2012

Adaptation of Reduction Indices to North American Assemblages: Developing a Methodology for the Investigation of the Quarry Creek Assemblages, Ft. Leavenworth, Kansas

Eric Skov
University of Nebraska-Lincoln

Adaptation of Reduction Indices to North American Assemblages: Developing a Methodology for the Investigation of the Quarry Creek Assemblages, Ft. Leavenworth, Kansas

Eric Skov

Abstract: *Reduction measures, especially those measures which compute a scaled index, have been profitably employed in archaeological research on many Old World assemblages. Utilization of these techniques is still a burgeoning subject in North American archaeology, however, and North American assemblages present unique challenges to the analyst. Chief among these difficulties are the greater prevalence of hafted bifaces and other formal tools, especially when contrasted to the Mousterian toolkits that have been the traditional targets for reduction analyses. Other researchers have developed new methods for analyzing projectile points or endscrapers, though these methods are not without weaknesses and I am critical of reduction analyses that rely on only a narrow spectrum of the lithic assemblage. This paper seeks to adapt reduction indices to North American assemblages through exploring the strengths and weaknesses of a variety of measures, with the goal of integrating several measures on multiple types of artifacts into a more comprehensive analysis. A particular site in northeastern Kansas has been chosen as a reference for this discussion, but it is hoped that this example will help illuminate issues that researchers in other areas will find useful.*

Introduction

The original purpose of this paper was to evaluate measures of reduction to propose a research design for analyzing the lithic assemblage recovered at a Kansas City Hopewell site in northeastern Kansas. It rapidly became clear that such a project could be of interest as a methodological problem for researchers across North America. In many ways, the Quarry Creek site has yielded a varied collection of stone artifacts – including cores, scrapers, informal flake tools, bifaces

From: Nebraska Anthropologist, Volume 27: 2012

contradicts Dibble's initial findings using retouch intensity measures to demonstrate that some Mousterian forms at Ghar, Israel were intentional. Though these studies include shape as a critical component of analysis, they also represent the beginnings of a shift away from two-dimensional artifact morphology towards an independent assessment of reduction intensity.

Explicit measures of reduction have focused on concepts of 'expended utility' (Shott and Ballenger 2007) or 'curation'. As Shott and Ballenger define curation, "the relationship between realized (or expended) and maximum utility of tools, i.e., how used up tools are at discard" (2007:154), the terms curation and expended utility are interchangeable. Shott also makes it clear that although use-life and curation co-vary with time, these terms are not interchangable – his example is that the height and weight of children also co-vary with time, but that "no one would confuse the two" (2007:154). While Shott and Ballenger (2007), expressed a primary concern for expended utility, most other previously mentioned studies (Buchanan and Collard 2010, Flenniken and Raymond 1986, Gordon 1993, Papagianni 1994, and Tankersley 1994) explored problems of typology rather than exploring curation as a variable worth analysis. As archaeologists began to see the implications of curation for interpretation, methods for measuring reduction have moved from qualitative and categorical variables towards quantitative indices. These various methods are reviewed in reference to the demands of an analysis at the Quarry Creek site. Therefore, a brief background of this site must be inserted into the discussion.

The Quarry Creek site

The Quarry Creek site is a well preserved Kansas City Hopewell occupation dating to A.D. 210-540 based on radiocarbon and artifact seriation data. Excavations from 1991 were published in a 1993 technical report (Logan et al. 1993) while data from the recent 2010 field school excavation is still being cataloged (Logan 2011). The initial investigations included a 14 meter trench through a midden and discovery of 9 features. The distribution of burned limestone in the levels of the trench was hesitantly interpreted as possible evidence for reduced site occupation intensity over time (Logan et al. 1993). A 10 meter trench from the 2010 field school intersects the 1991 trench, and it has been suggested that a look at the lithic assemblage recovered could shed more light on the formation of the midden (Logan 2011).

