# Were Unifacial Tools Regularly Hafted by Clovis Foragers in the North American Lower Great Lakes Region? An Empirical Test of Edge Class Richness and Attribute Frequency among Distal, Proximal, and Lateral Tool-sections

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Abstract

Using a regional dataset comprised of unifacial stone tools from seven Clovis sites in the North American Lower Great Lakes region, this manuscript examines whether these tools were regularly hafted. It was hypothesized that colonizing foragers would not have regularly hafted their unifacial stone tools because this practice would have decreased toolkit portability. Test predictions were formulated stating: (1) if unifacial stone tools were regularly hafted, then there should be decreased richness of morphological edge classes and a lower frequency of spurs and notches in the proximal tool-section relative to lateral and distal tool-sections; but (2) if unifacial stone tools were not regularly hafted then there should be similar amounts of edge class richness and similar frequencies of spurs and notches among proximal, lateral, and distal tool-sections. Test results were consistent with the notion that Clovis unifacial stone tools in the Lower Great Lakes region were regularly hafted.

Like in other regions in northeastern North America, such as the New England-Canadian Maritimes region (Bradley et al. 2008; Dincauze 1993; Lothrop et al. 2011; Spiess et al. 1998) and the Western Great Lakes (Ellis et al. 2011; Koldehoff and Loebel 2009; Loebel 2005), current interpretations of archaeological evidence suggest that the presence of Clovis foragers in the Lower Great Lakes represents early phases of colonization (Brose 1994:66; Ellis 2008, 2011; Ellis et al. 2011; Ellis and Deller 2000; Eren 2011; Eren and Andrews 2013; Eren and Desjardine 2013; Eren and Redmond 2011; Eren et al. 2011; Redmond and Tankersley 2005; Seeman 1994: 274; Simons 1997; Storck and Spiess 1994; Tankersley 1994; Waters et al. 2009). These interpretations do not necessarily mean that Clovis foragers were the first *people* ever to venture into the region (cf. Goebel et al. 2008; Overstreet 2004; Redmond et al. 2012). Nor do these interpretations assume that the *initial* Clovis colonization occurred around 11,000 B.P., which is currently suggested by radiocarbon dates from Sheriden Cave (10,915 ± 30 B.P., Waters et al. 2009) and Paleo Crossing (10,980 ± 75 B.P., Brose 1994). Instead, when taken in aggregate, the Clovis archaeological record in the Lower Great Lakes seems to represent the *initial stages* of colonization into, and settlement of, the region (Ellis 2008; Meltzer 2002), though whether that stage was the very first has yet to be conclusively determined. Overall, however, it is reasonable to suggest that the Lower Great Lakes region was, at the very least, almost entirely devoid of people when the first indications of a Clovis presence occur at 11,000 B.P.

How hunter-gatherers adapt to "empty" land masses is a question that is essential to understanding an important segment of human history (Kelly 2003: 44). Indeed, the ramifications of human migrations across the globe during the late Pleistocene shaped human interactions throughout the Holocene, and its reverberations are even still felt in the modern world (e.g., Diamond 1997; Meltzer 1993). But as Kelly (2003: 44) notes, understanding the mechanics of how hunter-gatherers colonize and adapt to "empty" landscapes can be a frustrating question, because there are no easy analogies: we have no cases of ethnographically known hunter-gatherers moving into *terra incognita*. Thus, significantly, this means that the only way to examine how colonizing hunter-gatherers

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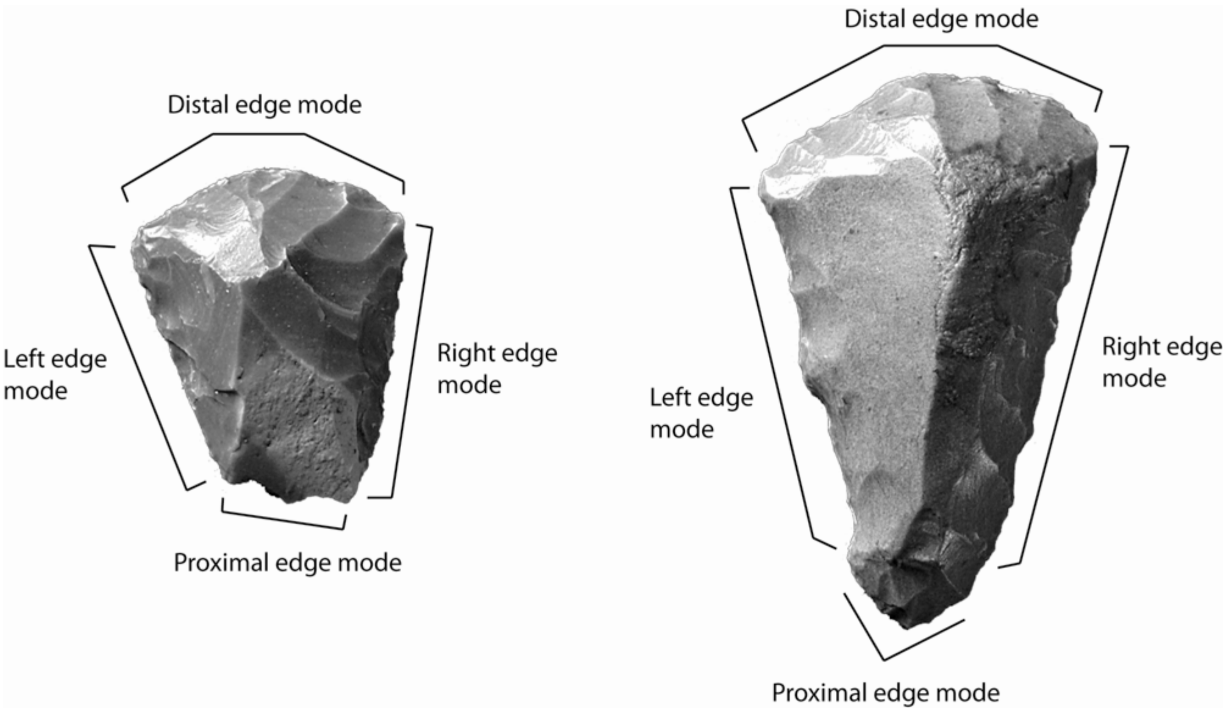


**Figure 1**. Examples of unifacial stone "tool-sections."

behave in unfamiliar landscapes is through the study of the archaeological record left by prehistoric examples (Eren 2011; Eren and Andrews 2013).

