2018

# Geometric Morphometrics of Gary Dart Points from the Davy Crockett National Forest

David A. Foxe
*National Forests and Grasslands in Texas, United States Forest Service*, dafoxe@fs.fed.us

Robert Z. Selden Jr.
*Center for Regional Heritage Research, Stephen F. Austin State University*, zselden@sfasu.edu

Juanita D. Garcia
*National Forests and Grasslands in Texas, United States Forest Service*, jdgarcia@fs.fed.us

# United States Forest Service

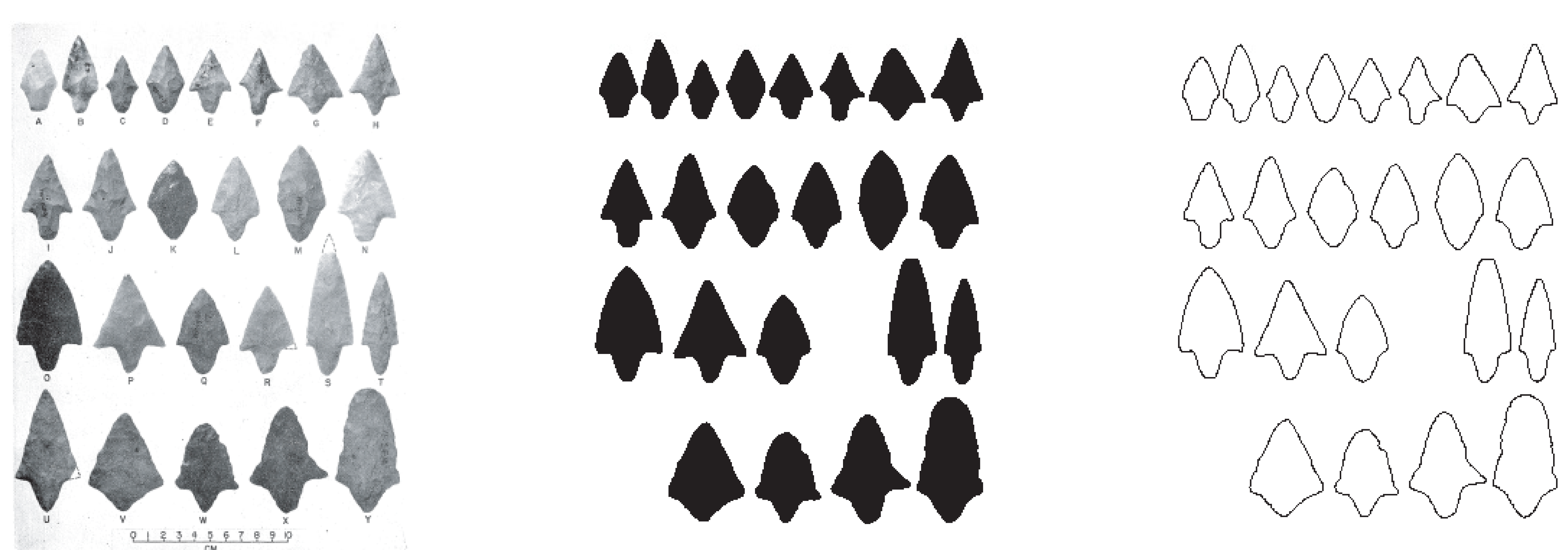
## National Forests and Grasslands in Texas

David A. Foxe; Robert Z. Selden, Jr.; and Juanita D. Garcia

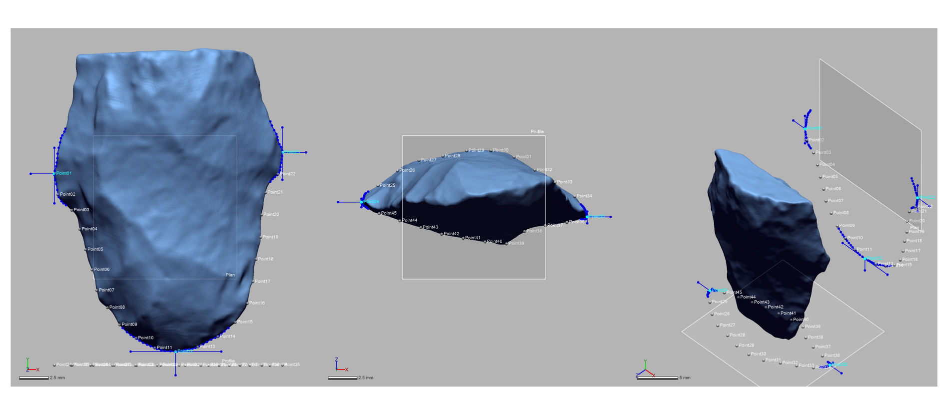
# Geometric Morphometrics of Gary Dart Points from the Davy Crockett National Forest