The 1991 excavation of 33 square meters uncovered over 20,000 lithic artifacts. Of these there are 194 blades, 255 bladelets, contradicts Dibble's initial findings using retouch intensity measures to demonstrate that some Mousterian forms at Ghar, Israel were intentional. Though these studies include shape as a critical component of analysis, they also represent the beginnings of a shift away from two-dimensional artifact morphology towards an independent assessment of reduction intensity.

Explicit measures of reduction have focused on concepts of 'expended utility' (Shott and Ballenger 2007) or 'curation'. As Shott and Ballenger define curation, "the relationship between realized (or expended) and maximum utility of tools, i.e., how used up tools are at discard" (2007:154), the terms curation and expended utility are interchangeable. Shott also makes it clear that although use-life and curation co-vary with time, these terms are not interchangable – his example is that the height and weight of children also co-vary with time, but that "no one would confuse the two" (2007:154). While Shott and Ballenger (2007), expressed a primary concern for expended utility, most other previously mentioned studies (Buchanan and Collard 2010, Flenniken and Raymond 1986, Gordon 1993, Papagianni 1994, and Tankersley 1994) explored problems of typology rather than exploring curation as a variable worth analysis. As archaeologists began to see the implications of curation for interpretation, methods for measuring reduction have moved from qualitative and categorical variables towards quantitative indices. These various methods are reviewed in reference to the demands of an analysis at the Quarry Creek site. Therefore, a brief background of this site must be inserted into the discussion.

The Quarry Creek site

The Quarry Creek site is a well preserved Kansas City Hopewell occupation dating to A.D. 210-540 based on radiocarbon and artifact seriation data. Excavations from 1991 were published in a 1993 technical report (Logan et al. 1993) while data from the recent 2010 field school excavation is still being cataloged (Logan 2011). The initial investigations included a 14 meter trench through a midden and discovery of 9 features. The distribution of burned limestone in the levels of the trench was hesitantly interpreted as possible evidence for reduced site occupation intensity over time (Logan et al. 1993). A 10 meter trench from the 2010 field school intersects the 1991 trench, and it has been suggested that a look at the lithic assemblage recovered could shed more light on the formation of the midden (Logan 2011).

The 1991 excavation of 33 square meters uncovered over 20,000 lithic artifacts. Of these there are 194 blades, 255 bladelets, 12,776 'chips' (flakes <2cm in length), 300 'chunks' (shatter >2cm), 21 cores, 39 edge-modified flakes, 3,083 flakes, and 3,539 pieces of 'shatter' (irregularly shaped lithic material lacking flake scars, negative bulbs of force or striking platforms). In addition to these artifacts, formal tools recovered were 45 projectile points (of which 35 are diagnostic), 5 drills, 4 bifacial blanks, 6 preforms, 4 indeterminate bifaces, 37 biface fragments, and 24 scrapers (20 endscrapers and 4 circular scrapers, some of these scrapers are bifacially worked) (Logan et al 1993). The total lithic assemblage recovered in 2010 is not yet available, but has been suggested to be similar to 1991 results. At present, 48 square meters of the site have been excavated (cubic meter data is not yet available), and 60+ projectile point / knives have been identified, though more may turn up in lab analysis (Logan 2011). Comparison of the rates of recovery (admittedly imperfect given the lack of cubic meter data and incomplete cataloging of 2010 artifacts) suggest that 2010 excavations hit deposits approximately equally as dense as the 1993 excavations. Extrapolating the 1993 data for the additional 2010 excavations, the estimated lithic assemblage is as follows:

Figure 1: Estimated number of lithic artifact types from the Quarry.

Flakes	~5132
Edge Modified Flakes	~57
Blades	~281
Bladelets	~370
Cores	~30
Projectile Points / Knives	~65
Drills	~7
Bifacial Blanks	~6
Preforms	~9
Indeterminate Bifaces	~6
Biface Fragments	~54
Scrapers	~35
Total Lithic artifacts	~29,100

Based on these projections, reasonable samples exist to measure reduction intensity for edge-modified flakes, projectile point/knives and scrapers. Reduction measures on cores will not be reviewed here, but could be included in a future analysis. These categories suggest that a program of analysis markedly different from many employed on European Paleolithic and Australian assemblages will be required.