One important aspect of behavior that all hunter-gatherers must take into consideration is the organization of their toolkits (Binford 1979). Mobility plays an influential role in the way forager hardware is designed (e.g., Eren and Lycett 2012; Kuhn 1994; Morrow 1996; Nelson 1991; Torrence 1983; Yellen 1976) regardless of whether a forger is a colonizer or not. While moving through a landscape, foragers are generally limited to what they can physically carry themselves (e.g., Gould 1969: 76-88; Torrence 1983: 13; Yellen 1976: 55). Thus, portability is a necessary property of most mobile forager toolkits for the simple reason that raw materials are not ubiquitous (Kuhn 1994: 427). But since the risk of extinction is greatest soon after dispersal (Belovsky et al. 1999), and colonizing hunter-gatherers may have arguably faced greater uncertainty than non-colonizing ones in a number of respects involving resource location and procurement (Meltzer 2002: 34), it would be especially important for colonizers to travel into unfamiliar landscapes with the correct kinds, and amounts, of supplies.

Meltzer (2002: 34; see also 2009) notes that foragers in an unfamiliar landscape should maximize mobility "in order to learn as much as possible, as quickly as possible, about the landscape and its resources (in order to reduce environmental uncertainty in space and time)." Toolkit considerations can help facilitate this goal. A well-constructed lithic tool-kit that minimizes tool transport costs while maximizing raw material use will permit a forager to travel more efficiently through unfamiliar territory without as much need to resupply toolstone. And since toolstone sources may be unknown to foragers in an unfamiliar landscape, maximizing raw material use is important since there may not be an opportunity for resupply (Dincauze 1993; Ellis 2011). One way foragers can minimize transport costs while maximizing raw material use is to carry small flake tools, rather than larger tools or cores (see Kuhn 1994). In the North American Lower Great Lakes region, the results of Eren and Andrews (2013) suggest Clovis colonizing foragers were doing exactly that. Rather than carrying mobile biface-cores and knapping flakes when needed, the analyses of Eren and Andrews are consistent with the hypothesis that flake-blanks were knapped before departure from a stone source in anticipation of future

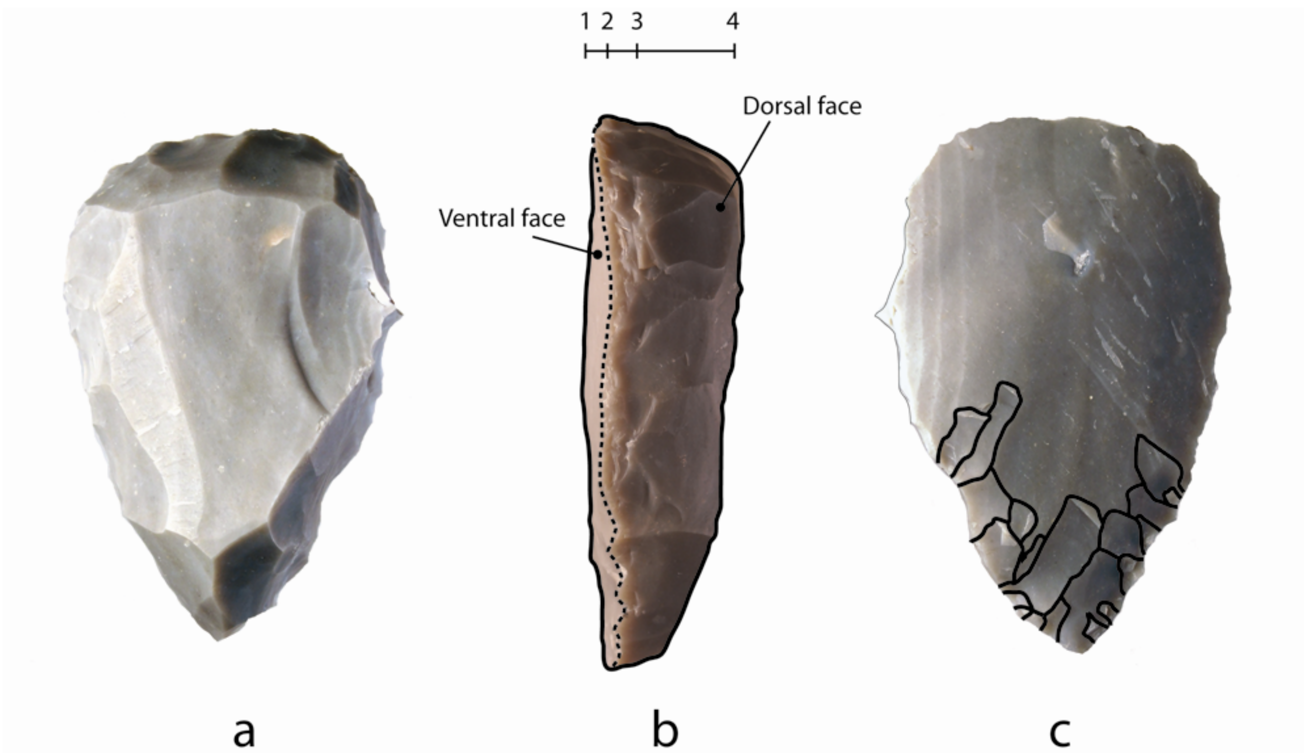


**Figure 2**. The three requirements of identifying a unifacial stone tool are that there is retouch on the specimen's dorsal face (a); that the intersection of the ventral and dorsal faces (b2) is no more than one third (b1 to b3) of the specimen thickness (b1 to b4); and that if there is retouch on the ventral face, it must not cover more than 50% of that face (c).

use.

