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# Projectile Point Analysis Using Photographic Records

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## Abstract

Private collections in the United States represent a substantial portion of the archaeological record, with these collections consisting predominantly of projectile points. Unfortunately, many of these collections are either not available for analysis, or the few photographs and images available do not contain high-resolution images from which most lithic analysis can be conducted. However, with the aid of simple photograph editing software, artifacts that would otherwise be overlooked for analysis can still provide useful information about the past. A small pilot-study of 178 projectile points have been analyzed to examine diachronic changes in Lithic Supply Zones of Upper Mercer chert across Ohio. The focus of this research is to both identify trends through time in projectile point use-life, and to demonstrate the techniques and methods applicable to images of projectile points which would otherwise be overlooked by researchers.

## Introduction

As Shott (2020) has emphasized, there are still many basic questions about projectile points that archaeologists struggle to answer. Part of this struggle stems from sampling, wherein most of the projectile points for research are in private collections (Shott 2008; Shott et al. 2018). Projects such as the Central Ohio Archaeological Digitization Survey, or the Paleoindian database of the Americas (PIDBA) are focused on documenting the distribution of projectile point types, among other research goals. In both these cases, standards were used for image quality for analytical purposes. Many hobbyists and projectile point collectors often do not use the same standards when documenting their finds. Hobbyists may not have access to high-resolution cameras. Sometimes projectile point photographs, when published either in print or online, have no scale, or perhaps a coin for scale. And in many cases, the provenience of projectile points when published by hobbyists and collectors is lacking. Likewise, the quality of the printed publication, or the quality of the photograph, can often be very poor for identification of raw material type, or even identifying flake scars. In all these instances, these projectile point images will be collectively referred to as “low-resolution.” However, these images of projectile points that are self-reported by the people that find them can still yield information about the past that would otherwise be overlooked by large data mining and aggregation projects. Individually, low resolution projectile points provide very minimal data to the archaeologist. But in the aggregate, these projectile points can supplement professional databases, or even form the basis of their own analyses.

When considering the utility of these low-resolution images for analysis, the kinds of attributes identified and measured on these projectile points must be inherently different from those of other professional databases with higher standards. However, with the use of digital measurement and geometric morphometric tools, such as TPSDig (Rohlf 2015), or Adobe Photoshop, these low-resolution images can still yield comparable data to other professionally aggregated databases such as COADS or PIDBA. Including low-resolution images from hobbyists, private collections, and auction websites has the potential to greatly increase the sample size of projectile points in North American archaeological research.

A pilot study of projectile points was conducted, using data previously compiled by Olson (2021). These data were compiled from auction websites, forums, old editions of *Ohio Archaeologist,* and other photographic open access records of projectile points. Olson's (2021) dataset consists of approximately 1,282 projectile points from across the state of Ohio. However, this dataset could be expanded to include even more projectile points using the methodology applied in this study. The goal of the current research is to examine the relationship between resharpening, and distance to raw material sources.

Seeman et al. (2020) utilized projectile point types and their spatial distribution by raw material sources to identify the "lithic supply zones," and thus the relative mobility of foraging peoples throughout the Archaic in relation to one another. Their study utilized county-level provenience and simple frequencies of projectile point types of raw material sources. Adding attributes that can identify the rates of resharpening and general use-life of projectile points may yield more nuanced information about mobility of foraging groups through time.

## Lithic Supply Zones

The concept of a "lithic supply zone" (LSZ) according to Seeman et al. (2020:115), and McCoy et al. (2010:174) is an area around a single raw material source, beyond which there is a drop-off in the frequency of that source. What this study proposes is a subset of the LSZ, the replacement range. Within the LSZ, there is some range at which foragers are close enough to the material source to replace an exhausted tool (Figure 1). This range, in theory, would represent the range of singular trips (which may be days or weeks) as opposed to multiple different trips (for seasonal or yearly ranges).

LSZs do not necessarily represent the maximum foraging ranges of past peoples. Rather they represent the limits beyond which it is more economical for foragers to utilize other raw material sources that are closer. Closer, in the diachronic sense, is a factor of the range of forager mobility. It is also possible that a tool may not reach exhaustion at the furthest point from a raw material source but at some point closer to the raw material source as foragers make their way back to the source of the raw material. In some cases, this may be at the raw material source itself or some distance from the source.

But how can this replacement range be evaluated in the archaeological record? Metric attributes such as length, width, thickness, and weight can all approximate overall size but do not accurately capture 3D morphology and in some cases cannot be recorded from photographs (e.g., weight). I address this problem using the following analogy. Projectile points are like wooden pencils. Both are reductive mediums, both have a "business end" that is involved with most of the use-life of the tool, and both have a "haft" element which is used to hold that utilized tip in place. The eraser casing, often metal, on a pencil does not change in size relative to the shortening in length of the pencil. The same is true of the half element of projectile points relative to the blade. Both have what is referred to in biology as "allometric scaling." Except, unlike biology, which studies the change in morphology of modules of anatomy over the course of growth and development, both pencils and stone tools must be studied in terms of their reduction and resharpening.

