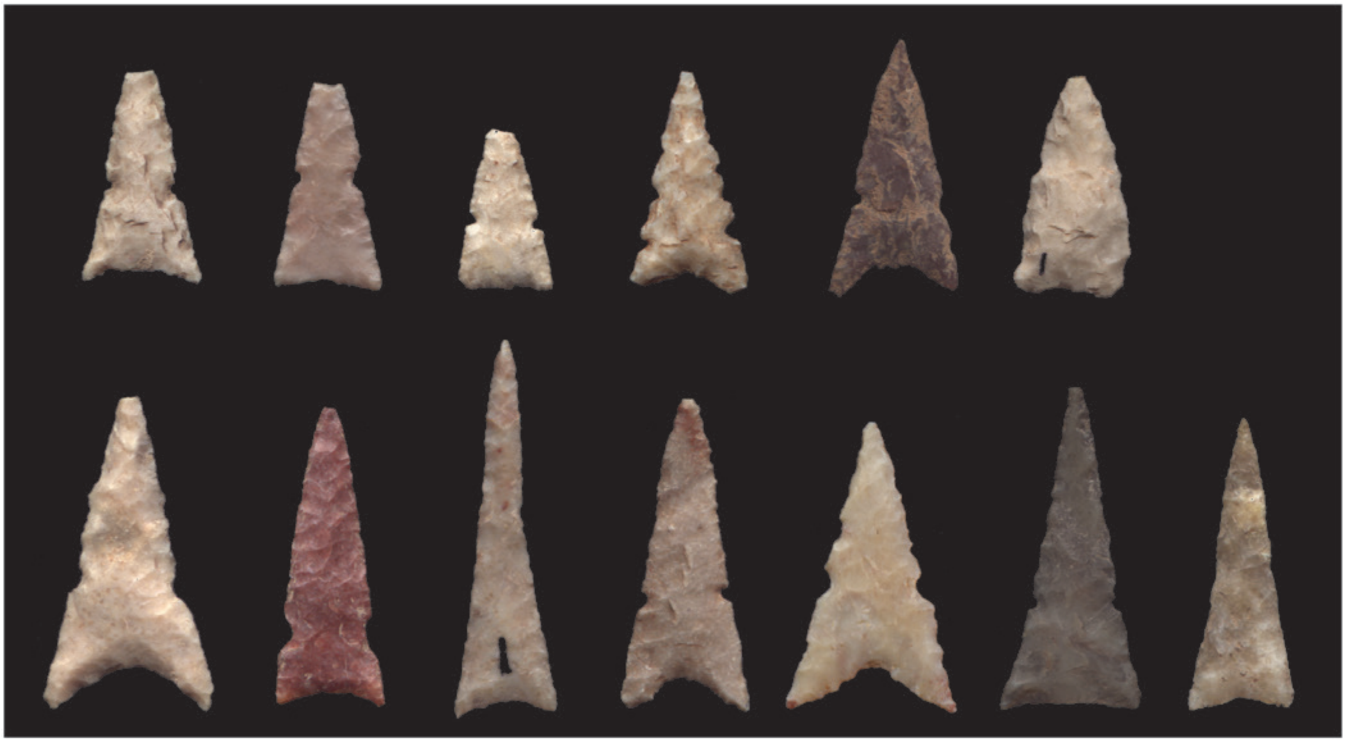

FIGURE 7. Projectile points included in cluster 4 of the 21 cluster run.

Cultural barriers may have impacted participation of knappers in the social network to a more significant degree. The hypothesized Puebloan immigrant intrusions (Clark 2001; Lindauer 1997) at Griffin Wash and one of the smaller sites at Schoolhouse Mesa (AZ U:8:454 [ASM]) were included in the network—but generally those ties were relatively weak. The results are consistent with an interpretation that immigrants were incorporated into the local system, but never so fully integrated into the community as residents of the local settlements. Interestingly, in almost no cases were there links recognized directly between these immigrant enclaves. A third possible immigrant intrusion, AZ V:5:128 (ASM), unfortunately did not have any projectile points that met the requirements for inclusion this project. Overall, these findings tentatively suggest that individual knappers participated at a variety of organizational scales in the eastern Tonto Basin, integrating villages on opposite sides of the Salt River into a tight-knit social network. These data are consistent with the hypothesis that a relatively large organizational scale such as the local system provided the context in which knappers' projectile points moved around the community.