Another factor that is thought to influence the transport costs of mobile toolkits is whether tools are hafted. It is well known that hafting engineers particular functional advantages (Keeley 1982; Morrow 1996; Wilmsen 1971: 71), such as magnifying a tool's potential for distal load (Rule and Evans 1985: 214-215), and possibly facilitating the functionality of small, short specimens (Ellis 2008: 302; Semenov 1964: 88). But, as Morrow argues (1996: 587-588), since a hunter-gatherer is only capable of carrying a toolkit with a certain fixed maximum weight or volume, and since many informal and formal flake tools can be profitably used by hand (Cox 1986; Keeley 1982; Semenov 1964: 87; Shott and Sillitoe 2005), the inclusion of tool-handles would ostensibly consume a portion of the toolkit that otherwise could be dedicated to more functionally versatile and flexible stone flakes. In other words, "a transported tool kit incorporating many small, specialized stone tools would also require the added costs of carrying many specialized tool handles" (Morrow 1996: 587-588) and "could result in a less portable toolkit" (Ellis 2008: 302).

For these reasons, I hypothesized that the unifacial stone tools of Clovis colonizers in the Lower Great Lakes would have been habitually hand-held, rather than regularly hafted. The design of the analysis to investigate this hypothesis expands upon the work of Clovis and non-Clovis case studies from the Lower Great Lakes region and beyond in several ways (e.g., Ellis 2004: 65; Ellis and Deller 2000; Jackson 1998; Lothrop 1988; MacDonald 1985; Rule and Evans 1985; Shott 1993, 1995; Storck 1997; Tomenchuk 1997). First, a previously unexamined variable in arguments for/against hafting was assessed: richness. Richness is the count of the number of classes or species present in an assemblage (Chao 2005), and it was particularly well-suited here for making predictions from the archaeological record (see below). Second, attributes that are often used in arguments for/against hafting, like notches and spurs,

**Table 1**. Dimensions and features used for the classification of unifacial stone tool edges.

| Dimension | Features | | | |
|---|---|---|---|---|
| **Edge angle** | 0-30 degrees | 31-60 degrees | 61-90 degrees | > 90 degrees |
| **Edge shape** | Convex | Concave | Straight | |
| **Notch presence** | One notch present | Two or more notches present | Zero notches present | |
| **Spur presence** | One spur present | Two spurs present | Zero spurs present | |

were quantitatively defined to eliminate the usual "appeals to authority" explanations common in typological and technological assessments of stone tools. Third, rather than examine a unifacial stone tool specimen as a whole, explicit quantitative predictions were constructed specific to unifacial stone "tool-sections." A unifacial stone tool was divided into four constituent tool-sections in order to facilitate comparison of edge class richness, and individual attributes, between them (Figure 1). Details regarding how the edge classes were constructed are available in the "Methods and Materials" section below. Fourth, rather than make an argument for or against hafting based on individual tools or sites, the present work examines evidence for habitual hafting on a regional level by combining the datasets of seven Clovis base-camp sites from the Lower Great Lakes region. This strategy resulted in the examination of 3,736 unifacial stone tool-sections compiled from 1,188 Clovis unifacial stone tools.

For the sake of clarity, I emphasize here that the investigated hypothesis and its null are not examining *if* hafting occurred. "Technological" and use-wear investigations of individual artifacts at isolated sites in the Lower Great Lakes region strongly suggest that hafting did sometimes occur within particular tool "types" (Jackson 1998; Loebel 2012; Lothrop 1988; Shott 1995). Instead, the analysis of a large, multi-site database of a broadly defined tool class—unifacial stone tools—allowed me to examine if hafting occurred *regularly*. The predictions of the present hypothesis and its null were constructed with this distinction in mind. But before turning to them, one more caveat is necessary. The emphasis in this study is on *morphology* (i.e., shape), not "*technology"* (i.e., how that shape was achieved, e.g., basal thinning, pressure retouch). The reason for this is as follows. If an unmodified tool-section was already, albeit roughly, the appropriate shape for hafting (e.g., Keeley 1982: 805-807; Weedman 2002: 734), it would not need basal thinning or secondary retouch. Thus, if a stone tool analyst depended on so-called "technological" attributes perceived to indicate hafting, many specimens that might have in reality been hafted would be mistakenly identified.

## Predictions

*Prediction #1: Edge Class Richness per Tool-Section*

If unifacial tools were regularly hafted by Clovis foragers in the Lower Great Lakes, then we should expect to see less morphological edge class richness in the proximal tool-section than in the distal and lateral tool-sections. The rationale for this prediction is two-fold. First, it is reasonable to propose on both logical and ethnographic grounds that handles would have had stone tools fitted to them, as opposed to handles altered to fit different stone tool shapes (Keeley 1982). Indeed a number of researchers have suggested that Paleoindian unifacial tool proximal sections were modified in particular ways to fit into a handle (Cox 1986; Rule and Evans 1985: 216; Shott 1995). If this were indeed the case *and occurred regularly on a broad scale*, then the morphology of proximal tool-sections should have been more standardized relative to the morphologies of the distal or lateral tool-sections, in turn resulting in less overall richness of proximal tool-section morphological edge classes. The second rationale for prediction #1 is that if proximal tool-sections were indeed hafted, then they would have been more or less unalterable while contained within the handle socket or binding. Thus, relative to other tool-sections, proximal-tool sections should show less morphological edge class richness because they could not be modified for the purposes

