An Investigation of the Distribution of Open Archaeological Sites in the Upper Kickapoo Valley Archaeological District, Vernon County, Wisconsin.

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Keywords: Archaeology, Site Selection, Upper Kickapoo River Valley Archaeology District, Kickapoo River, Wisconsin Archaeology, Spatial Statistics

Abstract

The Upper Kickapoo River Archaeological District contains over 500 archaeological sites. Spatial statistics and site selection factors were explored for 405 open archaeological sites. Nearest Neighbor Index and Ripley's K-Function analyses show that the sites have a clustering pattern. Hot spot analyses reveal concentrations near a few stream confluences. Topographic variables of the site locations show a preference for lower elevations and low slopes. Furthermore, comparisons of cultural affiliated sites indicate the Paleo-Indian sites were farther from water resources when compared to Archaic and Woodland affiliated sites.

Introduction

The Upper Kickapoo Valley Archaeology District (UKVAD) is located in Vernon County, Wisconsin, between the villages of La Farge and Ontario. With over 500 archaeological sites identified throughout the district, the UKVAD was recognized by the National Registry of Historical Places in 1999 (www.nps.gov/history/nr/).

The archaeological significance of the UKVAD was relatively unknown prior to 1960, with only a handful of sites reported for the area (Holtz and Boszhardt, 1998). However, during the late 1960's through the 1970's, extensive archaeological surveys were conducted in anticipation of an Army Corps of Engineers (ACOE) flood control project, known as the Lake La Farge Project. The project proposed the creation of a 1,780 acre lake to help mitigate flooding problems in the Kickapoo River Valley. The ACOE purchased over 8500 acres from local residents for the proposed reservoir and additional adjacent recreation areas.

Most of the archaeological surveys in the 1960's and 1970's were focused on the areas within the proposed reservoir pool level (Holtz and Boszhardt, 1998). Yet, some surveys covered the adjacent recreational areas surrounding the lake. Later surveys in the 1980's and 1990 targeted areas for road construction and highway realignment within the valley (Holtz and Boszhardt, 1998).

Due to many circumstances, the Lake La Farge project was not completed. In 1996, the project was officially decommissioned by the United States Congress. The ACOE acquired land was transferred to the State of Wisconsin and the Ho-Chunk Nation in 2000, creating the Kickapoo Valley Reserve.

In preparation of the land transfer,

Johnston, Ben. 2010. An Investigation of the Distribution of Open Archaeological Sites in the Upper Kickapoo Valley Archaeological District, Vernon County, Wisconsin. Volume 12, Papers in Resource Analysis. 18 pp. Saint Mary's University of Minnesota Central Services Press. Winona, MN. Retrieved (date) from http://www.gis.smumn.edu

the Mississippi Valley Archaeological Center conducted a final archaeological survey in 1998 of approximately 3,500 acres that were not covered in earlier surveys (Holtz and Boszhardt, 1998). These areas were mostly upland benches and terraces within the Kickapoo Valley Reserve.

Archaeological Cultural Periods in the UKVAD

Diagnostic artifacts such as stone tools of particular shapes and/or design, the presence/absence of pottery, and evidence of wooden tools are used to determine cultural periods, or time intervals when a site was occupied (Theler and Boszhardt, 2003). Other cultural specific indicators include burial practices and evidence of agriculture.

Many cultural artifacts have been found in the UKVAD. Three cultural periods represented include the Paleo-Indian Period between 12,000-9,000 B.P (before present), the Archaic Period, 9,000-2,500 B.P., and the Woodland Period 2,500-1000 B.P (Holtz and Boszhardt, 1998; Theler and Boszhardt, 2003). Cultural periods can be further divided into early, middle, or late sub-cultures (i.e. Middle Archaic).

Archaeological Sites in UKVAD

Archaeological sites are categorized according to the function of the site and/or features found at a given location. Some of the sites include camps, villages, lithic scatter, and isolated finds. Collectively, these sites are referred to as "open sites".