This analysis represents ancillary findings from a larger research project that remains focused upon better understanding the morphological variability associated with specific components for suites of diagnostic artifacts recovered from the National Forests and Grasslands in Texas (NFGT). While the methodological approach employed in this study is novel in several ways, it should be noted at the outset that geometric morphometrics (GM) is not new to archaeology, and has been used in material culture studies since the mid-1980s. The recent flourescence in GM applications to archaeological problems is largely a result of the Procrustes paradigm, as well as numerous theoretical and methodological advancements in paleontology and the biological sciences.

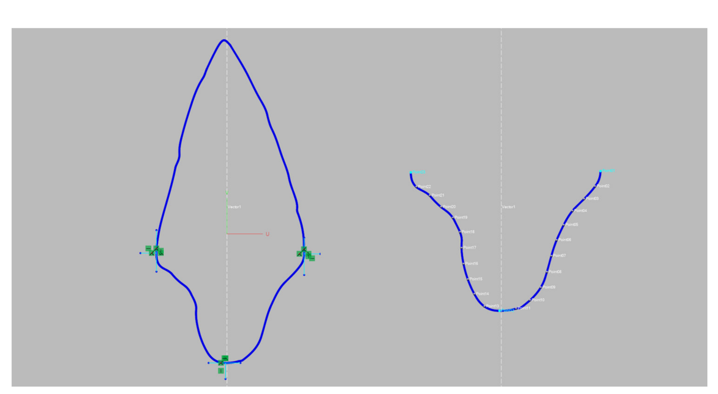
The initial challenge in this particular analysis was to devise a method in which three-dimensional (3D) and two-dimensional (2D) data could be used in the same analysis. The study required that the landmark and semilandmark configurations remain consistent across the entirety of the sample. An algorithm was created to translate the 2D specimens through a suite of pre-processing protocols that rendered a scaled and aligned model atop a planar surface within 3D space. The constellation of landmarks and semilandmarks relies upon reference geometry calculated in Geomagic Design X (Dx), where the landmarks associated with basal geometry are defined by three tangents (two vertical, one horizontal), with 10 equidistant semilandmarks between (below). Once populated, these data were exported and subjected to a generalized Procrustes analysis (GPA) (top center). Procrustes superimposition translates, scales, and rotates the coordinate data to allow for comparisons among objects. Principal components analysis (PCA) was used as an exploratory means of visualizing shape variation among the specimens (bottom center).




The algorithm scaled, aligned, and generated outlines for those specimens included in the type books. Any specimen that was missing a component of basal morphology was not included in this analysis. These outlines were imported to SolidWorks, where alignments were checked in advance of importing the outlines to Dx where reference geometry was calculated and the landmarks and equidistant semilandmarks were applied. Sliding adaptive semilandmarks were an initial consideration of this research design; however, they were abandoned following a recent study of Caddo bottles. Image of Gary points scanned from Suhm, Krieger, and Jelks (1954:Plate94); used with permission.