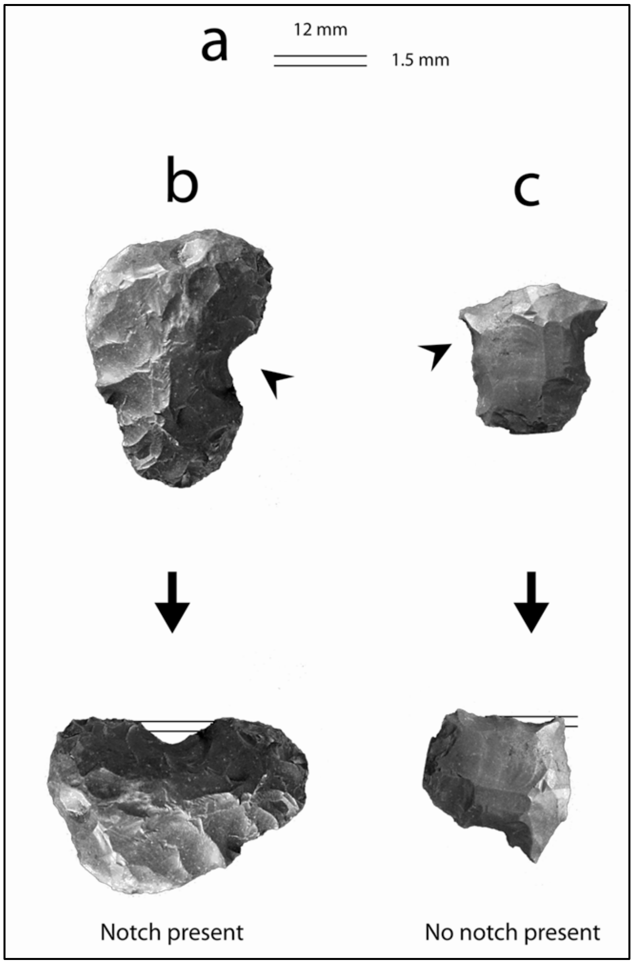


**Figure 3**. Two examples of how the presence of notches was determined. A box of 12 mm by 1.5 mm was constructed (a). A notch was any section of the edge less than 12 mm in length that possessed a concavity of more than 1.5 mm (b) (compare with c).

of rejuvenation or alteration of a tool's primary function[1].

Alternatively, if unifacial stone tools were *not* regularly hafted by Clovis foragers in the Lower Great Lakes region, which here is the favored premise, then we should expect to see similar amounts of edge class richness among all four tool-sections. This is because there would have been no impetus to standardize the proximal tool-section, and all four tool-sections would be available for use and modification.

*Prediction #2: Spur and Notch Frequency per Tool-Section*

There has been debate about the behavioral significance of spurs and notches present on Paleoindian unifacial stone tools. Some researchers maintain that spurs and notches were functionally intended for various tasks, while others have suggested that these items are merely the incidental result of retouch and edge rejuvenation (e.g., Deller and Ellis 1992: 41; Grimes et al. 1984; Jackson 1998: 96-101; Rule and Evans 1985; Weedman 2002). In spite of these debates, we can still predict that if unifacial tools were regularly hafted by Clovis foragers in the Lower Great Lakes region, then we should see a lower frequency of spurs and notches on the proximal tool-section than on the distal and lateral tool-sections. This is because if a proximal tool-section was contained within a handle socket or binding there would have been little chance for the creation of notches or spurs via retouch and rejuvenation - regardless of whether an intention was actually present to create notches or spurs.

Alternatively, if unifacial stone tools were not regularly hafted by Clovis foragers, then we should see similar frequencies of notches and spurs among the four tool-sections since each could have been used and rejuvenated with equal opportunity.

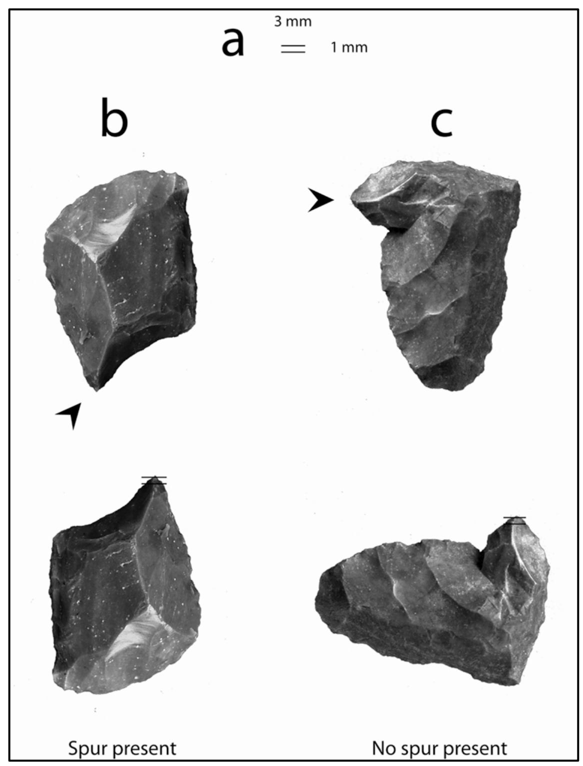


**Figure 4**. Two examples of how the presence of spurs was determined. A box of 3 mm by 1 mm was constructed (a). A spur was any projection no wider than 3 mm, but at least 1 mm long (b) (compare with c).

**Table 2**. Counts of unifacial stone tools, unifacial stone tool edges, and unifacial stone tool-sections from the seven Clovis sites assessed in this study.

| Site | Unifacial stone tool specimens | Total edge specimens | Distal edge sections | Proximal edge sections | Left lateral edge sections | Right lateral edge sections |
|---|---|---|---|---|---|---|
| Arc | 250 | 834 | 200 | 170 | 233 | 231 |
| Butler | 70 | 272 | 69 | 64 | 70 | 69 |
| Gainey | 64 | 203 | 46 | 43 | 59 | 55 |
| Leavitt | 71 | 222 | 51 | 44 | 62 | 65 |
| Paleo Crossing | 401 | 1220 | 278 | 241 | 362 | 339 |
| Potts | 123 | 351 | 78 | 67 | 101 | 105 |
| Udora | 210 | 634 | 148 | 137 | 173 | 176 |
| **SUM** | **1189** | **3736** | **870** | **766** | **1060** | **1040** |

## Materials and Methods

*Defining Unifacial Stone Tools*

"Unifacial tools" were defined following the three criteria of Eren (2011; see also Eren and Andrews 2013 ;Eren et al. 2012), namely:

(1) Volumetrically, the edge where the ventral and dorsal faces of a flaked stone tool meet must be, on average, located no more than one third the distance of maximum tool thickness from the ventral face,

(2) There must be retouch on the dorsal face of the tool, and

(3) In the event that there is retouch on the ventral face (e.g., bulb thinning flakes), the retouch must not cover more than 50% of the ventral face's area.