Metric attributes, in most cases where a photograph has a scale, can be captured with a plethora of digital applications (e.g., TPSDig, Adobe Photoshop, ImageJ). However, as Shott (2020: 248) notes, "dimensions are isolated attributes that lack geometric context within the whole…although simple ratios between them or ordination of sets of them can better approximate whole-object form." Ratios are a better approximation of morphological variation. As an added bonus, ratios do not require a scale. Ratios are based on the relationship of two variables, which can be in pixels just as effectively as they are in centimeters or inches.

Azevedo et al. (2014) noted that the blade length to stem length ratio (B/S ratio) is a very useful analytical unit for comparing the curation (also referred to as use-life) of projectile points. A "stem" is the general catch-all term used in some lithic analysis to refer to haft elements. Some archaeologists prefer to use the term "haft element" but this is the same concept. The area from which the shaft or handle of the tool is attached to the biface. Since the haft element, or stem, of projectile points is attached to the shaft of a dart, spear, or arrow, this module of a projectile point will receive little to no resharpening relative to the blade. The B/S ratio has been captured by other researchers as a simple proxy measure of the resharpening or use-life of projectile points (Nolan et al. 2022).

The ratio of maximum length to width (L/W ratio) represents an approximation of overall size of the projectile point. In an ideal world, with every artifact available for 3D scanning and geometric morphometric analysis, L/W ratios would be replaced with centroid size (a product of General Procrustes Analysis). But the pilot study here utilizes data as they are, not as they ideally could be. In general, projectile points are longer than they are wide in their earliest stages of use. Unlike blade-to-stem ratio, the L/W ratio is a generic size attribute, which can be applied when comparing different point types. This is because projectile points that begin their use-lives with very long blades relative to their stems would appear as outliers when sampled alongside projectile points that begin with relatively short blades.

In combination, these two indexes (B/S and L/W ratios) are a relatively simple measure of relative use-life of projectile points. When used in combination with spatial data, these data can be used to identify "drop-off" areas where B/S and L/W ratios are small compared to their nearest neighbors. This drop-off zone is the hypothetical "replacement range."