Methods of Measuring Reduction

As stated before, the goal of measuring reduction is to approximate the extent of utility extracted from a tool when it was discarded. This measure of curation is simply the utility extracted (how reduced the artifact is), over total utility available when the artifact was first formed.

Allometric Measures of Artifacts

Some efforts have sought to define curation with reference to certain absolute measurements. Blades (2003:143) cites several examples where researchers used shorter lengths and steeper angles on end scrapers, or "similar arguments...for Upper Paleolithic blade assemblages" as evidence of greater utilization intensity. Generally, however, measures of reduction based on artifact measurements have attempted to estimate original dimensions of the artifact or use a measurement assumed to be constant throughout use-life as a reference for the variable measure. In this way, the analyst can explore the measurements allometrically, often permitting the dimensions to be expressed as a ratio of original size. Barton (1990) compared edge angle to degree of retouch, suggesting that edge angles becomes less variable with greater invasiveness of retouch. This analysis carried the assumption that unretouched flakes resembled the original condition of retouched flakes. Blades' (2003) analysis of end scrapers relied on length as a primary indication of reduction extent. Dissatisfaction with the absolute measures of length from different assemblages led to comparisons of length measurements with thickness, width and end angle. These measures were also compared against each other to establish if consistent relationships existed between variables other than length. The only consistently significant relationship was between width and thickness, which is unsurprising since both are factors of blade initiation and are relatively unchanged by end scraper reduction. These efforts did not manage to establish any estimate of original length. Measurements of thickness, on the other hand, were assumed to remain relatively constant through reduction, so more reduced implements were recognized by the changing relationship between thickness and length or between thickness and width.

Other methods for interpreting original size or mass of reduced flakes have had more success. Dibble and Wittaker documented a relationship between platform area and blank surface area, but this was based on flake, not blade, removals. An experiment in blade production later produced a relationship with $r2 = 0.40$, $p < .01$ (Blades 2003:146). Dibble's method has shown various levels of success in predicting flake sizes: $r2 = 0.24-.54$ (Dibble 1995), $r2 = 0.50$ in Shott's 2000 analysis or $r2 = <0.1$ in Hiscock and Clarkson's 2007 study. The relationship between ventral area and platform thickness has performed similarly: $r2 = 0.45$. It has been suggested that the low inferential power of these methods is related to the inaccuracies of measurements of area with calipers (Hiscock and Tabrett 2010). An alternative to these methods of measurement has used digital scanning to record platform and showed a relationship to flake mass with an r2 of 0.87. By accounting for platform angle in addition to area, the predictive value of the technique rises to $r2 = 0.86-.95$. These methods are extremely promising, but require relatively expensive equipment and like the previous techniques require an intact platform (Hiscock and Tabrett 2010).

Shott and Ballenger (2007) suggest three other methods for establishing original length that are intended for bifaces. The first of these relies on haft/blade ratios. This method is similar to Blades' (2003) work, arguing that the hafted portion of bifaces is unlikely to change during use while the blade portion is reduced. Shott and Ballenger (2007) cite several studies that see much greater variation in blade dimensions than haft dimensions, though specific results are not given. Hoffman's 1985 work "expressed blade reduction as a function of the ratio of blade width to edge angle" and resulted in the merging of several types into "subdivisions of a reduction continuum" (Shott and Ballenger 2007:155). However, see Dibble and Bernard (1980) for a discussion of the inaccuracies of measuring edge angle. Shott and Ballenger's analysis of expended utility relies on a base width / blade width ratio (Shott and Ballenger 2007). Approaches that measure surface area of haft and blade portions are cited but these are criticized for being limited to certain shapes of artifacts (Shott and Ballenger 2007). Digital scanning (as has been performed for platform area) could resolve this problem but would suffer from the same cost restraints. Alternatively, the potential of photo-editing software to compute areas of complex shapes could provide a low-cost solution to this problem.