These criteria were established as generalized guidelines to facilitate the stipulation of the field to be analyzed (see Dunnell 1971: 52), and were assessed visually (see Figure 2). Importantly, while the majority of the analyzed artifacts would otherwise be labeled as "endscrapers" by archaeologists, the three criteria also require in the analyzed sample the inclusion of artifacts archaeologists would label as "sidescrapers," "retouched flakes," and "gravers," among others. The implications of this choice for the present analysis will be discussed further in the "Discussion" section below.

*Prediction #1 Data: Edge Class Creation*

Criteria for a paradigmatic classification were devised to classify the morphological shape of a unifacial stone tool's constituent parts, here defined as its four edges: distal, proximal, left lateral, and right lateral. This edge shape paradigmatic classification included four dimensions: edge angle, edge shape, notch presence, and spur presence (Table 1). Respectively, these dimensions possessed four, three, three, and three features, for a total of 108 possible classes (4*3*3*3 = 108). For further details on the dimensions and features of the paradigmatic classifications used here, see the supplementary materials from Eren et al. (2012), which are freely available for download.

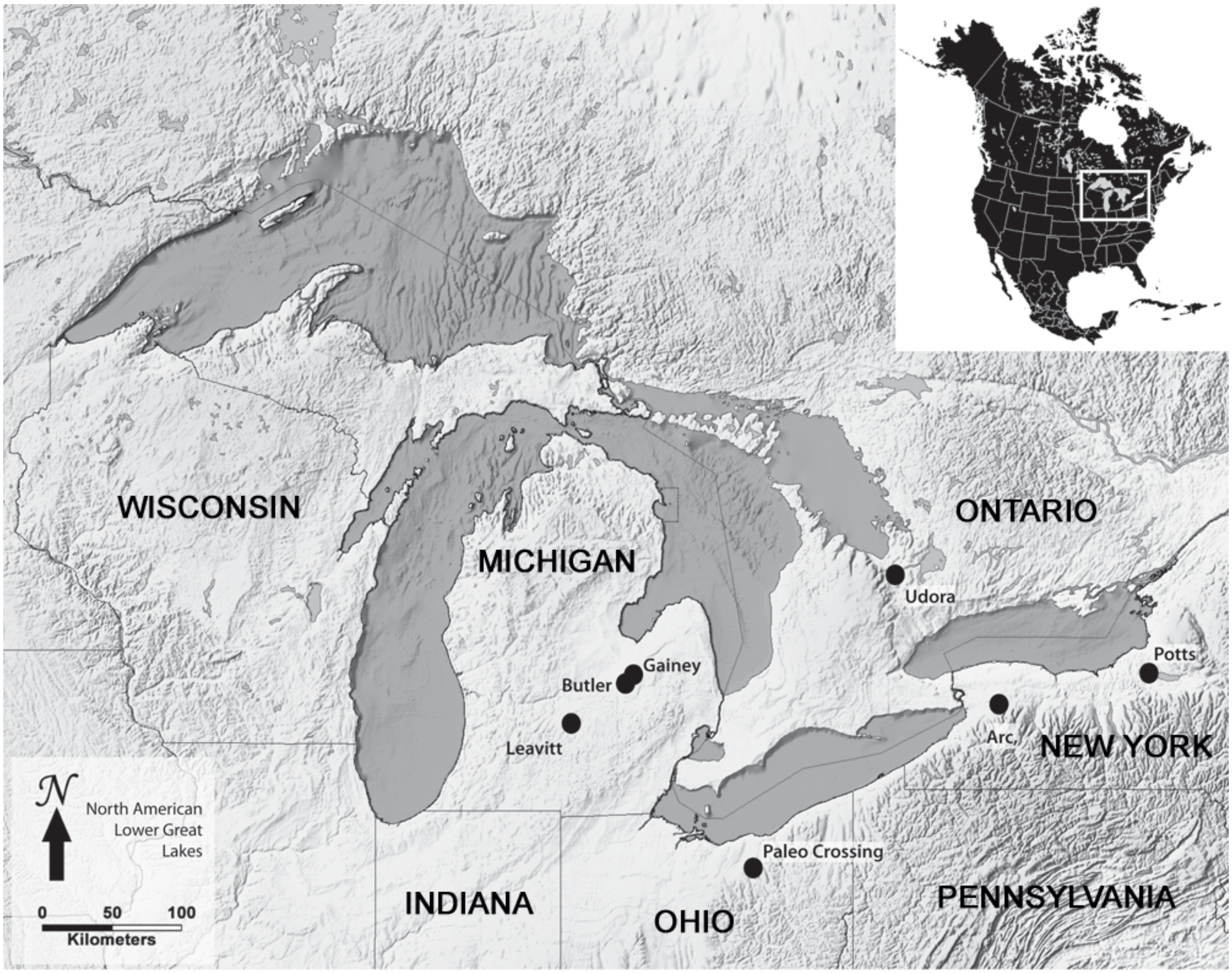


**Figure 5**. The Lower Great Lakes and locations of sites from which data were collected.

*Testing Prediction #1: Assessing Edge Class Richness per Tool Section*

The amount of proximal tool-section edge class richness relative to that of other tool-sections can be tested in three ways. First, a simple count of the number of classes present in an assemblage can be taken, here referred to as "Raw Richness." However, as noted by numerous researchers, this measure can be influenced significantly by sample size (Bobrowsky and Ball 1989; Shott 2010), necessitating some sort of calibration that standardizes, eliminates, or neutralizes differences in sample size. This brings us to the second test. "Estimated Richness" is calculated through rarefaction. First proposed by Sanders (1968), but revised by Hurlbut (1971), rarefaction is a method for analyzing the number of species or classes when all assemblages are standardized for sample size. Hurlbut's (1971: 581) calculations provide the expected number of species (E(Sn)) in a sample of n individuals selected at random, without replacement, from a collection containing N individuals and S species. Using Analytical Rarefaction (Version 1.4, Steve Holland), a 95% confidence interval of the estimated richness value can be calculated, allowing statistical comparison of different assemblages (population). While rarefaction is a powerful method for comparisons of richness, Hughes et al. (2001) note an important drawback: rarefaction only compares samples, not entire assemblages. Thus, "true" richness is impossible to gauge with rarefaction.