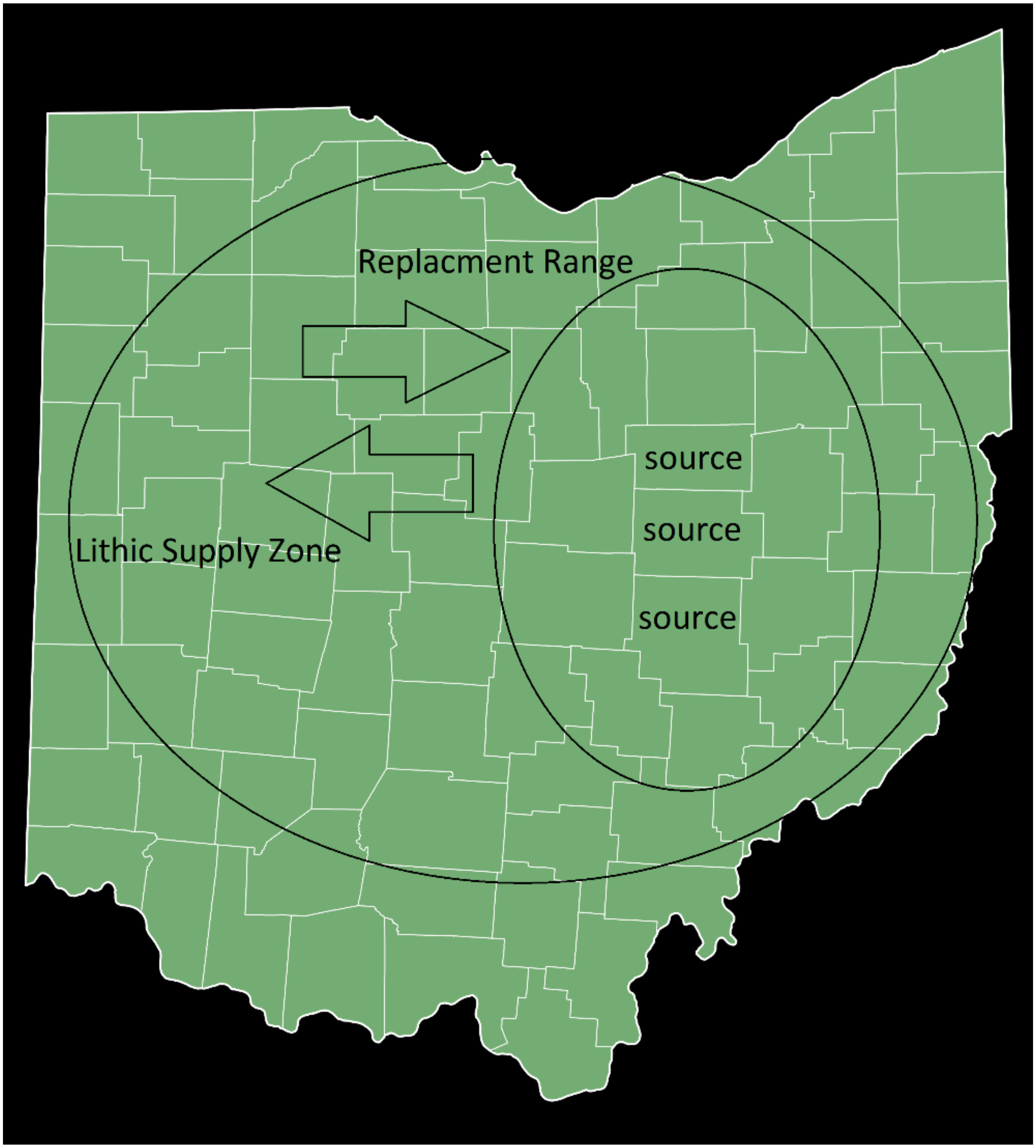


**Figure 1: A hypothetical lithic supply zone, and a replacement range for Upper Mercer chert.**

## Methodology

Though the projectile points are, for the purposes of this research, called "low-resolution," there are still minimum standards that must be met to be included in the analysis. Each projectile point should at the very least have county-level provenience, which both PIDBA and COADS require. Low-resolution projectile point photographs should also provide enough contrast to identify the outline of the projectile point in plan view. In other words, the image should have a high enough resolution that the projectile point, based solely on outline, could theoretically be assigned a diagnostic type (Figures 2 through 4). For the purposes of this research, the point typology of Olson et al. (2021) and COADS was used. This point typology lumps several morphologically and temporally similar types from Justice (1987) into 30 projectile point "clusters." These clusters are not identical to Justice's clusters, and instead favor more lumping of projectile point types than Justice (1987).

Modeling from the mobility study of Seeman et al. (2020), only a handful of projectile point clusters were selected which could yield large enough sample sizes for comparative purposes. These point clusters include Adena, bifurcates (which includes the types MacCorkle, and LeCroy), Brewerton (which includes corner, ear, and side notch varietals), Kirk, Lowe (which includes Chesser), Snyder, and Thebes. Paleoindian lanceolates were excluded from this analysis because, as Olson (2021) notes, they are overrepresented in collector reporting. In addition, low-resolution Paleoindian lanceolates are difficult to use to assess blade and stem elements. Late Woodland Jack's Reef and triangular points were also omitted due to low sample sizes, since collectors tend not to report these types. Additionally, in the case of triangular points, the identification of stems is difficult or even impossible even when the object is viewed with the naked eye, let alone a photograph.

Given the low quality of some of the images used for this study, the outlines are just clear enough to assign points to type clusters, but the scale may be absent or the image too fuzzy to landmark (Figures 2 and 3). Thus, rather than apply the rigorous methods of landmarking common to most geometric morphometric analysis (Buchanon et al. 2014; Azevedo et al. 2014), simple ratios of blade-to-stem and length-to-width were calculated by measuring lengths in TPSDig (Figure 5). Maximum width and length are straightforward enough to measure; however, calculation of the blade and stem lengths require differentiation of the haft element from the blade. The delineation of the stem and blade elements is identified using the same criteria as Nolan et al. (2022), that is, measurements are taken from a line running between the shoulders of the point. Note that this is not always the same as the maximum width of the projectile point, as illustrated in Figure 5. From this line dividing the stem and the blade, the distance to the tip represents the blade length, and the distance from this dividing line to the base is the stem length. For expediency, only the blade length was measured in TPSDig. After the fact, the haft length was calculated by subtracting the blade length from the maximum length.

For raw material sourcing, Upper Mercer was selected as the only source for analysis. This is primarily because Upper Mercer has a distinct color (dark black) that is rather easy to identify from photographs. The "varieties" of Upper Mercer, for the purposes of this research, are collectively lumped into the larger Geological category of "Upper Mercer," so there will be no distinctions of "Nellie," or "Coshocton black" in this study. These varieties are difficult (and potentially impossible) to consistently identify with the object in hand and magnification.

**Figure 2: An example of a Brewerton series projectile point from the Olson (2021) dataset.**
(Photo by the author).

**Figure 3: An example of an Adena projectile point from the Olson (2021) dataset.**
(Photo by author)

**Figure 4: An example of a Kirk series projectile point from the Olson (2021) dataset.** Photo retrieved from Rowland's Relics auction website.

## Results

Of the 1,282 projectile points in the Olson (2021) data, only a small subset was used for analysis (N = 178). The sample used for this research represents those projectile points that could reasonably be typed into the point clusters of interest and reasonably be assigned to the Upper Mercer flint source from photographs. Sometimes the publication from which the photo was derived included a narrative description with the author's interpretation of the flint source. These narrative descriptions sometimes helped differentiate raw material sources in black and white photos. Dark brown flints can appear almost black in simple black and white photos.