The Individual in Prehistory. Tonto Basin flintknappers, similar to knappers throughout the Southwest, crafted projectile points for a variety of purposes (Hoffman 1997; Loendorf 2010; Sliva 1997). The collections analyzed for this project were overwhelmingly dominated by utilitarian points most likely used, or intended for use, as tips of arrows for hunting or warfare. An important observation was that many individuals were probably not crafting only one style of point, nor were they necessarily limiting themselves to only one raw material type. That is broadly consistent with Loendorf's (2010) suggestion that Hohokam points were designed differently for hunting and warfare; individuals may have produced differently styled points because, in this case, the styles had specific functions.

These results suggest that traditional stylistic analyses may recognize differences in collections that are not by themselves good measures of cultural or social phenomena often of interest to the researcher (cf. Hoffman 1985; Sackett 1982; Weissner 1983). Individuals may have worked with multiple styles for any number of different reasons, including function (per Loendorf 2010), haste, material type, change in skills or preferences through time, or simply whimsy. A more sophisticated interpretation of traditional stylistic analyses, informed by individual-scale research, has potential to contribute much to the topic of crafting in prehistoric cultures (cf. Costin 1991; Nelson 1997). Analyses of projectile points could be bolstered considerably by a more nuanced understanding of how individual craftspersons work within, and crosscut, stylistic boundaries.

CONCLUSIONS

This article describes methods for identifying the handiwork of individual craftsmen that could be widely adopted by lithic analysts working with assemblages where individual-scale data may be particularly relevant to their research questions (see Figure 2). Importantly, these methods can be employed by many analysts with relatively little investment in new equipment or training. These methods should be broadly applicable beyond the presented case study. Readers interested in learning more are encouraged to contact the author; NetLogo code and detailed instructions for using the software will be provided upon request.

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Many archaeologists are unaccustomed to working at the scale of the individual craftsperson, but that scale is of considerable importance in many current theoretical approaches. Those philosophies subsumed under the "agency" or "practice theory" headings immediately come to mind (Hodder 2000; Dietler and Herbich 1998; Dobres and Hoffman 1994; Pauketat 2001). Other schools of thought, including Darwinian theory (Human Behavioral Ecology), also assume the importance of individuals in the past (Winterhalder and Smith 2000; Shennan 2002; Snow 2002). Nano-scale technological styles allow us to begin seeing traces of individuals moving around in their communities—a topic quite relevant to ethnoarchaeological concerns of much processual and nearly all postprocessual archaeologies (Kelly and Thomas 2010). The approach adopted for the present research provides data highly relevant to a rarely realized "ethnography of the past" (cf. Nettle 1997; Gillespie 2001; Knapp and van Dommelen 2008).

Application of this approach to the Roosevelt Project collections provided an opportunity to investigate the individual in prehistory and, specifically, artisans' participation in social networks and political organizations. The flintknappers that crafted the arrow points used for this analysis were actors playing out their social and political roles in a dynamic setting. They participated in a community that incorporated immigrants from other regions of the Southwest and saw the emergence of (and probably helped build) new integrative facilities such as platform mounds. While this project avoided the tempting but treacherous pitfall of assigning projectile points to specific individual flintknappers, it did measure signatures that revealed traces of prehistoric individuals' behaviors in a way rarely managed in archaeology. ■

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Notes

1. Several of the described procedures were developed by Gerardo Aldana, Ian Robertson, and the author as part of an analysis of large obsidian bifaces from Teotihuacán (Aldana et al. 2003). However, analysis of knapper signatures on small arrow points required emphasis of different measurements and statistics than were effective for the Teotihuacán collection—this was related to the large difference in blade length between the point styles, typically around 2 cm for the Tonto Basin points and over 7 cm for the Teotihuacán bifaces. The script coded for the current project was a distant cousin of a Java-based application programmed for the Teotihuacán project called *LithicA* (Aldana et al. 2003).
2. The *k*-means analyses were explored to see which runs had a better overall fit with the dataset. Specifically, a *k*-means run with low average distances from group centroids suggested a relatively good fit for the defined number of clusters. To determine the best fitting counts of analytical individuals, the mean distance from cluster centroids for each of the *k*-means cluster runs between 10 and 60 clusters was calculated. A nonlinear regression of the data (log x) and a ranking of the residuals identified the numbers of clusters that were a relatively better fit for the collection of projectile points. Interestingly, in this case, the best fit was 21 analytical individuals, though several runs in the upper twenties and upper thirties were also very good fits with the data.

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