Since rarefaction cannot be used to estimate total assemblage (asymptotic) richness, the nonparametric

**Table 3**. Sample size and richness per tool-section.

| Tool-section | n | Richness |
|---|---|---|
| Distal | 870 | 35 |
| Proximal | 766 | 24 |
| Left lateral | 1060 | 44 |
| Right lateral | 1040 | 38 |

estimator Chao1 (Chao 1984) can be used to predict that value. The Chao1 measure proceeds on the assumption that "rare species carry the most information about the number of missing ones" (Chao 2005: 7) and thus uses only singletons (the classes represented by only one specimen) and doubletons (the classes represented by two specimens) to estimate the number of additional missing species or classes. A 95% confidence interval of the predicted richness value can be calculated, but because paradigmatic classification imposes a fixed maximum of possible classes, doubly-bound confidence intervals were calculated using the method presented in Eren et al. (2012).

*Prediction #2 Data: Defining Notches and Spurs*

A notch was arbitrarily defined as any section of the edge less than 12 mm in length that possessed a concavity of more than 1.5 mm (Figure 3). A box of these dimensions was drawn and potential notches were fit into it in order to determine whether they met the metric requirements. Likewise, a spur was arbitrarily defined as any projection at least 1 mm long and no wider than 3 mm (Figure 4).

*Testing Prediction #2: Assessing Notch and Spur Frequency per Tool-Section*

Although the paradigmatic classification used to test prediction #1 includes both notch and spur presence as dimensions, assessments of edge class richness only analyze their contribution to the number of morphological classes when combined with other features, not their individual frequency (count). To analyze the differences in frequency of notches and spurs per tool-section, I used the nonparametric chi-squared test. Chi-square allows us to compare observed data with data we would expect to obtain according to a particular hypothesis.

*Archaeological Data Sets*

The unifacial stone tools came from seven Lower Great Lakes Clovis base-camp sites: Arc, Butler, Gainey, Leavitt, Paleo Crossing, Potts, and Udora (Figure 5). All these sites possess diagnostic artifacts, and some possess chronometric evidence, that indicate they are Clovis sites. The unifacial stone tool, and edge, sample sizes are provided in Table 2.

## Results

*Edge Class Richness per Tool-Section*

The raw edge class richness values of the four tool-sections are presented in Table 3. The proximal tool-section yields the least amount of richness, which is consistent with the notion that unifacial stone tools were indeed regularly hafted. However, there appears to be a strong correlation between sample size and edge class richness (Figure 6), suggesting that the former is driving the latter.

We can therefore standardize the sample sizes via rarefaction. Setting the sample size for each tool section at 700, we find the 95% confidence intervals support the initial assessment: the proximal tool section does indeed yield significantly less richness than

**Table 4**. Results of the rarefaction analysis.

| Tool-section | E(n) | $E_{700}$ Mean | Variance | 95% CI |
|---|---|---|---|---|
| Distal | 700 | 32.1 | 2.29 | 29.17 - 35.10 |
| Proximal | 700 | 23.2 | 0.71 | 21.57 - 24.87 |
| Left lateral | 700 | 38.1 | 3.98 | 34.22 - 42.04 |
| Right lateral | 700 | 34.5 | 2.49 | 31.37 - 37.56 |

the other three tool sections, whose confidence intervals all overlap (Figure 7, Table 4). This result supports the prediction that unifacial stone tools were regularly hafted.

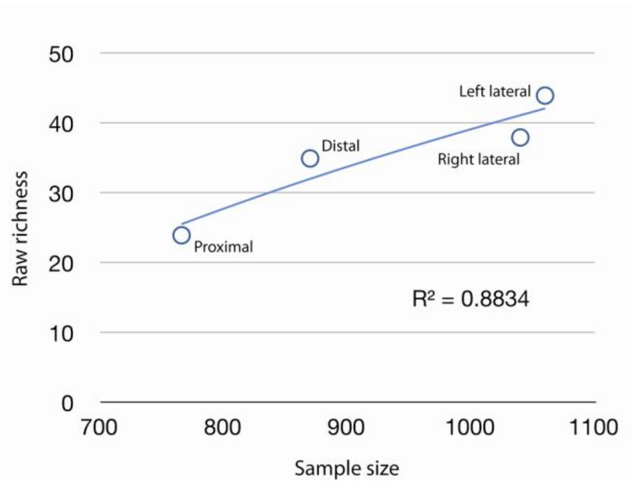


**Figure 6**. The relationship between sample size and tool-section edge class richness.

Applying the Chao1 estimator with doubly-bounded confidence intervals, we find that the mean proximal tool-section richness value is less than the mean distal tool-section richness value, but not less than the mean richness values of the lateral tool-sections (Figure 8, Table 5). However, the proximal tool-section confidence interval is wider than the rest, implying a larger standard error due to a sparse number of doubletons and singletons, and thus this result may not be reliable (Anne Chao, personal communication).