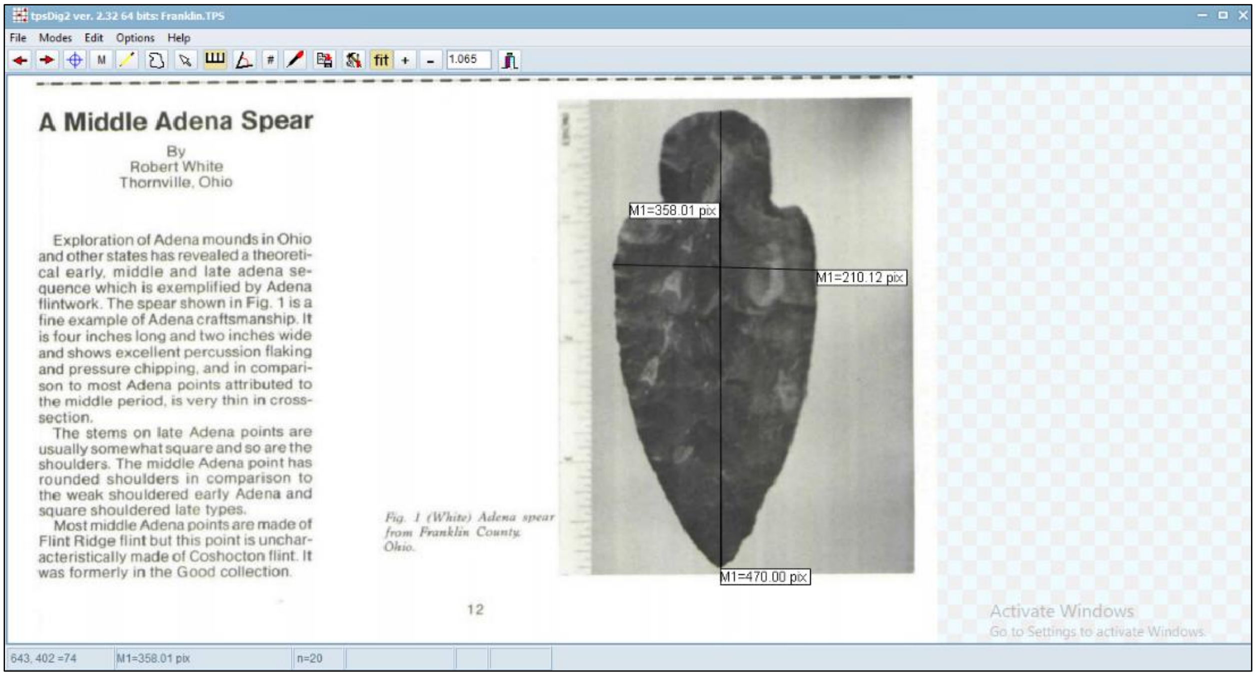


**Figure 5: A Screenshot of TPSDig with measurements (in pixels) of maximum width, length, and the length of the blade. (**Base image from Robert White, *Ohio Archaeologist* 35(2): 12.)

Given the low frequency of points, analyzing them by point cluster would result in very small sample sizes. Table 1 shows the frequencies of points and county localities by cluster. By combining point clusters into larger, time period categories (i.e., Early, Middle, Late Archaic and Woodland), the sample sizes increased while generally describing the same changes through time. Effectively, this combined Kirk and Thebes points into one Early Archaic category, Lowe and Snyders into one Middle Woodland category, Bifurcates as Middle Archaic (which will not be controversial at all), Brewerton as Late Archaic, and Adena points as Early Woodland.

**Table 1. Frequency Distributions of Points and County Localities by Cluster**

| Type Cluster | Point Count | County Locality Count |
|---|---|---|
| Adena | 24 | 13 |
| Bifurcate | 26 | 7 |
| Brewerton | 37 | 15 |
| Kirk | 33 | 14 |
| Lowe | 22 | 15 |
| Snyders | 12 | 8 |
| Thebes | 24 | 13 |

With these combined groupings, the results were categories with at least 20 or more cases (Tables 2 and 3). The two smallest samples come from the Middle Archaic and the Early Woodland, which are represented by Bifurcated points and Adena points, respectively. Bifurcates, to some archaeologists, might be more "properly" classified as Early Archaic. However, for the purposes of this research, they are younger than the Early Archaic points of Thebes and Kirk, but older than the Brewerton point type. Four projectile points were removed from the sample, as their values were outliers when plotted on a simple scatter plot of L/W ratio over B/S ratio. These outliers were all identified as Kirk projectile points (Table 4).

**Table 2. Descriptive Statistics of Blade-to-Stem Ratios**

| Time Period | Count | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|
| Early Archaic | 53 | 3.48 | 1.03 | 1.52 | 6.17 |
| Middle Archaic | 26 | 2.42 | 1.03 | 1 | 5.51 |
| Late Archaic | 37 | 3.06 | 1.02 | 1.64 | 6.35 |
| Early Woodland | 24 | 2.43 | 0.89 | 1.18 | 4.32 |
| Middle Woodland | 34 | 2.69 | 0.83 | 1.1 | 5.45 |

**Table 3. Descriptive Statistics of Length-to-Width Ratios**

| Time Period | Count | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|
| Early Archaic | 53 | 3.48 | 0.39 | 1.08 | 2.52 |
| Middle Archaic | 26 | 2.42 | 0.31 | 1.01 | 2.37 |
| Late Archaic | 37 | 3.06 | 0.37 | 1.12 | 2.58 |
| Early Woodland | 24 | 2.43 | 0.41 | 1.59 | 3.45 |
| Middle Woodland | 34 | 2.69 | 0.52 | 1.1 | 3.05 |

**Table 4: Outlier Projectile Points**

| County_ID | Type | B/S Ratio | L/W Ratio |
|---|---|---|---|
| Medina_11 | Kirk | 8.006491853 | 2.292848116 |
| Licking_45 | Kirk | 3.904923939 | 3.637915677 |
| Stark_3a | Kirk | 6.819293296 | 2.048971976 |
| Jackson_2 | Kirk | 7.360711674 | 2.144 |

Box-and-Whisker plots were generated using the descriptive statistics in Tables 2 and 3 (Figures 6 and 7). Starting first with the L/W ratios, which are meant to approximate overall size, there is a general uniformity in the Archaic period, and a noticable change in size in the Woodland period (Figure 6). In general this may be a reflection of the overall widths of archaic points being much wider than woodland points, resulting in lower ratios.