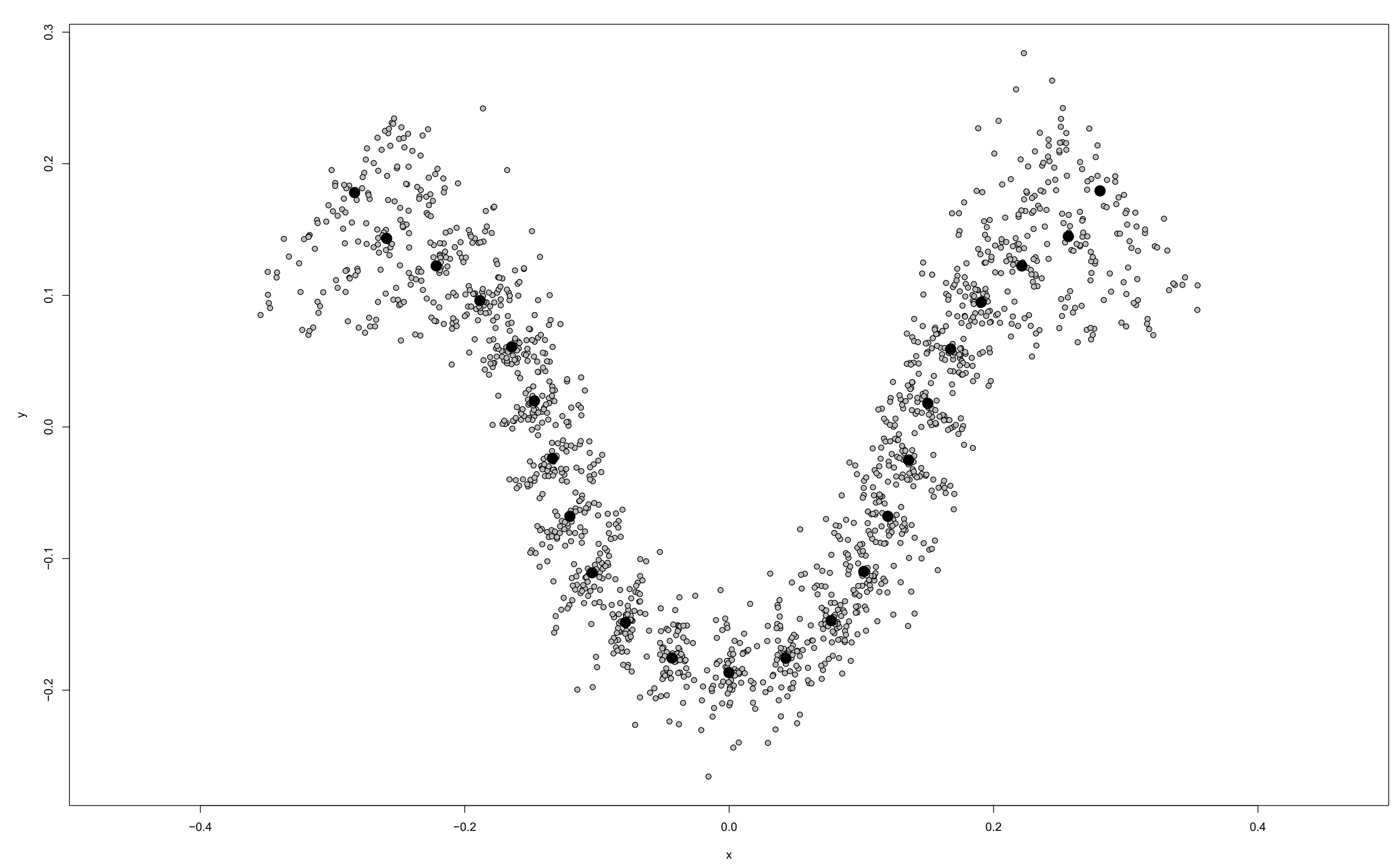


The 3D configuration of landmarks includes those landmarks included in this study, and a second configuration that will be used in a subsequent study of intra-Gary varaibility. Some of those studies include measures of thickness, which this configuration accomodates.