The term "village" used in the UKVAD describes larger camp areas of extensive use over time (Holtz and Boszhardt, 1998). Lithic scatter sites are characterized by the presence of numerous rock flakes or chips associated with the shaping of stone for tool production. The presence of these flakes suggests a tool making location and/or short term camp (Holtz and Boszhardt, 1998).

"Isolated finds" are sites where only a few artifacts were identified, but not substantial enough to make any definitive conclusions of the site use. These could be lost stone tools, short stopovers or discarded items (Holtz and Boszhardt, 1998).

Rock shelters are another type of archaeological site found within the UKVAD. These are rock overhangs or recess caves produced by differential erosion between sandstone layers. Archaeological surveys at several rock shelters have yielded evidence indicating occupancy by prehistoric people, most likely during winter (Theler and Boszhardt, 2003). A total of 91 rock shelters have been identified in the UKVAD.

Distribution of Archaeology Sites

A distribution study of archaeological sites is dependent upon three factors (Guccione, 2008). The first is whether or not a site is preserved over time. Natural process such as sedimentation during a flood can bury a site. Yet stream migration can later expose or destroy a site (Guccione, 2008).

A second variable in site distribution is based on the site selection process by prehistoric people. Proximity to available resources such as water (Zhang, Zhao, and Lui, 2007), hunting/foraging areas (Carlisle and Friedel, 2009), natural shelters, and sources for stone tools (Theler and Boszhardt, 1998) are key selection factors. Physical environment variables such as topography (elevation, slope, aspect) can influence site selection. Political, spiritual, and social factors may also affect the site selection process; although the role of these factors is not easily determined from the archaeological record (Ebert, 2004).

A third factor in site distribution is the available archaeological information. The archaeology record is never complete since sites may not be located and/or significant artifacts may not be found during a survey (Guiccone, 2008). Furthermore, sites with more extensive use are more likely to be identified during an archaeological survey versus a site used only for a short time.

Purpose of This Study

This study investigated the distribution of archaeological sites within a portion of the Upper Kickapoo Valley Archaeological District (UKVAD). Spatial statistic tools from ArcGIS 9.3 were used to evaluate spatial patterns. Four different data sets were used for the analysis; the entire population of open archaeology sites, and sites affiliated with each of the three cultural periods: Paleo-Indian, Archaic and Woodland.

Furthermore, the study explored relationships among topographic variables and distances to resources with the open site locations. Topographic variables included aspect, slope and elevation. Resources considered for this study were rock shelters, water, cliffs/steep areas, and stream confluences. Proximity to particular stream sizes was also evaluated.

A third part of the study compared the cultural affiliated site based on locations. Five variables were selected to investigate possible differences among the cultural periods.

The Study Area

This study focused on the areas of the UKVAD within the Kickapoo Valley Reserve. In addition, a 500 m buffer was created surrounding the Kickapoo Valley Reserve to incorporate an additional 16 open sites. This particular study area was delineated due to the available archaeological data. Forty additional sites beyond the 500 m buffer were excluded from this study since detailed archaeological information was not available.

Physical Setting

The geology of the UKVAD consists of Cambrian sandstone layers at the valley bottoms and along hillsides. These layers are capped by Ordovician carbonate layers occurring near the ridge top elevations. Variations in relative hardness of the sedimentary layers have resulted in differential erosion, producing a dramatic landscape.

The Kickapoo River is the largest stream within the study area. The total length within the study area is 26.6 kilometers. The Kickapoo Valley watershed is characterized as dendritic with deeply incised stream channels (Holtz and Boszhardt, 1998).

Seven major tributaries join the Kickapoo River within the study area. In addition, many smaller streams (i.e. unnamed creeks and/or intermittent streams) are also present. Evidence for stream meandering is present along portions of the Kickapoo River and some of the major tributaries.

The total relief for the study area varies between 90 m (meters) to 152 m. The valley elevation values are between 253 m at the upstream most point to 240 m at the downstream most point of the Kickapoo River. The major tributaries have slightly higher elevations of approximately 270 m.