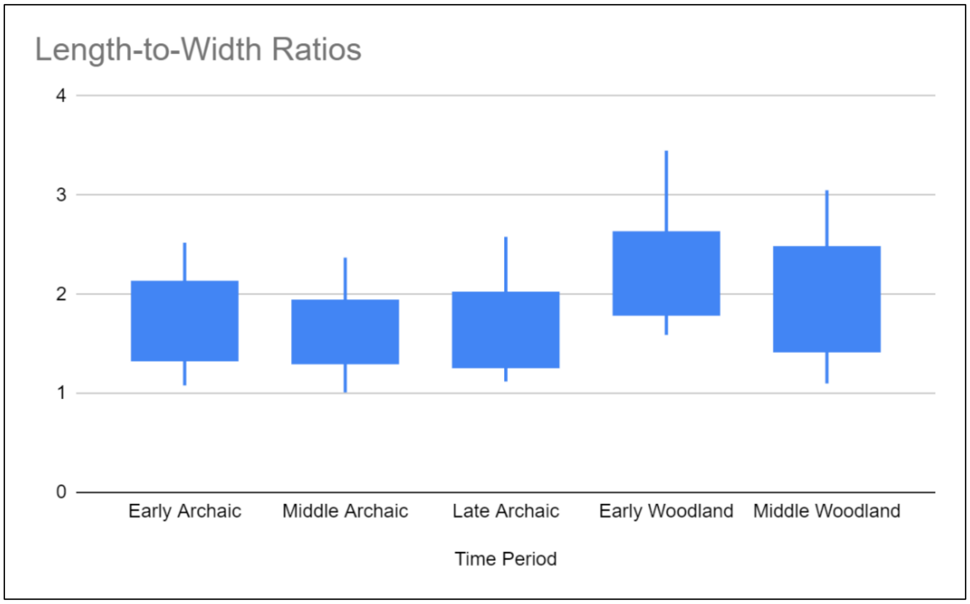


**Figure 6: Box-and-Whisker plot of Length-to-Width Ratios by time period.**

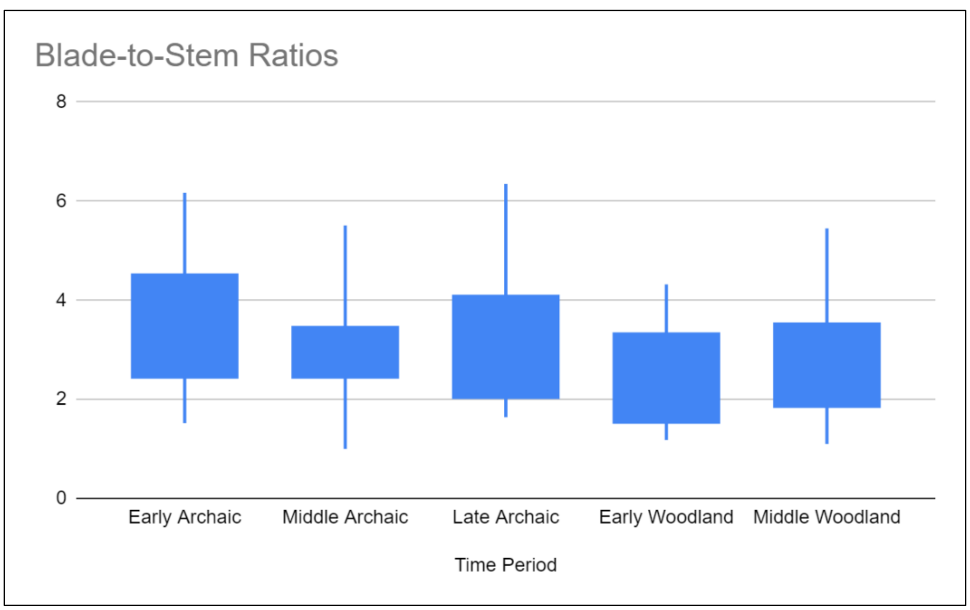


**Figure 7: Box-and-whisker plot of Blade-to-Stem ratios.**

Looking at the box-and-whisker plot of B/S ratios, there is a general decrease in ratios from the Early Archiac to the Middle Woodland. The most visually apparent difference in the plot are the Middle Archaic (bifuracte) points, which have a rather small range of variability for the majority of points within one standard deviation of the mean.

When these data are compared spatially, the results are much more tenuous. This is primarily due to the sample sizes within each county. Some counties have only one projectile point for all the types examined for this research, while others contain at least one case of all point types. The results are a spatial distribution of all projectile points which reflects the overall pattern of spatial distribution of the larger dataset from Olson (2021). The counties with the most abundantly reported projectile points are Adams, Coshocton, Delaware, Erie, Huron, Knox, Lake, Licking, Stark, and Wayne. Figure 8 shows the distribution of all projectile points, and their mean L/W ratios for each county. In total, there are 36 counties represented in this sample.

