Pattern or bias? A critical evaluation of Midwestern fluted point distributions using raster based GIS

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Abstract
Because the abundance and distribution of fluted points has long played a critical role in interpreting various colonization and settlement scenarios of North America, correlations made between fluted point distribution and patterns of Early Paleoindian land use need to be critically evaluated. Gauging not just the source, but also nature of bias within distributional data of this sort is important if we are to improve the accuracy and reliability of our inferences concerning the timing, source, and mode of the radiation of human populations throughout the western Hemisphere. In this study, I employ a raster based GIS approach using a continuous non-site distribution of fluted biface distributions across a twenty-nine county (46,000 km²) study area of northern Illinois. The results suggest that when sources of bias are revealed and controlled for, significant settlement patterning can not only be identified, but more accurately interpreted.

1. Introduction

Archaeologists have long been concerned with the patterns behind the abundance of archaeological remains across the landscape. Distributions of artifacts and sites have often been interpreted as accurately reflecting the presence of prehistoric peoples across the landscape. Because inferences made regarding prehistoric behavior are in reality, based on a sample of the archaeological record, we need to identify and examine biases that may be conditioning the reliability of such inferences. The integration of archaeological data into Geographic information systems (GIS) based models offers a powerful means to analyze data using a host of geospatial variables to identify potential biases and explore underlying patterns attributable to prehistoric human behavior. With the knowledge that multiple sources of bias are in operation, researchers need to address the question of how much of the archaeological record accurately reflects Paleoindian land use, and how much is the result of sampling and other biases.

The distribution of fluted points has long played a critical role in interpreting various colonization and settlement scenarios of North America, therefore, correlations made between fluted point densities and patterns of Early Paleoindian land use need to be critically evaluated. Here, through the use of a raster based GIS approach, I explore the patterning and bias present within fluted point data from northern Illinois. This approach not only allows for the identification of the source and nature of potential biases, but also provides a means of evaluating the accuracy of the inferences of Paleoindian land use made based on distributional patterns of fluted points.

2. History of fluted point distributional studies

Building on earlier work by Quimby (1958), Ron Mason (1962) published a seminal article that began a shift from concentrating on Paleoindian artifact discovery and description towards defining regional issues of Paleoindian adaptation and land use. In that publication, Mason suggested that although the Western U.S. had provided the bulk of available information for the Fluted Point Tradition, the shear numbers and typological diversity of fluted points found in the eastern U.S. also held implications regarding the origins and antiquity of Humans in the New World (Mason, 1962: 235). Mason acknowledged the possibility of modern bias within the record; however, he did not know how or to what degree this bias was in operation. The editorial discussions that followed the publication of these pioneering studies marked the beginnings of modern fluted point surveys.

County-level counts were one of the first units employed in fluted point surveys, and most subsequent studies have continued to survey and examine the distribution of fluted points using county level data (Anderson and Faught, 1998, 2000; Anderson and Faught, 2000; Anderson and...
Gillam, 2000; Bever and Meltzer, 2007; Billeck, 1998; Blackmar, 2001; Brennan, 1982; Buchanan, 2003; Chapman, 1975; Daniel, 2000; Higginbottom, 1996; Hofman, 1994; Hofman and Hesse, 1996; Lantz, 1984; Largent et al., 1991; Lepper, 1983; Meltzer, 1986; Meltzer and Bever, 1995; Morrow and Morrow, 1994; Prasciunas, 2011; Seeman and Prufer, 1982; Shott, 2002; Stoltman and Workman, 1969; Tankersley et al., 1990). Typically, regional or statewide counts of fluted points have been compiled; with the resulting county-by-county densities used to infer the character of Early Paleoindian land use. Most researchers have readily acknowledged the potential presence of biases in these studies, but few have attempted to gauge the source of potential biases that may be present. Notable exceptions include Seeman and Prufer's (1982, 1984) and Lepper's (1983, 1985) discussions concerning the effects of modern land use and population densities in the eastern U.S., Meltzer's (1986) exploration of the effects of collector activity in Texas, Wiánt (1993) examination of Paleoindian site distributions in Illinois, Shott's (2002) study of sample bias in fluted biface density in the Midwest, and Buchanan's (2003), and Prasciunas (2011) examination of sample bias on fluted point recovery in the U.S. Each of these studies found significant evidence that fluted point densities and/or site locations were at least partially equated with intensity of prior archaeological research, level of collector activity, modern population distributions, geomorphic processes, and modern land use practices. Ultimately, the majority of these approaches have only demonstrated the presence of various biases, without the ability to gauge the effect of biases in operation across each study area. While previous distributional studies have certainly added important insights into our understanding of regional adaptations during the Late Pleistocene, their results also reinforce the limitations and problems researchers are faced with when attempting to use distributional data to address questions of Paleoindian land use. When we can identify not just the source but also the extent and effects of any such biases in operation across a study area, our understanding of Late Pleistocene hunter-gatherer land-use will ultimately improve.