Ridge elevations within the study area are between 367 m to 375 m. Just below the ridge line is an occurrence of cliff faces (Holtz and Boszhardt, 1998). Cliffs also occur along portions of the Kickapoo River and the major tributaries.

The slope at the river bottom and on the ridge top is generally flat. Hillside slopes have a wide range and can often exceed 50 degrees.

Upland terraces or benches occur between 275 m to 305 m above sea level (Holtz and Boszhardt, 1998). Rock shelters are located just below this terrace level (Hatfield, 2009).

Alluvial terraces are present along the stream channels and flood plains (Holtz and Boszhardt, 1998). The original (middle Holocene age) valley alluvium deposits are covered by more recent (+/- 200 years) erosion deposits from post-European agriculture practices. These "Post Settlement Alluvium" (PSA) deposits consist of eroded upland top soil exceeding several feet in some areas (Holtz and Boszhardt, 1998; Johnson, 1976).

Methods

Spatial statistical analyses and GIS data manipulations were conducted using ESRI ArcGIS 9.3. Tools referenced for analyses were from the Spatial Statistic Tools, Spatial Analyst Tools, and Data Management tool boxes. Microsoft Excel was used for data organization, manipulation, distribution analysis, and descriptive statistics calculations. All graphs were created in Excel as well.

Archaeological Data Sources

The Kickapoo Valley Reserve provided a shapefile containing over 450 archaeological sites. These were the locations of archaeological surveys conducted prior to 1997. According to the metadata, the point features were digitized in 1997 prior to the land transfer. The data source was USGS 7.5' topographic field maps provided by the State Historical Society.

Also in 1997, the Army Corps of Engineers compiled the results of the archaeological surveys into an electronic database. Archaeological information included the cultural period affiliated at each site as well as the type of site (i.e. open, rock shelter, burial mound, etc). The shapefile and database were linked by corresponding site numbers.

The Kickapoo Valley Reserve provided a printed copy of the archaeological results of the 1998 Mississippi Valley Archaeological Center survey. The report included maps showing archaeological sites identified during this survey. These were plotted on sections of 7.5' USGS 20 ft contour topographic maps.

From these maps, point locations were digitized in ArcGIS for this study. Site locations were referenced with 20 ft contours generated from a 10 m digital elevation model (DEM). Site number, type of site, and cultural period from the 1998 MVAC report were entered into the attribute table. The 1998 data points were combined with the pre-1997 data into one shapefile.

In compliance with the metadata provided with the KVR archaeology shapefile data, a request to use the archaeological data for this study was submitted to the Wisconsin State Historical Society on January 30, 2010. Permission was granted on February 2, 2010. The Ho-Chunk Nation, Department of Cultural Heritage Preservation was also notified of the project on January 30, 2010.

Archaeology Database Development

For the purpose of this study, the geographic location, site number, site type, and cultural period information were extracted from the compiled archaeology databases. The ACOE database contained multiple records for many of the sites, reflecting different surveys from different years. These records were consolidated into one record.

Furthermore, since the ACOE compiled database only listed sites as "Open" without any additional information, the more specifically described open sites from Holtz and Boszhardt (i.e. lithic scatter, camp, village, isolated find), were all generalized as "Open sites". Therefore, this study made no distinction between camps, lithic scatter, or isolated finds.

The cultural periods associated with each archaeological site were tallied in a spreadsheet. For each of the three major cultural periods (Paleo-Indian, Archaic, Woodland), a tally was recorded if a site had any cultural components linking it to a given period. Sites with multiple sub-cultures listed (i.e. early, late, middle), only had one tally recorded to represent the major period.

For sites with cultural periods listed as "probable" or with other questionable qualifiers, the period was recorded as definitive. A tally was also generated for sites from which no cultural components (i.e. "undetermined prehistoric", "prehistoric", etc) were found.