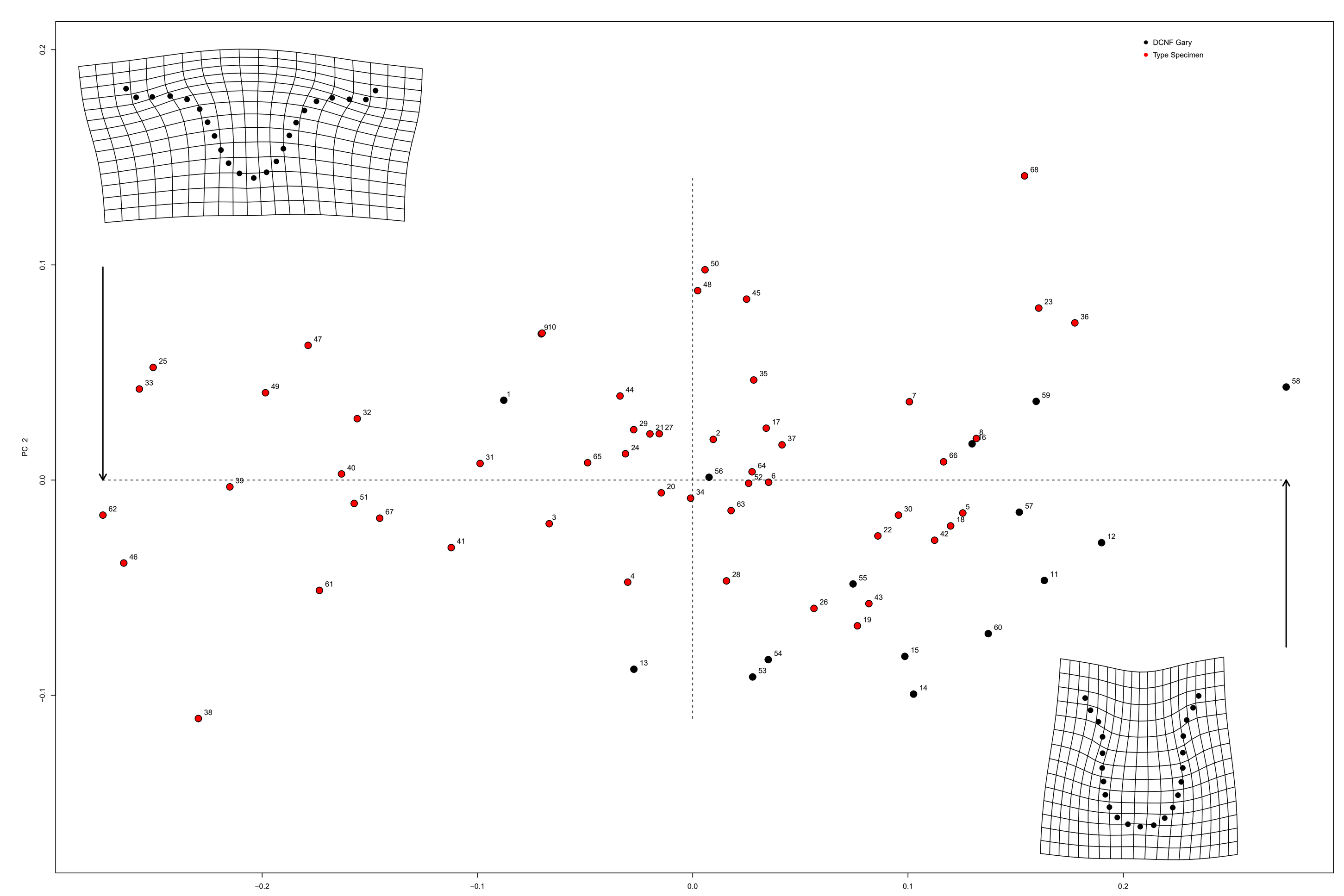


The 2D configuration is identical to the 3D configuration with the exception that width measures are not included due to the nature of the data.

*Three-dimensional scans of Gary dart points recovered from the Davy Crockett National Forest are employed in tests of basal morphology by site, size (allometry), and asymmetry. Variability in basal morphology for Gary points from sites on the Davy Crockett National Forest is presented and compared to specimens from the published type books. The hypothesis that Gary basal morphology differs between sites containing Woodland-era sand tempered ceramics and those where no sand tempered ceramics were recovered is then tested and the results discussed.*