3. Identifying bias and patterning in fluted point distributions

To accurately infer the land use patterns of early Paleoindian groups, researchers must qualify the reliability of the archaeological dataset, refine the grain at which they examine the archaeological record, and employ meaningful and comparable units of analysis. Counties, while serving as convenient contrivances to measure distributions across the landscape (Shott, 2002), do not represent an even grid system across the landscape and frequently cross-cut physiographic regions that may have influenced hunter-gatherer settlement systems. On the other hand, counties are numerous, spatially bounded, are convenient to define study areas, and are the most often, if not the only record of provenience recorded for many items (Shott, 2002). However, what is needed is a detailed record of continuous fluted point distributions across the landscape, not one that is averaged over larger landscape units. Shott (2002, 2005) has noted that the known archaeological record is often a refraction rather than a reflection of the actual record.

4. Methodology and study area

The absence of data concerning the Early Paleoindian period in the western Great Lakes area reflects the lack of research as much as anything else, as little or no systematic long-term efforts have been directed towards this region since Stoltman and Workman’s, 1969 work in Wisconsin. The dearth of available information has given scholars the impression that this area saw limited occupation during the Early Paleoindian period, and often precludes the inclusion of this area in current studies (e.g., Shott, 2001, 2002, 2005; Tankersley, 1989). In an effort to assemble a regional database to address questions concerning Early Paleoindian land use, chipped stone tool technology, and lithic raw material use in Illinois and Wisconsin, an on-going research effort directed at synthesizing information through excavation, examination of public and private collections, and archival research is underway (Loebel, 2005, 2007).

Although counties are in general, often inadequate to capture the nature of Early Paleoindian settlement systems, they are useful for defining study areas, and are used as such in the present study. In addition, the majority of available GIS data is generated on a county level basis, forcing the need to bound and examine the study area on a county level basis. A study area encompassing over 46,000 km² and defined by the northern 29 counties of Illinois was selected for a GIS raster based analysis of fluted point distributions (Fig. 1). The distributional data used in this study, however cross cuts county boundaries and is examined on a continuous distribution across the study area.

A GIS database maintained by the Illinois Archaeological Survey (IAS) containing 382 sites reported as having Paleoindian components was obtained from the Illinois State Museum (ISM). Using GIS ArcInfo, all site locations were reprojected into common Zone 16 Universal Transverse Mercator coordinates, converted into ArcView compatible files and plotted. Within the existing IAS registry, Early Paleoindian sites are not distinguished from Late Paleoindian sites, and as a result, any plot of sites is a palimpsest masking potential patterning due to cultural and/or chronological variation. Therefore, all site files were individually reviewed to assign an appropriate temporal component. Problems within the site files were apparent after examination of material from 37 of these sites curated at the ISM, as only 5 could be confirmed as having a fluted point component. Many sites were assigned a Paleoindian component based solely on the presence of unifacial endscrapers. Endscrapers, although ubiquitous within Early Paleoindian assemblages, are an unreliable temporal marker. A large number of the assemblages examined were diagnostic of later cultural components such as Dalton or Agate Basin.

At this point I should clarify my use of the terms “Early Paleoindian” and “Fluted Point” as representing general Clovis aged occupations within the study area. I concede that many of the fluted points documented within this survey would be considered Gainey points by other researchers, however, at this point I prefer to use the term Clovis/Gainey due to the morphological, technical, and chronological variations within the Clovis complex which are not well understood. In addition, the typological differences between finished Clovis and Gainey points have been overemphasized (Amick et al., 1999; Koldehoff, 1999; Mason, 1997). Given the lack of stratified, excavated samples and associated radiocarbon dates I feel it is more prudent to view Gainey as a Great Lakes variant of Clovis and that the term Gainey is currently most useful to denote a geographical implication or distributional range (Loebel, 2005). Current age estimates for Clovis/Gainey occupations of the Great Lakes region suggest a date close to 10,900 C 14 as available radiocarbon dates from sites within the area such as Sheridan Cave, Paleo Crossing, and Shawnee-minisink indicate (Waters and Stafford, 2007).

Sites were placed into one or more of the following categories if sufficient description, drawings, or inspection enabled a confident level of identification: Clovis/Gainey, Folsom, Dalton, Late Paleoindian (includes items described as Agate Basin, Plainview, Beaver Lake, or Unfluted Lancelote), or unspecified Paleoindian. As a result, 147 Clovis, 6 Folsom, 61 Dalton, and 91 Late Paleoindian designations were ascribed. In compiling designations, I erred on the side
of caution. In the end, 102 sites were omitted due to insufficient description, missing information, or misidentification. I encountered a similar situation when reviewing and compiling fluted data for Wisconsin, when I could only verify less than half of the reported Paleoindian sites reported within the Wisconsin state site files (Loebel, 2007). Remaining sites were entered into an excel spreadsheet and imported into an Arc/Info coverage, plotted (Fig. 2), and the coverage “clipped”, resulting in 39 State File sites with confirmed Fluted Point components located within the study area (Fig. 3, Table 1).

In reality, professional archaeologists seldom recover fluted points. Historically, the majority of fluted points and fluted point sites have been discovered and reported by private individuals. For example, nearly 75% percent of the fluted point sites registered within the Illinois state site files were recorded as a result of finds made by amateur archaeologists. Meltzer (1986) encountered a similar situation during the Texas fluted point survey, as did LaBelle (2003) during work in eastern Colorado. Most Paleoindian sites are low-density lithic scatters in need of repeated collection to yield diagnostic artifacts, and cultural resource management seldom affords this opportunity. The low probability of accurately identifying Paleoindian sites during single collection CRM survey suggests that these sites are frequently misdiagnosed and “written-off” as small lithic scatters unworthy of additional investigation. As a result, sites of this time period are generally under-represented in most state site files. To restrict Paleoindian studies to only those materials recovered during professional archaeological investigations would severely limit the amount of available data and create a significant bias in its own right (Amick, 2002: 160; LaBelle, 2003: 119). Because of the nature of the Paleoindian record researchers must work with the private sector to actively record data if we are to obtain satisfactory and representative samples (Shott, 2002: 118).