In general, if Coshocton, Hocking, and Muskingum are assumed as the "epicenter" for most Upper Mercer flint sources, an interesting trend is observable in both B/S and L/W ratios moving away from this center. Coshocton County is often one of the smallest values in the entire state, and the counties surrounding Coshocton (Holmes, Knox, Licking, Tuscarawas) have lower values. The exception is Licking County, which generally has some of the largest projectile points in the sample across all point types.

At the edges of the state, in counties like Ashtabula, Darke, Defiance, and Lucas, the ratios are larger than in Coshocton County. These values may not represent a true pattern, since most counties (n = 21) have a sample size of less than three. However, given the low sample sizes for each county, the same maps were generated where counties had at least three projectile points (Figures 9 and 10). The same pattern of decreasing B/S and L/W ratios is more apparent when only counties with three or more samples are included. The exceptions to this general decay radiating out from Coshocton County are Delaware, Huron, Licking, Lucas, and Portage Counties.

## Conclusions

The first and most obvious conclusion is that more data are needed to better understand the relationship between Lithic Supply Zones and Replacement Ranges. Only about 13.5% of the total available dataset was used in this study. However, the other projectile points are variable in image quality to the point that identifying the raw material source is unlikely for the majority.

Though the sample size was too small to make any meaningful conclusions about replacement ranges over time, there are some interesting patterns that may maintain these trends in larger sample sizes. Delaware, Huron, Licking, and Portage counties had much larger Upper Mercer projectile point sizes than those closer to the "epicenter" (Cochocton, Hocking, Muskingum counties). This may perhaps be a reflection of material choice decisions by past peoples opting to replace tools with materials local to those counties (e.g., Delaware, Pipe Creek, Flint Ridge, Onondaga and Plum Run).

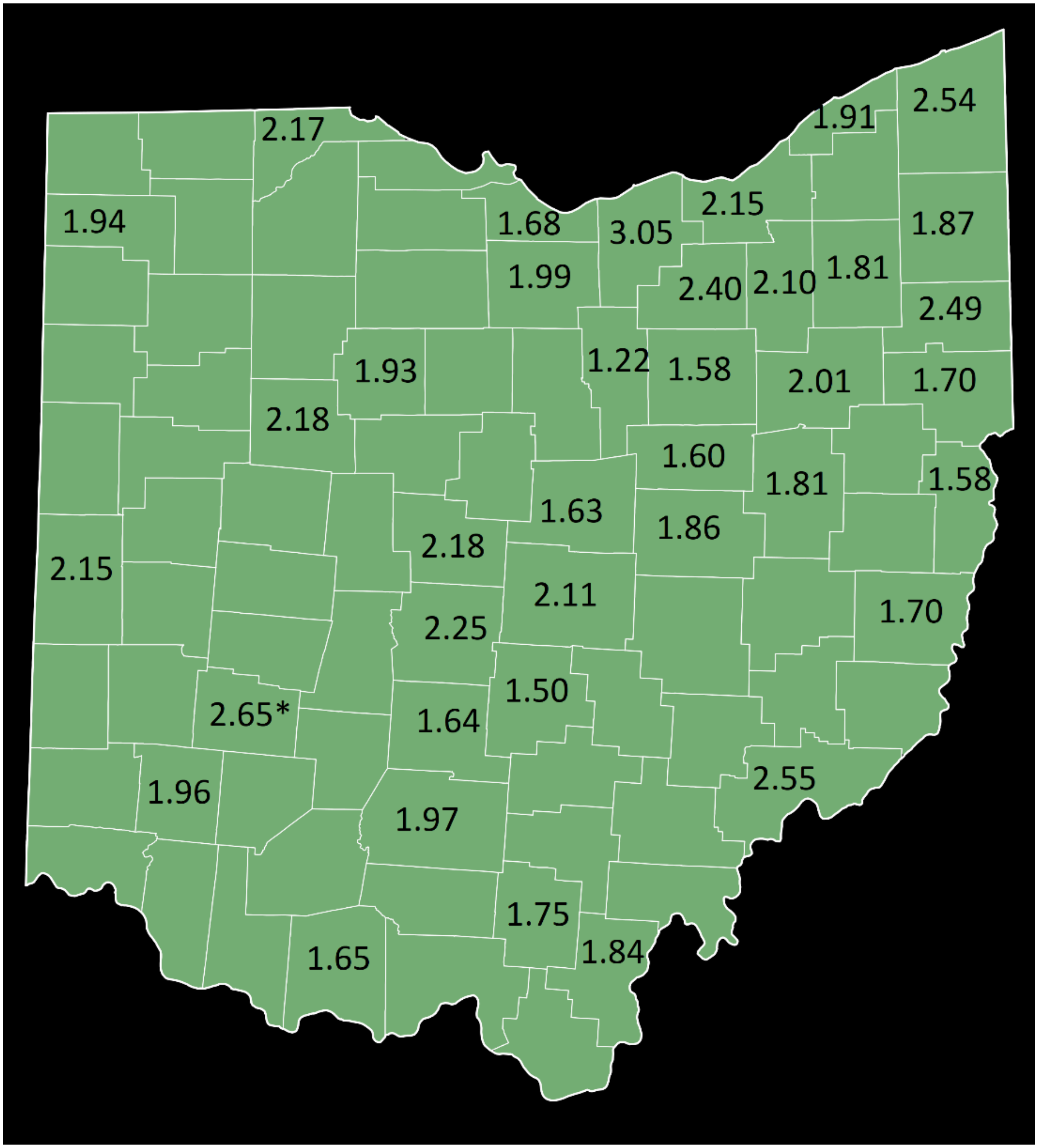


**Figure 8: Mean L/W Ratios for each County for all projectile points (N=174).**

*Greene County is an isolated case documented from a mound excavation.