Limited experimentation with ImageJ, a free photo-analysis and photo-editing program, appears to substantiate this claim.

A second method for establishing allometric relationships relies on the archaeological context of finds. Specifically, cache finds are argued to have little to nil utility extracted and so can be used to estimate original dimensions of all implements (Shott and Ballenger 2007). Methodological concerns arise because the amount of remaining utility of cached artifacts is not independently assessed and because cached finds may not represent typical artifacts.

Estimations from Retouch Characteristics

The third method Shott and Ballenger (2007) cite is the use of retouch invasiveness. This approach was formulated for flake tools by Clarkson (2002) and was adapted to measure biface reduction by Andrefsky (2006). Additional methods include Kuhn's (1990) GIUR for unifacial artifacts, Eren et al.'s 2005 adaptation of GIUR to produce an Estimated Reduction Percentage (ERP), and qualitative classifications of retouch (Hiscock and Tabrett 2010).

Qualitative classification of retouch uses "the kinds of retouch scars as an indicator of the amount of retouching" (Hiscock and Tabrett 2010:551). This approach has been criticized for its use of ordinal categories which are not necessarily present with all kinds of retouch or on all sizes of artifacts and because patterns of retouch can be obliterated by further reduction. Experimental evaluation of this method is limited but suggests inferential power on the order of $r2 = 0.45$ (Hiscock and Tabrett 2010). This approach was utilized in Barton's (1990) analysis as well as Papagianni's (1994) preliminary study. The method was also profitably employed by Gordon (1993) to suggest that pointed Mousterian forms at Ghar, Israel were intentional tool categories rather than the result of retouch.

The Geometric Index of Unifacial Retouch (GIUR) measures retouch scar height relative to thickness of the artifact (Kuhn 1990, Hiscock and Tabrett 2010). Multiple methods for computing the index exist. Retouch height can be measured directly with calipers but with a small degree of error due to ventral curvature, or an edge angle measurement and a length of scar measurement can be computed to give height (Hiscock and Tabrett 2010). This method is not favored because of the difficulty of measuring edge angles (Dibble and Bernard 1980). Thickness of the artifact can be measured once at the maximum thickness or can be paired with the retouch scar measurements. The latter method is preferred by Hiscock and Tabrett (2010) because this method increases the sensitivity of the index. Finally, though three measurements of scar height are proposed by Kuhn, some researchers have chosen to average the results of more measurements to increase sensitivity and decrease the effect of variable scar length (Hiscock and Tabrett 2010). When used to measure marginal, non-invasive retouch GIUR has been very effective at predicting mass loss ($r2 > 0.8$). However, KUHN is strictly limited to artifacts with only dorsal retouch and may be less effective at assessing distal retouch (such as is seen on end scrapers) or retouch on relatively flat flakes. In these situations, GIUR reaches maximum value quickly and subsequently loses most sensitivity to additional retouch. Experimental evaluation has found that ventral curvature mostly obviates these concerns (Hiscock and Tabrett 2010). Exactly how ventral curvature resolves the problem inherent in measuring reduction of end scrapers is not explained and I am inclined to agree with the critics that heavily reduced end scrapers may not be a suitable candidate for GIUR.

Estimated Reduction Percentage uses the trigonometric method of GIUR to compute the cross-sectional area missing from the implement and multiplies this area by the perimeter of retouch to produce an estimate of volume lost. Expressed as a ratio of original volume, this measure can vary between 0 and 1 (Hiscock and Tabrett 2010) but in actual practice ERP values cannot approach 1 because the implement would have to vanish entirely. This lowers the sensitivity of the index. Reliance on determining edge angle with goniometers (Hiscock and Tabrett 2010) introduces a large source of error to the analysis (see Dibble and Bernard 1980) that further reduces this index's usefulness. These difficulties are in addition to the limitations of GIUR. Coefficient of determination values have been <0.5 in experimental studies (Hiscock and Tabrett 2010).