The Illinois state site file data was supplemented by an intensive survey of private collections, yielding 153 previously undocumented fluted points from the study area (Loebel, 2005). As a result, over 68% of the study sample is a product of the documentation of private finds. In order to maximize the reliability of provenience information, an effort was made to target personally collected items in the possession of noncommercial collectors and avocational archaeologists, and to avoid specimens that had traded hands extensively. All artifacts were personally examined, assigned a Fluted Point Survey (FPS) identification number, measured, photographed, and drawn. Owners were interviewed about collecting habits and asked to plot find locations on either an Illinois DeLorme Gazetter 1:62,500 atlas, United States Geological Survey 7.5' topographic maps, and/or County Plat maps.

To minimize the biasing effects of uneven collection and research across the study area, I used fluted point recovery locations instead of fluted point counts as the basis for the study. Counties containing large or well-researched sites that have yielded multiple fluted points tend to “skew” interpretations...
towards these areas. By regarding the archaeological record as consisting of a continuous “non-site” distribution of remains across the landscape (Ebert, 1992: 55–60), potential skewing effects, as well as problematic definitions often associated with the term “site” were avoided. As a result, 130 previously unrecorded and 21 finds from verified, unpublished archival data fluted point locations were plotted and digitized into an Arc/Info coverage (Loebel, 2005). In the end, 190 fluted point localities from the study area were entered into the Arc/Info coverage (Fig. 4).

Visual, the distribution appears uneven across the study area. Fluted point finds are noticeably scarce within the Green River Lowlands and Rock River Hill Country except along the Rock River, the Chicago Lake Plain, and within the southeast counties of the study area. Apparent clusters exist within the Bloomington Ridged Plain along the Upper Illinois River in Bureau and Lasalle counties and along the Wheaton Morainic system. At face value, these distributions may be interpreted as faithfully representing patterns of Early Paleoindian land use.

Fluted point distributions were analyzed using GIS raster-based regional coverage to facilitate a large scale, yet fine-grained approach to not only identify the source of potential biases that may affect distributional data, but to also to gauge the extent to which these biases may be in effect across the study area.

Fig. 2. Distribution of Illinois State Museum Paleoindian sites by reassigned cultural component (n = 305).
Raster or "Grid" based GIS consists of vector maps that are converted into geo-referenced grids containing rows and columns of cells within which each cell has a unique identity. These can be overlain with other data layers and corresponding grid cells from each layer can “pick-up” or attach grid cell values of other data layers. In a sense, county-based studies are similar to Raster GIS based models, in that the county functions as a very large "cell" and fluted point counts are a data layer that can be assigned to a corresponding county cell. The advantage of incorporating this type of data into a raster based GIS coverage is the ability to analyze geospatial relationships between site locations and a host of variables on a scale much finer than the county and in terms more relevant to the prehistoric record.

To evaluate patterns in fluted point distribution, archaeological sites were compared against a plot of randomly generated points. Both random and archaeological points were analyzed against multiple data layers and subjected to a Multi-Variable Discriminant Function Analysis. By this method, both potential patterning and biases in the distributions could be explored by determining which variables contributed the most to the ability to discriminate between fluted point locations or random “non-site” locations.

### 4.1. GIS data layers

The following data layers were used in the analysis. Most data layers were analyzed at a 1 hectare (100 m) grid cell resolution, effectively breaking down the study area into 4,649,900 analytic units, each capable of representing a particular characteristic of the study region represented by that cell on each data layer.

#### 4.1.1. Random points

Using an Excel random number generator function, 9567 X and Y coordinates (5 percent sample of 500 m grid) were generated. This file was then imported into ArcView and the random points plotted. Any random point within 500 m of a known site was rejected, leaving only random “non-sites.” Twenty-one random points were rejected, resulting in a data layer containing 9546 random non-sites (Fig. 6).

#### 4.1.2. All Point Mask

Private collection data (FPS), archival, and IAS site file sites were combined into a single coverage and each location \( n = 190 \) assigned a single numeric identifier. Random points \( n = 9546 \) were also joined into this coverage but given a different numeric identifier to allow for separation of the two datasets during statistical analysis. This data layer was converted into a one-hectare cell grid coverage and each one-hectare grid cell containing either a random point or archaeological location was “extracted.” When this coverage was overlain with other data layers, the corresponding values for each data layer grid cell matched to a grid cell

![Fig. 3: Illinois State Museum/Illinois Archaeological Society fluted point locations (n = 39) within the 29 county study area.](image-url)

### Table 1

Illinois Archaeological Society (IAS) fluted point sites recorded within study area.