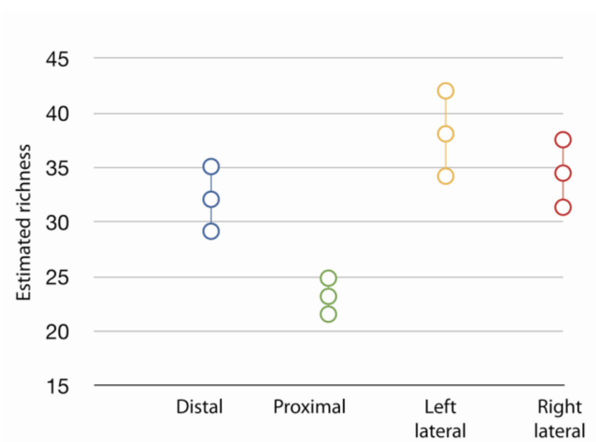


**Figure 7**. Tool-section edge class richness measured via rarefaction, indicating the proximal tool-section possesses statistically less richness than the other three tool-sections.

*Notch and Spur Frequency per Tool-Section*

The frequency of notches per unifacial stone tool-section is provided in Table 6. The frequency of notches occurring on the proximal tool-section is significantly less than both the distal (chi-square with yates correction = 7.58, p = 0.0059, df = 1) and lateral tool section (chi-square = 105.42, p < 0.0001, df = 2)[2].

The frequency of spurs per unifacial stone tool-section is provided in Table 7. The frequency of spurs occurring on the proximal tool-section is not significantly less than the distal tool-section, but the difference is tending toward statistical significance (chi-square = 3.51, p = 0.0610, df = 1). The frequency of spurs on the proximal tool-section is significantly less than the lateral tool-sections (chi-square = 12.98, p = 0.0015, df = 2).

The notch and spur frequency data are generally consistent with the notion that Lower Great Lakes Clovis unifacial stone tools were regularly hafted.

## Discussion

Following Morrow (1996), I hypothesized that Clovis colonizing foragers would not have regularly hafted their unifacial stone tools in order to minimize toolkit portability and maximize raw material use. However, overall, the tests of tool-section richness and attribute frequency do not support this hypothesis. Instead, the results are consistent with the proposal that Clovis unifacial stone tools were habitually hafted in the Lower Great Lakes region. Furthermore, these results in favor of habitual hafting come *in spite of* our definition of "unifacial stone tool," which incidentally included artifacts that have not traditionally been considered by archaeologists to have been hafted, like "retouched flakes," "sidescrapers," and "gravers." In other words, not only do the results support the notion that unifacial stone tools were regularly hafted, they do so in defiance of non-endscraper "noise" concomitant with our analytical definition of "unifacial stone tool."

This result in no way should be interpreted to mean that Clovis unifacial stone tools from the Lower Great Lakes were *always* hafted, or that the proximal tool-section was never used. Some proximal tool-sections, rather than being stuck in a haft, could have been the functionally working section, occasionally retouched in a manner similar in appearance to distal or lateral "scraping" morphologies (e.g., see Ellis and Deller 1988: 115-116). In addition, at Paleo Crossing

**Table 5**. Results of the Chao1 analysis.

| Tool-section | Mean predicted richness value | 95% CI | Singletons | Doubletons |
|---|---|---|---|---|
| Distal | 67.66 | 42.83 - 103.07 | 14 | 3 |
| Proximal | 64.60 | 29.68 - 103.04 | 9 | 1 |
| Left lateral | 48.12 | 40.25 - 80.35 | 15 | 6 |
| Right lateral | 62.75 | 49.41 - 96.83 | 9 | 4 |

the proximal tool-section morphology of some select specimens appears to have been used for engraving or boring (Figure 9), but this assertion needs to be tested with use-wear analysis (see Tomenchuk and Storck 1997).

Nevertheless, the results are in contrast to the favored hypothesis, and therefore the two are in need of reconciliation. Why would foragers *regularly* haft their unifacial stone tools if the latter can be profitably used by hand, and hafts would either reduce toolkit mobility or occupy space that could otherwise be dedicated to toolstone? In other words, why would colonizing foragers in the Lower Great Lakes go to the trouble of optimizing the mobility of their toolkits in one regard (Eren and Andrews 2013), only to seemingly negate that gain in another (i.e., via hafting)? To reiterate Morrow's (1996: 587-588) stance from above, "In short, a transported tool kit incorporating many small, specialized stone tools would also require the added costs of carrying many specialized tool handles."

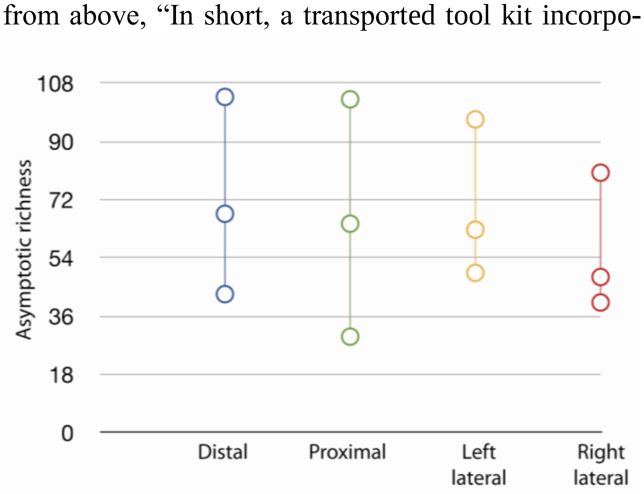


**Figure 8**. Tool-section edge class richness estimated via the Chao1 nonparametric estimator indicated the proximal tool-section yielded less richness than the distal tool-section, but more richness than the lateral tool-sections. However, the wide 95% confidence interval implies a larger standard error due to a sparse number of doubletons and singletons, and thus the result may not be reliable.

But would it? One should note that the use of the word "many" in Morrow's (1996) statement is an assumption, not a fact. Keeley (1982) makes the point that,

> Because the handle or shaft is usually more "expensive" than the tool that arms it, it follows that the former would be regarded as especially valuable, and therefore highly curated and carefully conserved, while the hafted tool would be replaced several times during the use-life of the haft.