Clarkson's (2002) Invasiveness Index divides an artifact into 5 equal segments down its length. The middle 3 segments are divided along the artifact's central axis. Retouch flakes in the resulting 8 segments are then evaluated. Segments without retouch score a 0, segments with retouch that does not extend halfway to the midline score 0.5 and segments with retouch extending past halfway to the midline score 1.0. This process is repeated for the opposite face and the total is then divided by 16 to give an index value between 0 and 1. Much like the measurements in GIUR, the number of segments can be varied to increase sensitivity, and some researchers (e.g. Hiscock and Tabrett 2010) choose to divide segments at the halfway to midline point and evaluate each of these 32 segments individually. The index can be adapted for unifaces by evaluating only one face and dividing by 8 rather than 16. This avoids a loss of sensitivity when only one face of the implement is retouched – the maximum theoretical index value to be used for all artifacts. Ideally, multiple methods would be used on each class of artifact, permitting cross-checking between indices.

Variability of reduction may fit temporal patterns and/or be based on raw material. Kansas State University has an excellent lithic comparative collection, though for this area of northeastern Kansas it may be necessary to use the University of Kansas' facilities and the University of Iowa's comparative collection and "VBS Lithics Program" (available at http://www.uiowa.edu/~osa/lithics/).

No description is given of the edge-modified flakes, but as a preliminary measure it is possible to plan for Invasiveness Index and GIUR analyses. If any of these flakes are bifacially or ventrally worked, however, only the Invasiveness Index will be applicable. Additionally, GIUR may lose sensitivity when applied to some types of flake cross sections (Hiscock and Tabrett 2010). Alternatively, if edges are steeply retouched, GIUR will be the more reliable index though the Invasiveness Index can still be calculated. Other measures may also prove useful in describing these artifacts. Perimeter of retouch can be easily measured with string and when divided by total perimeter gives a value between 0 and 1. To help determine which index will be more accurate, the cross-sectional shape of the artifact can also be described and supplemented with measurements of width, thickness and length.

Analysis of the scrapers presents a further challenge. Many of the end scrapers from the site are bifacially retouched, and the circular scrapers from the site have invasive retouch (Logan et al. 1993). This eliminates GIUR from part of the sample and calls into question its usefulness for other artifacts. If the length of a flake scar is pictured as the hypotenuse of a right triangle, then the lengths of the two other sides co-vary with length of the hypotenuse, but to different degrees depending on the angle of retouch. For instance, at a 30° angle, an increase in scar length of 1cm will correspond to an increase in retouch invasiveness of ~8.6mm, but only 5mm of retouch height. Since length of the flake corresponds with mass removed, this simple geometry can be used to explore the suitability of the Invasiveness Index and GIUR at different retouch angles. When retouch is at less than a 45° angle to the ventral face, the Invasiveness Index is preferable, while if retouch is at angles of greater than 45° GIUR is more sensitive to mass removal. Accurate measures of angles are not essential – when angles are near 45° the indices should be of equal usefulness so both could be used – but can be obtained using the modified caliper method found in Dibble and Bernard (1980). Bifacially worked artifacts are still only amenable to the Invasiveness Index, but this method may aid determining which index to use with unifacial artifacts.

The sample of end scrapers is relatively small, but an analysis similar to that from Blades (2003) may be profitable. Between batches of artifacts, length / thickness ratios are likely to decline with extended curation. Due to the low inferential power of this measure and the limited sample size, differences are likely to be insignificant. However, it is included because of the speed and ease of this analysis.