<table>
<thead>
<tr>
<th>County</th>
<th>IAS site #</th>
<th>County</th>
<th>IAS site #</th>
<th>County</th>
<th>IAS site #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boone</td>
<td>19</td>
<td>Kane</td>
<td>93</td>
<td>Lee</td>
<td>1</td>
</tr>
<tr>
<td>Bureau</td>
<td>168</td>
<td>Kankakee</td>
<td>31</td>
<td>Lee</td>
<td>2</td>
</tr>
<tr>
<td>Cook</td>
<td>222</td>
<td>Rock Island</td>
<td>573</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cook</td>
<td>309</td>
<td>Kendall</td>
<td>81</td>
<td>Will</td>
<td>53</td>
</tr>
<tr>
<td>Cook</td>
<td>605</td>
<td>Kendall</td>
<td>85</td>
<td>Will</td>
<td>67</td>
</tr>
<tr>
<td>Cook</td>
<td>614</td>
<td>Kendall</td>
<td>105</td>
<td>Will</td>
<td>90</td>
</tr>
<tr>
<td>Cook</td>
<td>890</td>
<td>Lasalle</td>
<td>68</td>
<td>Will</td>
<td>91</td>
</tr>
<tr>
<td>Dekalb</td>
<td>216</td>
<td>Lasalle</td>
<td>117</td>
<td>Will</td>
<td>1145</td>
</tr>
<tr>
<td>Du Page</td>
<td>57</td>
<td>Lasalle</td>
<td>165</td>
<td>Will</td>
<td>1240</td>
</tr>
<tr>
<td>Du Page</td>
<td>282</td>
<td>Lasalle</td>
<td>310</td>
<td>Will</td>
<td>1655</td>
</tr>
<tr>
<td>JoDaviess</td>
<td>370</td>
<td>Lasalle</td>
<td>327</td>
<td>Will</td>
<td>53</td>
</tr>
<tr>
<td>JoDaviess</td>
<td>387</td>
<td>Lake</td>
<td>344</td>
<td>Winnebago</td>
<td>290</td>
</tr>
</tbody>
</table>
containing a site or random point was joined to the All Point Mask coverage attribute table.

4.1.3. Modern population

Inverse distance weighted interpolation of 1990 population counts (U.S. Census Records) were aggregated by 10 km grid cells and averaged over a 80 km radius. The study area was buffered to include populations within contiguous counties located in Iowa, Wisconsin, and Indiana. This data layer was generated to gauge potential collector activity over the landscape, theorizing that collectors mostly operate within a 80 km radius of their home area. The resulting data layer map shows areas of the landscape with...
most potential population draw, and theoretically those areas that are most accessible to collectors (Fig. 7). However, interviews with collectors reveal that many collectors reside in rural areas and hunt for artifacts in nearby locations, while others routinely travel from areas with less available landscape for collecting opportunities. While this may present a possible bias, the majority of collectors interviewed and collections documented during this study suggest that the majority routinely “hunt” within a relatively close area of their homes.

The following raw data layers were obtained from the Illinois State Geological Survey web page (http://www.ilsgs.com) and Illinois Department of Natural Resources CD-ROM Volumes 1 and 2.

4.1.4. County boundaries and loess deposits
A base county outline map of Illinois was downloaded, reprojected, and clipped to the 29 county study area. A map of average thickness of loess deposits was generated and overlain to test for possible geologic biases caused by Late Pleistocene loess fall (Fig. 8).

4.1.5. Quaternary Deposit
A data layer consisting of Quaternary Deposits was generated to test for potential differences in landform use within glaciated and unglaciated portions of the study area (Fig. 9). Resulting distributional counts obtained through spatial overlays were subjected to a Chi-squared analysis to test for significance.

4.1.6. Hydrography
Separate coverages were created for tributaries, streams, and rivers. These coverages were buffered using ArcView Spatial Analyst. Buffering generates zones within a given distance of a specified set of coverages; as a result, the distance from each random point or site to the nearest rank order drainage could be calculated. Correlation to drainage rank order and distance to water sources may reflect preferences in site location and resource availability or the proposed importance of major drainage corridors in large-scale settlement models (Anderson, 1990).

4.1.7. Wetlands
Individual county level data were converted into shape files in ArcView and coverages merged using the Geoprocessing Wizard extension. All artificial wetlands and riverine wetlands were identified and eliminated in an attempt to keep the data as relevant as possible to prehistoric conditions. Point wetland coverages were buffered by 10 m, rendered into polygons, and merged with the wetland polygon coverage. The coverage was then buffered, so that distance to wetland values from each site or random point could be obtained. Because wetlands offer a diverse range of subsistence resources, this data layer was generated to gauge the potential degree to which site location may have been orientated towards these potentially important resources. Northern Illinois contains a series of well-studied bog, lake, and wetland deposits which provide high-resolution paleoenvironmental records that span the terminal Pleistocene-Early Holocene period, and highlight the potential importance of these areas to prehistoric hunter-gatherers (Curry et al., 2007; Gonzales and Grimm, 2009; Huber and Rapp, 1992; King, 1981).

4.1.8. Soil association/variety
This coverage was analyzed at a 500 m grid cell using the Spatial Analyst Neighborhood Statistics function to count the number of different soil associations present within a 10 km radius of each grid cell. Results reveal areas of complex soil mosaics, potentially reflecting local paleoenvironmental diversity that may have influenced site location preferences.

4.1.9. Distance to roads
County road maps were downloaded and joined to create a single coverage. Distance of each pixel containing a random point or site was calculated to the nearest road. This was done as a possible corollary of collector bias, theorizing that fields nearer to roads or other routes of vehicle access are more prone or subject to collecting due to ease of access.