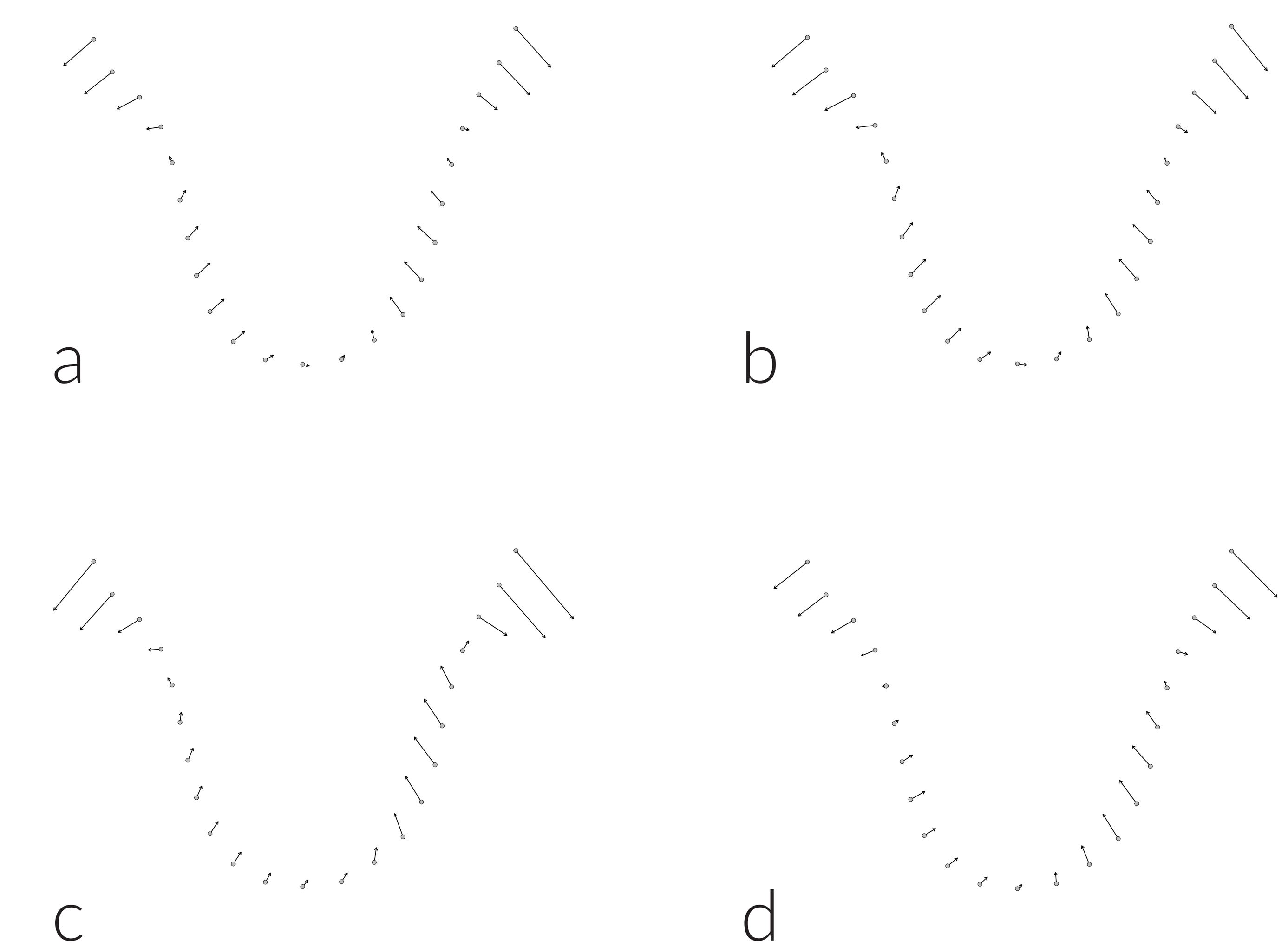


Results of generalized Procrustes analysis for the basal morphology of Gary dart points from the published type books, and the Davy Crockett National Forest. Mean consensus configuration shown in black; samples in gray.



Results of PCA summarizing shape variation in the Gary dart point sample. Red points represent type specimens, and black points represent those recovered from the Davy Crockett National Forest.

A Procrustes ANOVA was run to assess whether a significant difference exists between the type specimens and the sample from the Davy Crockett National Forest (DCNF). A residual randomization permutation procedure (RRPP; n=1000 permutations) was used for all Procrustes ANOVAs, which has higher statistical power and a greater ability to identify patterns in the data should they be present. Results indicate that there is a significant difference in basal morphology between the type specimens and those recovered from the DCNF (RRPP = 1000, Rsq = 0.19551, Pr(>F) = 0.002). This was followed by a Procrustes ANOVA with pairwise comparison to identify which of the type volumes differ significantly from the DCNF sample. Results indicate that the DCNF sample differs significantly from those specimens included in the Suhm, Krieger and Jelks (1954) (effect size = 5.010964, P-value = 0.001), Turner and Hester (1999) (effect size = 3.434841, P-value = 0.005), and Turner, Hester, and McReynolds (2011) (effect size = 3.200086, P-value = 0.007) volumes.




Comparison of mean consensus configurations for DCNF Gary points and the type books found to differ significantly; (a) DCNF Gary (gray) and all type volumes, (b) DCNF Gary (gray) and Suhm, Krieger, and Jelks (1954), (c) DCNF Gary (gray) and Turner and Hester (1999), (d) DCNF Gary (gray) and Turner, Hester, and McReynolds.

While some of the basal shapes vary significantly by site on the DCNF, recent finds are being added to this study, and will be reported at a later date. Significant allometry was found in that sample, and may aid in the refinement of resharpening trajectories that can be further explored using phenotypic trajectory analysis. Future directions include the addition of Gary samples from sites where the type was in use prior to the publication of the Suhm, Krieger, and Jelks (1954) volume. The high degree of variation in Gary morphology has been noted for some time; however, it has been difficult to characterize. These findings, while preliminary, highlight the utility of the GM approach to the analysis of the Gary type, where this robust and rigorous analytical toolkit is aimed at our taxonomic definitions and the construct of a morphological epistemology rather than an analysis of cultural implications.

*Acknowledgments. We would like to thank Dean Adams, Emma Sherratt, Michael Collyer, Michael Shott, Loren Davis, Stephen Lycett, and Mercedes Okumura for their useful comments and constructive criticisms throughout the development of this research design. Production of the GM analysis for the Gary dart points from the Davy Crockett National Forest was funded by a grant to RZS from the United States Forest Service.*