Projectile points can be analyzed a number of ways. Andrefsky's (2006) HRI is most obvious. It has a reasonably high inferential power and can be performed on point fragments. The difficulty of performing this analysis on chert bifaces is not presently known. It is likely that flaking patterns on some materials will be more difficult to discern than when on obsidian, which could lead to a drop in inferential power. In keeping with Andrefsky's recommendation, points of different typologies will be analyzed separately – of 35 diagnostic points from the 1991 excavation, all but 2 were either corner-notched dart points or contracting-stem dart points (Logan et al. 1993). Since haft elements aren't included in the HRI, comparison between these typologies may be possible.

Another method suggested by Shott and Ballenger (2007) relies on comparison of the areas of haft and blade elements. This requires a complete artifact, though estimations may be possible in some cases by 'drawing in' missing parts. This method of analysis could also fill in the gaps when the HRI becomes inaccurate as width/thickness approaches 1. Furthermore, this method would be strictly limited to comparing within types. Using ImageJ, polygons are traced around the haft and blade portions and the program is asked to measure each. The area given does not have units, but in a scaled measurement that will not matter. If haft area is divided by blade area, the result will generally fall between 0 and 1, with the 1 value denoting the most reduced specimens. It will be possible for values greater than 1 to result if the blade is reduced to a smaller area than the haft, but this should be a rare occurrence. Similarly, the minimum value of 0 is mathematically impossible. Results could be adjusted for this scale by curving the score of each artifact so that the least reduced specimen receives a 0 value. Conducting the computer operations for this measurement only take around two minutes, and the software is free, making this an extremely economical measurement of reduction, though also a limited one. To the author's knowledge, such a technique has not been attempted previously, so a complete analysis should include an experimental component to test the power of this index.

Conclusion

Analysis of the Quarry Creek assemblage can proceed on multiple fronts. Edge-modified flakes and scrapers can be measured for standard dimensions, analyzed for perimeter of retouch and the Invasiveness Index. The GIUR can be used on any unifacial tools encountered, and in these cases the Invasiveness Index should also be adjusted to include only the dorsal segments. A method for determining which retouch index is more suitable for each edge angle is discussed. In addition, thickness/length ratio is discussed as a way to compare batches of endscrapers, though the success of such an effort is doubted. Analysis of projectile points will take two forms. The HRI can be performed on any projectile points in the collection, but it is predicted that the inferential power of the index will be lower than in Andrefsky's (2006) experimental study due to the inferior raw materials at the Quarry Creek site. The haft area/blade area ratio can be calculated on complete projectile points, or those missing only a small piece which can be 'drawn in'. This methodology will rely on free photo editing software and is easy to perform. However, it is also strictly limited to comparisons within types and individual results will likely not be comparable to HRI data. In some circumstances, however, haft/blade ratio may be more reliable than the HRI, so it is suggested that as thickness/width approaches 1 the HRI results are dropped in favor of the new technique.

Results of each measure will not be comparable between the three groups of artifacts discussed, but the patterns of those results can be compared. Simultaneous rising or falling reduction intensities among flake tools, scrapers and projectile points could have far different implications than a change in only one of these categories. Though it is not the intent of this article to delve into the interpretation of reduction data, arguments should be strengthened by an approach which analyzes a broader spectrum of artifacts. Reduction indices measure the curation of an artifact (Shott and Ballenger 2007) – an analysis based upon one artifact type reveals merely the curation of that artifact class. If the broader patterns of human adaptation are to be interpreted, archaeologists will need to grapple with the difficulties of comparing the curation patterns of multiple artifact classes.

References Cited

Andrefsky, William Jr.
  2006 Experimental and Archaeological Verification of an Index of Retouch for Hafted Bifaces. *American Antiquity* 71(4):743-757.

Barton, C. Michael
  1990 Beyond Style and Function: A View from the Middle Paleolithic. *American Anthropologist* 92(1):57-72.

Benfer, Robert A.
  1972 Factor Analysis as Numerical Induction: How to Judge a Book by Its Cover. *American Anthropologist* 74(3):530-554.

Benfer, Robert a. and Alice N. Benfer
  1981 Automatic Classification of Inspectional Categories: Multivariate Theories of Archaeological Data. *American Antiquity* 46(2): 381-396.