Fig. 6. Fluted point find spots versus random “non-site” points data layer.
4.1.10. Percent slope
The ISGS DEM map was used to calculate the slope of the landform for each pixel containing a site or random point to gauge the potential effects of both geomorphic processes on site exposure through erosion or burial or site placement preferences.

5. Discriminant function analysis
The resulting attribute table containing the attached values of all the overlain data layers was imported into SPSS v. 11.00 where potential predictors of fluted point distribution were examined.

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Fig. 7. 1990 Population Index coverage and fluted point locations.

Fig. 8. Depth of loess across study area data layer.
through discriminant function analysis (DFA). DFA can be used to
determine which variables contribute the most to the ability to
discriminate between two or more groups, in this case fluted point
locations versus randomly generated locations. It can also be used
as a predictor of group membership and was used to examine
factors affecting regional fluted point distributions.

DFA requires roughly normal distributions for the interval scale
variables in the analysis; therefore, the variables were examined for
skewness and other deviations. A review of standard deviations
around the mean, the shape of the histograms, and skewness values
indicated skewed distributions for most data layers variables
except soil variety. Skewed data layers were subjected to a natural
log transformation to normalize distributions prior to analysis
(Table 2). In addition, zero values for distance buffered data layers
were recoded into 10 m distances to avoid missing data values after
natural log transformation.

Log transformation improved the skewness values on several
data layers, but increased or shifted the skewed distributions on
others. As a result, some raw data layers (Soil Variety, Distance to
Road, Distance to Stream, Distance to River), and some transformed
data layers (Log Loess, Log Population, Log Wetland, Log Tributary,
Log Slope) were used to employ the least skewed datasets available
(Table 2). In addition, zero values for distance buffered data layers
were recoded into 10 m distances to avoid missing data values after
natural log transformation.

The following step-wise results indicated which variables best
discriminated between fluted point locations or random points.
That is, this procedure chooses in the first iteration the “best”
variable for distinguishing between actual fluted point locations
and randomized locations, then selects the second variable which
most correlates with the remaining variance, and so on. With all
variables entered into the program, distance to wetland was the
major factor conditioning differences between sites and random
points, followed by population, distance to tributary, distance to
stream, and then percent slope (Table 4). The program was able to
correctly classify 64.4 percent of all cases (Table 5). Given the rather
large ratio of random versus archaeological locations (50:1), I felt
this to represent a significant classification result.

Review of the correlation matrix table indicated a significant
negative correlation (−.646) between loess thickness and
population index. This suggested these variables were competing,
so the analysis was run twice more, removing one coverage in each
run to gauge the effects of each variable independent of the other.
Removal of the Loess Thickness layer did not alter results; however,
when the analysis was run without the Population data layer, the
contribution of Loess Thickness replaced Population in the
discrimination between random and fluted point locations
(Tables 6 and 7). This suggests that Population effects may be in
stronger operation in conditioning the distributional results.

5.1. Results of discriminant function analysis

The results of the DFA indicate that patterning of fluted point
locations is significantly affected by modern population distribu-
tions across the study area. Higher numbers of fluted point sites are
reported in areas of high modern populations, and may reflect the
greater access of these landscapes to the efforts artifact collectors,
recording efforts, or may residually reflect prehistoric landscape
use. The frequency of fluted point recovery generally declines
toward the Mississippi River, as both modern population decreases
and thickness of loess deposition increases. The most recent and
ubiquitous deposit across the study region is the Peoria Loess,
which has been securely radiocarbon dated to 25–10 kya (Bettis
et al., 2003; Forman and Pierson, 2002). While the major pulse
of loess deposition seems to have been completed circa 12–11 kya
(Bettis et al., 2003), minor loess deposition continued sporadically
until 10 kya, creating the possibility for site burial, particularly in
portions of the study area closer to the Mississippi and its major
tributary valleys.

These findings were evaluated by conducting a Chi-squared
analysis of fluted point locations by Quaternary Deposit across
the study region (Table 8). Higher than expected frequencies of
fluted point locations are observed along the Wisconsin recessional
moraine system (M1) ringing the northeast portion of Illinois, while
lower than expected frequencies are observed in lake deposit sediments (E1), and the Illinoisan till planes (I1) and Driftless areas. Lower than expected frequencies are observed in lake deposit sediments may reveal an avoidance of poorly drained areas occupied by former glacial lakes. However, the highest frequencies of fluted point recoveries are observed on landforms within the portions of the study area that have both the highest potential modern population draw and lowest levels of loess deposition, and fluted point sites are significantly under-represented in the portions of the study area that have both the most loess deposition and the lowest modern population levels. Results of the Chi-squared analysis support the results of the DFA, revealing that fluted point distributions within and across the study area are being affected to varying degrees by both collection and possibly geomorphic bias.

To further examine regional effects of collection and geologic bias, IAS site file data was employed to explore the distribution of sites by cultural component across the study area. It was reasoned that if Late Paleoindian and possibly Early Archaic site distributions within the western portion of the study area were similar to the Paleoindian record, it would support a geologic bias towards the burial of older sites by residual loess deposition, and thus an under-reporting of sites of this age. If Late Archaic/distribution patterns to the west were similar to earlier components, it would support a geologic bias towards the Mississippi River and tributary valleys ceased circa 12 kya (Forman and Pierson, 2002), or prior

Table 2
Raw and normalized data layer distribution characteristics.