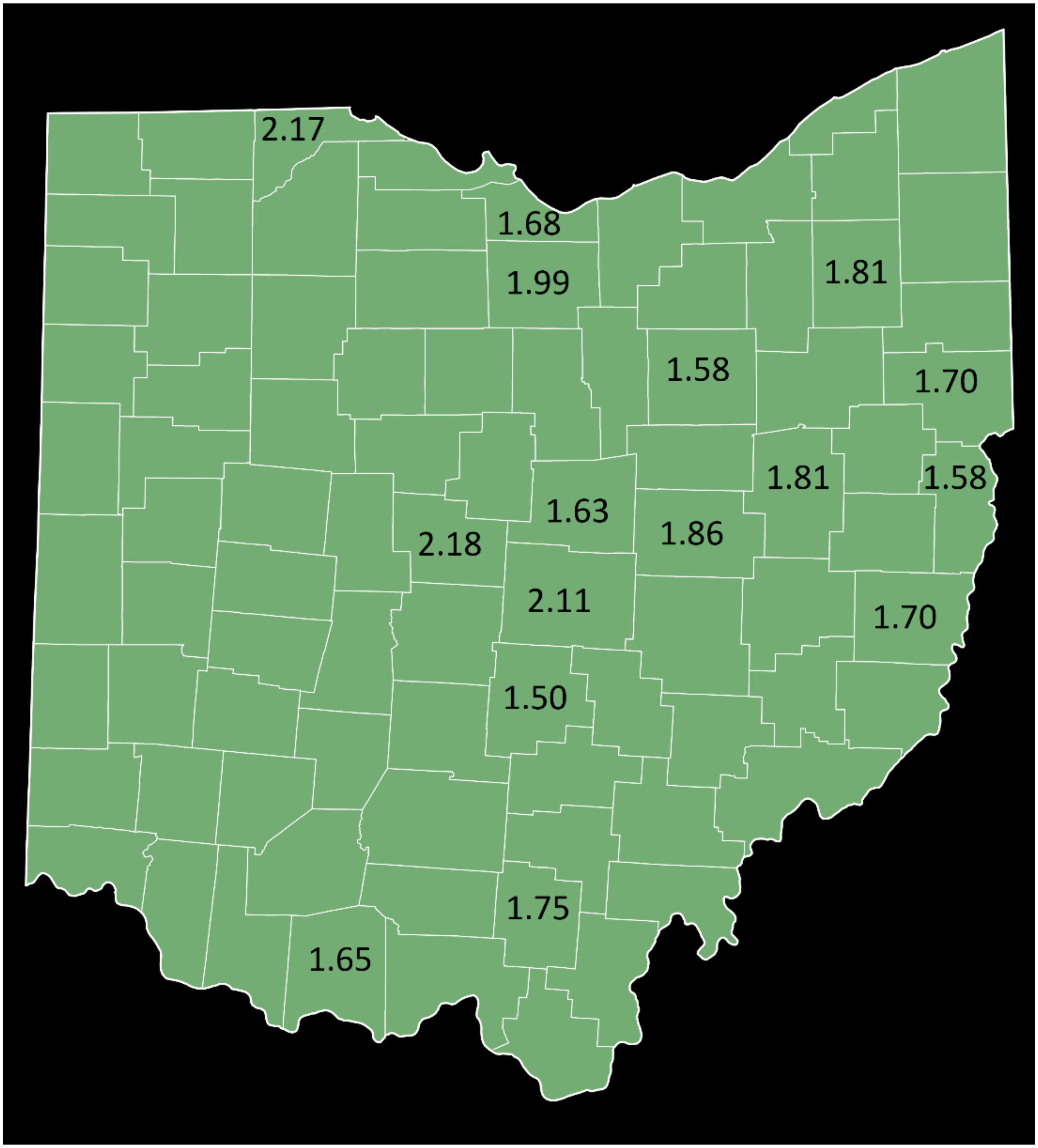


**Figure 9: Length-to-Width Ratios where projectile point samples are larger than three.**

The projectile points from counties represented by three or fewer points present another interesting pattern. These points were spatially isolated from other Upper Mercer points and were almost always substantially larger than their counterparts closer to the source. There are numerous hypotheses that might explain this pattern. One hypothesis is a non-utilitarian function for these projectile points. Intentional manufacture of stone tools for burial or ceremonial purposes will lead to little to no resharpening of the projectile point. A classic example is the