Based on cultural components found at each site, three data sets were developed, one for Paleo-Indian affiliated sites, one for Archaic affiliated sites, and one for Woodland affiliated sites.

The Popularity Index

An index value was created in order to quantify the popularity of sites across multiple cultures. This was developed to serve as weight for a spatial distribution analysis. To obtain this index value, each open site was given a value of one, since values of zero would not be considered as a weight. Thus, all sites without any cultural components identified (i.e. "undetermined prehistoric") received a total value of one. Then, for each sub-culture period listed (i.e. early, middle or late) an additional tally was given. If only a general period was listed (i.e. "Archaic"), only one tally was recorded, not three. The tallies were added together to reach the popularity index value.

Spatial Statistical Analysis

Nearest Neighbor Index

Nearest Neighbor Index (NNI) calculates the distance between each feature and the closest neighboring feature (Mitchell, 2005). The calculated average minimum distance between all features is compared to an approximation of the expected average distance of a random distribution of points (Levine, 2004). The Nearest Neighbor Index is the ratio of observed distribution over the expected distribution. The ratio provides a generalized distribution pattern of the points within a given study area.

A clustered distribution produces a ratio of less than one whereas a ratio greater than one is reflective of a dispersed distribution. A ratio value equal to zero is a perfect random distribution (Wheatley and Gillings, 2002).

For a nearest neighbor analysis, a Z-score value is calculated by dividing the difference between the observed and the expected values, with the standard error (Mitchell, 2005). Positive Z-scores are reflective of dispersed distributions and negative values correspond to clustering. Statistical significance exists if the absolute Z score value is greater than 1.96 (Mitchell, 2005).

Nearest Neighbor Index values were calculated for all four sample data sets using the *Average Nearest Neighbor* tool. Euclidean distance was chosen for the distance calculation method.

Since the variations of the total extent of the point features can affect the results of the Z score (Mitchell, 2005), the entire study area (61,422,251.8568 square meters) was consistent for all Nearest Neighbor Index calculations.

Ripley's K Function

Ripley's K function is similar to Nearest Neighbor Index except it evaluates the dispersion pattern at multiple distances. Rings, or bands, are drawn at a fixed interval, around each point. A value (K) is calculated based on the number of features or points within each distance band (Mitchell, 2005). The process is repeated for each point in the data set.

The observed results are compared to an expected value of a random distribution of points, based on similar band number and interval (Levine, 2004). The K Function describes the distance at which the dispersion pattern exists.

If the observed K values are greater than the expected K values, the observed pattern is considered clustered. Conversely, if K-observed is less than K-expected, the pattern is dispersed.

Upper and lower confidence levels are used to determine the statistical significance of the observed values (Mitchell, 2005). The confidence level values are generated by calculating K values for a random distribution of points. Each Ripley's K Function analysis defines a confidence envelope.

Since one random distribution can vary significantly from the next, multiple permutations, or versions, are generated. The confidence interval values are based on the lowest and highest values from all permutations for each band (Mitchell, 2005). If observed values are greater than the upper confidence values, the observed pattern is statistically significant. Values lower than the lower confidence limit indicates a significant pattern as well.

K-function values were calculated for all data sets using the *Multi-Distance Spatial Analysis (Ripley's K Function)* tool. Distance intervals were set at 300 m for a total of 20 bands. The band interval was calculated by using half of the greatest x/y dimension distance (12,242 m) of the study area divided by the number of bands (20) (Mitchell, 2005). 99 permutations of random points were generated for a 99% confidence envelope.

Since features near the study area edges may skew the results due to a reduction in possible neighboring points (Mitchell, 2005), the edge correction option "Simulate over boundary values" was employed in the *Ripley K Function* tool. This correction method "mirrors" points across the study area boundary to reduce edge effects. The study area parameter was set to the study area polygon.

The output K values were transformed by the ArcGIS tool. The transformation value, L(d), minimizes the height of the vertical axis (Mitchell, 2005). As a result of the transformation equation, the expected distribution value equals the distance interval, producing a line with a positive slope of 1 (Mitchell, 2005).