<table>
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<tr>
<th>Data layer</th>
<th>n</th>
<th>Mean</th>
<th>Median</th>
<th>Standard deviation</th>
<th>Skewness</th>
<th>Standard Error of skewness</th>
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<td>7.4</td>
<td>4.6755</td>
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<td>.025</td>
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<tr>
<td>Popindex</td>
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<td>1,393,396.61</td>
<td>414,079.0</td>
<td>1,925,259.70</td>
<td>2,233</td>
<td>.025</td>
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<td>Solitary</td>
<td>9735</td>
<td>8.00</td>
<td>8.0</td>
<td>2,599</td>
<td>.345</td>
<td>.025</td>
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<tr>
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<td>238.89</td>
<td>200.0</td>
<td>201.684</td>
<td>.894</td>
<td>.025</td>
</tr>
<tr>
<td>Distwet</td>
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<td>1,210.12</td>
<td>943.0</td>
<td>1,051.40</td>
<td>1,983</td>
<td>.025</td>
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<td>316.0</td>
<td>408.022</td>
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<td>.025</td>
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<td>.025</td>
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<td>.58</td>
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<td>.025</td>
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</table>

**Table 3**
Real and random point characteristics within data layers.

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<th>Type of point</th>
<th>Data point characteristics</th>
<th>Mean</th>
<th>Median</th>
<th>Skew</th>
<th>Total</th>
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<tbody>
<tr>
<td>LogLoess</td>
<td>Real</td>
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<td>1.96</td>
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<td>LogPop</td>
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<td>190</td>
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<tr>
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<td>Random</td>
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<td></td>
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<td>6.85</td>
<td>−1.50</td>
<td>9545</td>
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<tr>
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<td>Real</td>
<td>5.16</td>
<td>5.30</td>
<td>−.94</td>
<td>190</td>
</tr>
<tr>
<td></td>
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<td>5.75</td>
<td>−1.20</td>
<td>9545</td>
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</tr>
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<tr>
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<td>6366</td>
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<tr>
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<td>8.00</td>
<td>.35</td>
<td>9545</td>
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</table>

**Table 4**
Discriminant function analysis results, all variables entered.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Tolerance</th>
<th>F to Remove</th>
<th>Wilks' lambda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logwet</td>
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<tr>
<td>Logpop</td>
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<td>.977</td>
</tr>
<tr>
<td>Logtrib</td>
<td>.000</td>
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<td>.995</td>
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<tr>
<td>LogSlope</td>
<td>.000</td>
<td>10.135</td>
<td>.994</td>
</tr>
<tr>
<td>DistRiv</td>
<td>.000</td>
<td>6.717</td>
<td>.994</td>
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<tr>
<td>Logwet</td>
<td>.000</td>
<td>9.590</td>
<td>.994</td>
</tr>
<tr>
<td>Logpop</td>
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<tr>
<td>Logtrib</td>
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<td>.994</td>
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<tr>
<td>Disttortrib</td>
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<td>6.617</td>
<td>.993</td>
</tr>
<tr>
<td>LogSlope</td>
<td>.000</td>
<td>3.926</td>
<td>.993</td>
</tr>
</tbody>
</table>
the suggested occupation of the area by fluted point using groups. Lower numbers of sites of all time periods are found to the west in comparison to the east, indicating that in general, the archaeological record in this region is under reported. Nearly 2.5 times as many archaeological sites are known from the eastern 15 counties than have been reported in the western counties (10,958 versus 4496). Northwest Illinois also has some of the highest percentage of occupation of the area by early Paleoindian culture. The portion of the study area west of the Rock River, especially JoDaviess, Carroll, and Stephenson Counties, has a relatively lower amount of land in agricultural production than the rest of the study area, with more land given over to grassland and forest cover than counties to the east. Results of the DFA and Chi-square analysis suggest that lower modern population densities perhaps in combination with modern land use practices may limit the exposure and recovery of fluted bifaces, and partially account for the lack of reported Early Paleoindian sites within this region. Lepper (1983, 1985) reached similar conclusions in Ohio, where he found that modern population density and intensity of cultivation have conditioned the distribution of fluted point finds. Residual loess deposition in this area may also have created the potential for buried sites. As a result, a lack of sites in this region cannot be fully attributed to an avoidance of this landscape, but instead may be conditioned by the potential burial of older living surfaces resulting in lower rates of disturbance, recovery, and reporting. A modest fluted point assemblage recovered from the Withington site in Grant County, Wisconsin, and multiple isolated finds in the surrounding Driftless region, suggests that Early Paleoindians were indeed active within portions of this landscape (Loebel, 2009), and fluted point distribution within the Rock River Hill Country does seem to be correlated with the River drainage, suggesting a correlation. Future survey and research in the Driftless Region and the study region can be assessed. Because hunter-gatherers adapt to landscapes on a regional scale, correlation of fluted point locations with physiography provides one relevant means of examining patterns of Early Paleoindian land use. The Rock River Hill Country, Driftless Region, Kankakee Plain, Green River Lowlands, and Chicago Lake Plain contain relatively few fluted point locations (Fig. 5). Some of this pattern is relatively easy to explain, such as the “blank” spot within the Chicago Lake Plain caused by the destruction of the archaeological record created by the construction and expansion of the City of Chicago. However, the absence of fluted points within areas such as the Rock River Hill Country west of the Rock River and the Driftless Section is now not as easy to reliably determine.