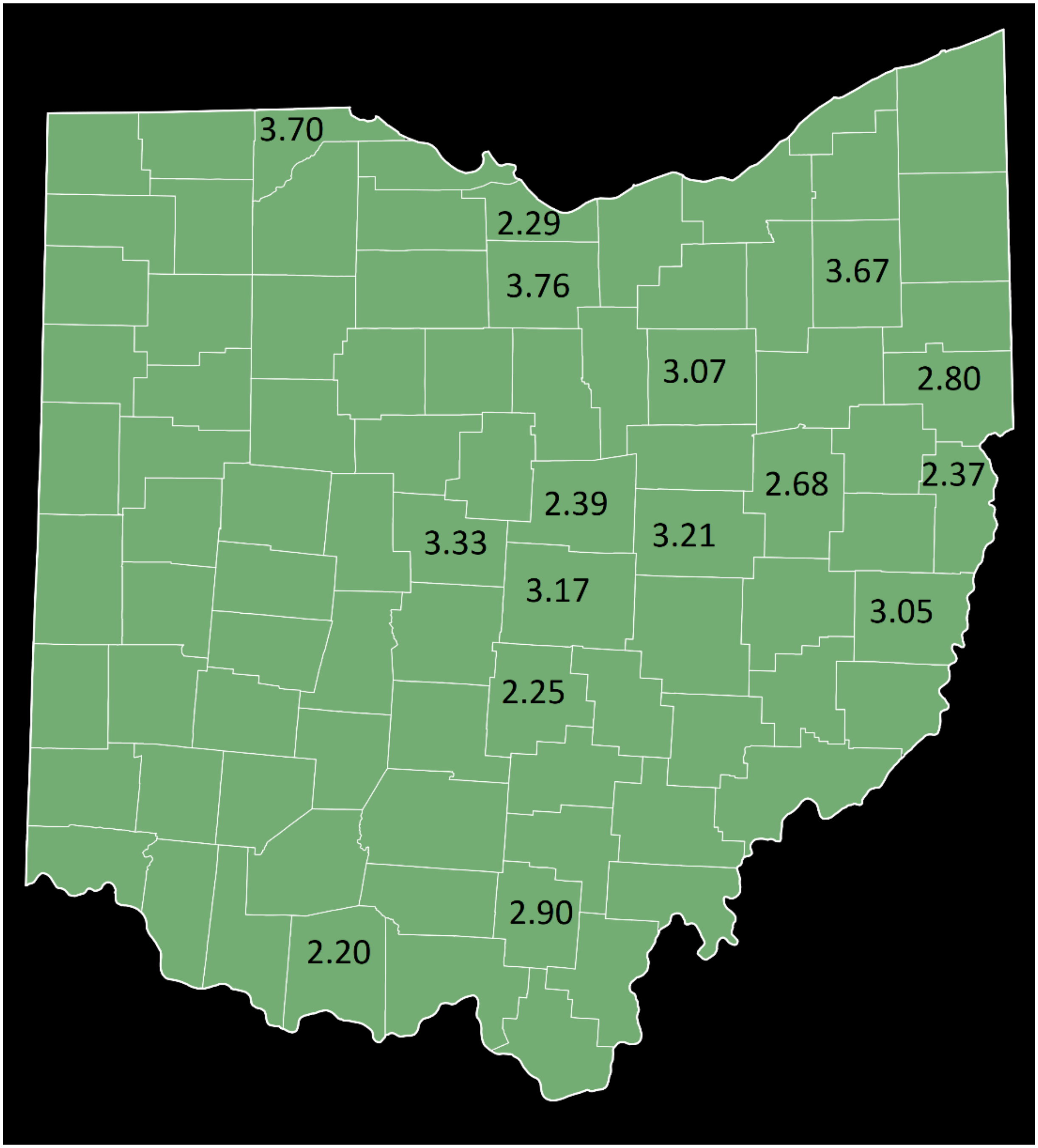


**Figure 10: Blade-to-Stem Ratios by county where at least three projectile points were identified.**

Ross Barbed Spear points recovered from the Hopewell Mound Group, none of which showed evidence of use (Yerkes et al. 2020: 223). The single projectile point from Greene County in this sample was recovered in a burial context within a mound, likely also an intentional deposition. Items manufactured for trading might also explain these outlier values for B/S ratios and L/W ratios far from the Upper Mercer sources. A stone tool intended for trade likely will travel further before being used than a tool that is in use the moment it leaves the flintknapper's hands.

Two other explanations have nothing to do with past human behavior. The first is misidentification of raw material sources. Upper Mercer could potentially be misidentified from Holland chert or Kanawha chert, especially in low-resolution images. The second is sampling bias. As Olson (2021) noted, collectors tend to over-report complete points of types with Early Archaic and Middle Woodland points being the most represented in collector reporting. It seems likely that collectors are also over-reporting very large projectile points. Small, heavily used projectile points appear to be less desirable among collectors who buy and sell artifacts.

Future research should incorporate larger datasets of projectile points, regardless of raw material source. There may be spatial patterns in use-life of projectile points over time that are not source dependent. Or, conversely, the proximity to sources, regardless of the raw material of the projectile point, may impact their overall size. An interesting comparison would be to include the non-Upper Mercer sources to see if there are similar or different patterns of use-life.

Lastly, incorporating Geometric Morphometric Analysis would better account for the whole point rather than an approximation like B/S or L/W ratios. Many of the projectile points in the Olson (2021) dataset contain some type of scale, which is necessary to conduct two-dimensional landmarking. Centroid size would be a much more accurate measure of overall point size than simple L/W Ratio.

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