The analysis of tool-section morphological class richness above implies a degree of standardization in proximal tool-sections that suggests that Lower Great Lakes Clovis foragers were indeed fitting numerous tools to finite hafts (see also Shott 1995: 58). As such, if there were only a handful of handles, presumably made from raw materials lighter than stone like wood or bone, the added cost of carrying them may have been minimal (e.g., Surovell 2009: 150).

Alternatively, perhaps Lower Great Lakes Clovis colonizers postponed haft manufacture until they reached their destination. Unlike knappable stone, raw materials for hafts, like wood, can be ubiquitous in certain landscapes. During the Clovis colonization of the Lower Great Lakes, the environment is often referred to as a "spruce parkland," also including flora like pine, oak, elm, ash, and birch (e.g., Ellis and Deller 2000; Eren 2009; Shane 1994; Shane and Anderson 1993; Shuman et al. 2002). In this situation, the question for optimizing toolkit portability might seem to shift from *whether* colonizing foragers should haft, to *when*—a question not currently testable with the current resolution of the archaeological record. However, in this scenario Morrow (1996: 588) still

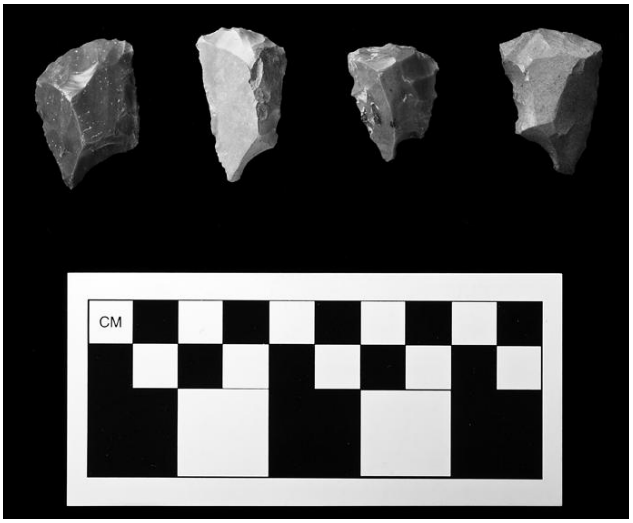


**Figure 9**. Examples of possible boring tools manufactured on the proximal tool-sections of specimens from the Paleo Crossing site, Ohio.

asserts that delaying handle manufacture would still decrease toolkit portability because "extra lithic tools would be needed to make them [the handles]." But if unifacial stone tools were being fit to handles, and not *vice versa*, then only a limited number of handles would need to be produced. In turn, only a limited number of "extra lithic tools" would need to be included in the portable toolkit, *if any* –after all, we have no empirical evidence one way or another directly speaking to the maximum functional capacity of a "normal" Paleoindian lithic toolkit, whatever that might look like. Ethnographic studies show that wood handles may only require carving (Weedman 2006, and Personal Communication), a task that conceivably could have been accomplished with only a few flakes, easily within the confines of the "usual" toolkit (again, whatever that might look like). Furthermore, experimental archaeology shows that handles can be made expediently in a variety of innovative ways (Baker 2009; Judge 1973; Wadley 2005), which should cause us to question the perception that a large number of "extra lithic tools" would have had to be carried by Paleoindian to manufacture handles.

**Table 6**. Counts of notch presence per tool-section.

| Tool section | Notch present | No notch present |
|---|---|---|
| Distal | 41 | 829 |
| Proximal | 16 | 750 |
| Left lateral | 220 | 840 |
| Right lateral | 180 | 860 |

## Conclusions

Analyses of tool-section morphological class richness and attribute frequency support the notion that unifacial stone tools were habitually hafted by Clovis colonizing foragers in the North American Lower Great Lakes region. Because this result contradicted the hypothesis favored by this researcher, namely that Clovis foragers would not have regularly hafted their unifacial stone tools, it prompted a brief reexamination of the perception that hafting increases toolkit transport costs. That reexamination indicated that the use of handles for unifacial stone tools may not *necessarily* have reduced toolkit portability, calling into question the foundational premise of the favored hypothesis and suggesting that the hafting of unifacial stone tools is not inevitably opposed to the goal of optimizing tool-kit portability.

**Table 7**. Counts of spur presence per tool-section.

| Tool section | Spur present | No spur present |
|---|---|---|
| Distal | 94 | 776 |
| Proximal | 61 | 705 |
| Left lateral | 139 | 921 |
| Right lateral | 129 | 911 |

The results of this study indicate that the focus of future research should now center on *why* Clovis colonizing foragers in the Lower Great Lakes regularly hafted their unifacial stone tools. Two commonly held ideas often come to the fore. First, as mentioned in the introduction of this manuscript, hafting provides certain mechanical advantages (Keeley 1982; Morrow 1996; Wilmsen 1971: 71). Second, hafting may extend the use-life of small tools that would otherwise be difficult to use solely by hand (Semenov 1964; Ellis 2008). These ideas are not mutually exclusive, and the challenge for future research will be to show in specific contexts whether one, both, or conceivably neither, of these postulations was influencing prehistoric forager decisions with regard to the complexity and design of their tools. Given that colonizing foragers should be especially economical in toolkit construction, research examining the second proposal, namely the relationship between hafting and unifacial stone tool use-life, might shed much light on the organization of Clovis toolkits in the Lower Great Lakes region.

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## Notes

1. Clearly, it is an assumption that proximal tool-sections would be entirely contained in the haft, as opposed to distal or lateral tool-sections. However, on the population level, to my mind it is a reasonable assumption because use-wear analysis consistently shows working edges to be located on the distal or lateral sections of unifacial tools (e.g., Loebel 2012).

2. The reader might note that the lateral tool-sections also possess significantly more notches than the distal tool-section (chi-square = 104.91, $p < 0.0001$, df = 2). This result supports the notion that in addition to being used for functional tasks, or incidentally occurring as a result of resharpening or recycling, lateral notches also served to facilitate hafting. Otherwise, we might predict that the frequency of notches on distal and lateral tool-sections be similar. Indeed, that parts of lateral tool-sections were contained in the haft is supported by use-wear (Loebel 2012).

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