The portion of the study area west of the Rock River, especially JoDaviess, Carroll, and Stephenson Counties, has a relatively lower amount of land in agricultural production than the rest of the study area, with more land given over to grassland and forest cover than counties to the east. Results of the DFA and Chi-square analysis suggest that lower modern population densities perhaps in combination with modern land use practices may limit the exposure and recovery of fluted bifaces, and partially account for the lack of reported Early Paleoindian sites within this region. Lepper (1983, 1985) reached similar conclusions in Ohio, where he found that modern population density and intensity of cultivation have conditioned the distribution of fluted point finds. Residual loess deposition in this area may also have created the potential for buried sites. As a result, a lack of sites in this region cannot be fully attributed to an avoidance of this landscape, but instead may be conditioned by the potential burial of older living surfaces resulting in lower rates of disturbance, recovery, and reporting. A modest fluted point assemblage recovered from the Withington site in Grant County, Wisconsin, and multiple isolated finds in the surrounding Driftless region, suggests that Early Paleoindians were indeed active within portions of this landscape (Loebel, 2009), and fluted point distribution within the Rock River Hill Country does seem to be correlated with the River drainage, suggesting a correlation. Future survey and research in the Driftless Region and the

### Table 6

Discriminant function analysis results, population data layer removed.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Tolerance</th>
<th>F to Remove</th>
<th>Wilks' lambda</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>Step 2</td>
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<td>.997</td>
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<td>.996</td>
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</tr>
<tr>
<td>Step 4</td>
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<td></td>
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<td>.995</td>
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<td>.995</td>
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<td>.995</td>
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<td>.941</td>
<td>7.951</td>
<td>.994</td>
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<tr>
<td>DisttoStm</td>
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<td>.994</td>
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<tr>
<td>Logslope</td>
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<td>.994</td>
</tr>
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</table>

### Table 7

Classification results, population data layer removed.

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<th>Total</th>
</tr>
</thead>
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<td>3400</td>
<td>9545</td>
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<tr>
<td>Real</td>
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<td>120</td>
<td>190</td>
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<tr>
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</tr>
<tr>
<td>Real</td>
<td>36.8%</td>
<td>63.2%</td>
<td>100.0%</td>
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</tbody>
</table>

### Table 8

Chi-squared analysis of sites by Quaternary Deposits.

<table>
<thead>
<tr>
<th>Quaternary Deposit</th>
<th>Area (km²)</th>
<th>Expected number of sites</th>
<th>Observed number of sites</th>
<th>$\chi^2$</th>
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</thead>
<tbody>
<tr>
<td>C1</td>
<td>11,185</td>
<td>46</td>
<td>48</td>
<td>.087</td>
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<tr>
<td>E1</td>
<td>3590</td>
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<td>2</td>
<td>11.07</td>
</tr>
<tr>
<td>M1</td>
<td>11,501</td>
<td>47.3</td>
<td>79</td>
<td>21.25***</td>
</tr>
<tr>
<td>GM1</td>
<td>8654</td>
<td>35.6</td>
<td>45</td>
<td>2.48</td>
</tr>
<tr>
<td>H1</td>
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<td>40.9</td>
<td>15</td>
<td>16.4***</td>
</tr>
<tr>
<td>P1</td>
<td>1283</td>
<td>5.3</td>
<td>1</td>
<td>3.49</td>
</tr>
</tbody>
</table>

$p < .05$.  
$p < .01$.  
$**p < .001$.  
$C1$ – Waterlain river sediment and wind blown beach sand.  
$E1$ – Fine grained sediments deposited in lakes.  
$GM1$ – Diamict deposited as till and ice-marginal sediments during Wisconsin glacial episode.  
$H1$ – Diamict deposited as till and ice-marginal sediments during Illinoian glacial episode.  
$P1$ – Bedrock, exposed or covered by loess and/or residuum.
Rock River Hill Country may prove promising for the future discovery of minimally disturbed sites. A reporting/sampling bias may also be in effect for Iroquois, Ford, and Livingston Counties, where fewer collections were examined. However, sandwiched between the well sampled counties of Will and LaSalle, the lack of fluted points recorded in Grundy County is intriguing, and cannot be easily attributed to a lack of collector contact. Grundy County has not registered a single fluted point in either the IAS site files or the FPS conducted as part of this research. Much of Grundy and Iroquois counties lie within the Kankakee Plain, a comparatively flat area between the Marseilles Moraine and the Valparaiso Morainic System that roughly corresponds with the former Glacial Lakes Wauponsee and Wataseka basins (Willman, 1971; Willman and Frye, 1970). Much of the presettlement vegetation of this area consisted of wet, tall-grass prairie. The result was an extensive collection of wetlands called the “Grand Marsh” covering nearly 400,000 acres, reaching into Indiana as far east as South Bend. The lack of finds in the Kankakee Plain may reflect an actual avoidance of former glacial lake beds due to the presence of extensive wetlands. However, areas ringing former glacial lakes, such as the Marseilles and Valparaiso moraines, were likely attractive ecotonal locations to exploit a wide range of resources; this may account for the higher than expected frequency of fluted point locations within these landforms.