Blades, Brooke S.
  2003 End Scraper Reduction and Hunter-Gatherer Mobility. *American Antiquity* 68(1):141-156.

Buchanan, Briggs and Mark Collard
  2010 An Assessment of the Impact of Resharpening on Paleoindian Projectile Point Blade Shape Using Geometric Morphometric Techniques. In: *New Perspectives on Old Stones: Analytical Approaches to Paleolithic Technologies* [ed] Lycett, S.J. and P.R. Chauhan

Clarkson, Chris
  2002 An index of invasiveness for the measurement of unifacial and bifacial retouch: a theoretical, experimental, and archaeological verification. *Journal of Archaeological Science* 29:65-75.

Dibble, Harold L.
  1987 The Interpretation of Middle Paleolithic Scraper Morphology. *American Antiquity* 52(1):109-117.
  1995 Middle Paleolithic Scraper Reduction: Background, Clarification, and Review of the Evidence to Date. *Journal of Archaeological Method and Theory* 2(4):299-368.

Dibble, Harold L. and Mary C. Bernard
  1980 A Comparative Study of Basic Edge Angle Measurement Techniques. *American Antiquity* 45(4):857-865.

Dibble, Harold L. and Philip G. Chase
1981 A New Method for Describing and Analyzing Artifact Shape. *American Antiquity* 46(1):178-187.

Flenniken, J. Jeffrey and Anan W. Raymond
1986 Morphological Projectile Point Typology: Replication Experimentation and Technological Analysis. *American Antiquity* 51(3):603-614.

Gordon, David
1993 Mousterian Tool Selection, Reduction, and Discard at Ghar, Israel. *Journal of Field Archaeology* 20(2):205-218.

Hiscock, Peter and Chris Clarkson
2007 Retouched Notches at Combe Grenal (France) and the Reduction Hypothesis. *American Antiquity* 72(1): 176-190.

Hiscock, Peter and Amy Tabrett
2010 Generalization, inference and the quantification of lithic reduction. *World Archaeology* 42(4):545-561.

Kuhn, Steven L.
1990 A geometric index of reduction for unifacial stone tools. *Journal of Archaeological Science* 17:583-593.

Logan, Brad.
2011 Personal Communication. (Private emails and discussions)

Logan, Brad [ed] Mary J. Adair, William E. Banks, Eva Lord Cook, Christopher Raymond, Robert Rothman and John W. Weymouth
1993 *Quarry Creek – Excavation, analysis and prospect of a Kansas City Hopewell site, Fort Leavenworth, Kansas.* For KC District Corps of Engineers, DACA41-92-P-0615. Available at: http://handle.dtic.mil/100.2/ADA281351

Moore, Mark W.
2000 Lithic Technology in Tasmania. *Archaeology in Oceania* 35(2):57-73.

Papagianni, Dimitra
1994 Beyond 'flint scatters' and 'findspots': assessing the potential for compiling a synthesis of the Greek Middle Paleolithic surface data. *British School at Athens Studies* 3: The Paleolithic Archaeology of Greece and Adjacent Areas: Proceedings of the ICOPAG Conference, Ioannina:130-136.

Rolland, Nicholas and Harold L. Dibble
1990 A new Synthesis of Middle Paleolithic Variability. *American Antiquity* 55(3):480-499.

Sackett, James R.
1969 Factor Analysis and Artifact Typology. *American Anthropologist* 71(6):1125-1130.

Shott, Michael J.
1997 Stones and Shafts Redux: The Metric Discrimination of Chipped-Stone Dart and Arrow Points. *American Antiquity* 62(1):86-101.

Shott, Michael J. and Jesse A. M. Ballenger
2007 Biface Reduction and the Measurement of Dalton Curation: A Southeastern United States Case Study. *American Antiquity* 72(1):153-175.

Tankersley, Kenneth B.
1994 The Effects of Stone and Technology on Fluted-Point Morphometry. *American Antiquity* 59(3):498-510.