I suggest that the absence of data within the Green River Lowlands also accurately reflects Paleoindian land use patterns. Bordered by the Bloomington Moraine system to the east, the Green River Lowlands existed as an extensive marsh system covering large portions of four counties at the time of European settlement. The presence of extensive low-lying areas may have acted as a natural barrier to the movement of both Humans and game animals, deflecting movements along the perimeter of the Green River Lowlands. A substantial number of fluted points have been recorded along the Arlington Moranic system just to the east, suggesting that survey on the Bloomington Moraine along the southeastern edge of the Green River Lowlands in Bureau and Lee Counties may provide promise for the discovery of additional fluted point sites.

The results of the DFA strongly imply an association of fluted point finds with wetlands. Buchanan, in his examination of fluted point density at the state level also found a significant correlation between fluted points and wetlands (2003). This patterning may be the result of the fairly well sampled area east of the Rock River, which contains a greater distribution of wetlands than does the western portion of the state. However, fluted point concentrations along the margins of large former wetland basins such as the Green River Lowlands and the Kankakee Grand Marsh may signal the redundant use of these landscapes by fluted point using groups.

The use of projectile points does potentially bias distributional data toward presumed hunting activities; however, several large sites containing diverse assemblages and tool types have been documented within the study area, often located adjacent to upland wetland resources (Loebel, 2005). Patterns of raw material procurement and discard within these assemblages reflect the high residential mobility of these mixed groups, not just the movements of sub-sets of presumably higher-mobility male hunters (Koldenhof and Loebel, 2009; Loebel, 2005). The positioning of sites containing a less mobile population of women, children, and the elderly near upland wetlands which offer a substantial and diverse resource base would have provided an opportunity to broaden diet breadth and offset subsistence risks associated with large mammal hunting.

Overall fluted point distributions appear to reflect a remnant settlement patterning suggesting site location preferences or partial subsistence orientation towards wetlands resources. Furthermore, the cluster of fluted points around the Starved Rock area of the Illinois River, outside of densely populated areas suggests patterning that is unaffected by modern population factors or geomorphic exposure. These data suggest a broad regional pattern of Clovis land use focused on upland areas adjacent to wetlands and overlooking tributary drainages (Loebel, 2005; Loebel and Amick, 2006).

7. Implications and summary

There are several theoretical implications resulting from this study. Our ability to accurately interpret Paleoindian land use patterns is subject to multiple and complex biases, including modern population distributions and collector effects, recording protocol, and geologic processes. Additionally, this study has confirmed that factors such as intensity of prior archaeological research, modern population distribution, and survey and sampling methodology also affect the character of fluted biface distributions (Bever and Meltzer, 2007; Lepper, 1983, 1985; Meltzer, 1986; Meltzer and Bever, 1995; Shott, 2002). Results presented here in general refine and support Shott’s, 2002 examination of sample bias in the distribution of Midwest fluted bifaces, Buchanan’s, 2003 examination of sample bias in North American fluted point distributions, and Lepper’s, 1983 and 1985 work in Ohio. Both Shott and Buchanan found that modern population and survey effort greatly affect the character of fluted point distributions; where more people live, more fluted bifaces have been found, and where more sites have been recorded, more fluted bifaces have also been found (Buchanan, 2003: 333; Shott, 2002: 116). Lepper’s examination of fluted point distributions in Ohio suggest that modern population densities and modern land use practices can impact the distribution of reported fluted point finds and our ability to accurately perceive bias within the observed patterns (Lepper, 1983, 1985). However, the overall results of the current study suggest that Midwest distribution patterns are more strongly a function of collecting and reporting than of modern land use practices.

By employing a raster based GIS approach using a detailed record of continuous fluted point distributions across the landscape, this study has been able to not only identify the source of potential biases within the sample, but also provides the ability to gauge the effects of these biases across the study area. When armed with this type of knowledge, researchers are able to greatly increase the confidence of inferences made regarding observed patterning.

The results of this study reinforces the suggestion that we should be cautious when interpreting distributional studies at face value, and that it is premature to reliably equate present county level fluted biface frequency studies with intensity of Paleoindian land use patterns without due regard to potential biasing factors (Shott, 2002). On a larger scale, a conservative approach should be used when employing this type of distributional data in building models concerning the Early Paleoindian colonization of North America and subsequent radiation of human populations throughout the western Hemisphere (Anderson, 1990; Anderson and Faught, 2000; Anderson and Gillam, 2000). While there certainly is an underlying register of truth within observed distributional patterns, a better understanding of the nature of the biases present within our data sets is essential for a clearer understanding of the broad temporal and geographic patterns concerning Paleoindian land use.

Acknowledgments

A great many thanks are due to a great many people who contributed data and time to this project. First and foremost are the many colleagues and private individuals who generously shared...
their data and finds with me. A large “blank” on the map has been included in this because. Robert Hasenstab deserves special thanks, he planted the seed of the idea for this analysis, and it was largely due to his willingness to spend many long hours with me in the GIS lab that this project reached completion. Larry Keeley and Dan Amick sharpened my thoughts on topics of hunter-gatherer land use and issues of sample bias. Laura Junker assisted in the statistical analysis and interpretation. In addition, comments from three anonymous reviewers provided advice that substantially strengthened the overall paper. However none of these good folks should be implicated by association in any shortcomings, those rest squarely with me.

References