Density/Hot Spot Analysis

Archaeological hot spots could be

considered as areas in which many sites are present (i.e. density), or as the areas where sites were used most often (i.e. "popular sites"). Both of these possibilities were explored in this study.

The kernel density function calculates the magnitude of point features per unit area based on an output raster (ESRI, 2010). The population parameter within the Kernel density tool serves as a weight value to indicate the number of times to count an individual point. If a weight field is not specified, all points are considered equally.

Two kernel density surfaces were created: one based on site density, the other using the popularity index as a weight. For each kernel density analysis, the surface search radius was set to 300 m and the output was set to a 10 m cell size. The resulting density values from each raster were extracted at each point using the *Extract Values to Points* tool.

Next, two hot spot analyses were conducted. The first used site density values and the other used the popularity density values.

The *Hot Spot Analysis (Getis-Ord Gi*)* tool calculates a Z score value for each point feature by subtracting an expected Gi* value of a random distribution from the calculated Gi* values. The difference is then divided by the square root of the variance (Mitchell, 2005). If features in close proximity to each other have similar high values, the Z score value will be high, identifying a "hot spot". "Cold spots" are reflective of negative Z score values, showing concentrations of low values. Z score values near zero show no similarity in values. Statistically significant values at the 95% confidence level are greater than or less than positive or negative 1.96, respectively (Mitchell, 2005).

Z score results from each Hot Spot analysis were used to create raster surfaces, through the *Interpolate to Raster* tool, using the Inverse Distance Weight (IDW) Method.

GIS Data and Manipulations

Topography

Four 10 m DEMs covering the study area were obtained from the Natural Resources Conservation Service (NRCS) Data Gateway Website. These were combined into one DEM using the *Mosaic* tool. Slope (degree) and aspect raster surfaces were created using the Spatial Analyst toolbar.

Distance Surfaces

Distances to numerous resources were evaluated. All distance surfaces were created using the spatial analyst extension in ArcGIS. Cell values were set to 10 m and Euclidean distances were calculated. Each of the 5 distance surfaces is briefly described below.

Distance from Water Sources

Water is a very important resource, across all cultures and time. Shapefiles of the Kickapoo River and streams within the study area were provided by the Kickapoo Valley Reserve. A distance surface from the Kickapoo River was created. An additional distance surface was created based on distance from any streams, including the Kickapoo River.

Distance from Confluences

Archaeological sites are often concentrated near stream confluences (Howard, Brown, Carey, Challis, Cooper, Kincey, and Toms, 2008). The joining of two streams creates a unique environment, possibly providing unique food resources. Confluences with the Kickapoo River and the seven major streams were digitized as point features. A distance surface was created based on these points.

Distance from Rock Shelters

Evidence from rock shelters within UKVAD has shown prehistoric use. Open site locations may have been influenced by proximity to rock shelters as possible refuge from storms or other threats. A distance surface was generated from rock shelters within the study area.

Distance to Cliffs/Steep Areas

The numerous cliffs and overlooks in the UKVAD may have been utilized by past cultures for hunting, scouting, and possibly for wind and sun protection. To evaluate these areas as a factor for site selection, areas with a slope greater than 20 degrees were isolated from the slope raster using the reclassification tool of the Spatial Analyst toolbar. Distances were calculated from these areas.

Stream Preference Analysis

Site selection may be a factor of stream size. Larger streams may offer a greater abundance of food resources; yet a small stream valley may provide more protection.

To assess a preference of stream size for site selection, a spatial join was performed based on the proximity of the open sites to the nearest stream.

Raster Surface Data Extraction

Values from topographic rasters and distance surfaces were extracted at each open site location by using the *Extract Values to Points* tool. All extracted data were exported from ArcGIS and imported into Excel. The results from the stream preference spatial join were also exported from ArcGIS and then imported into Excel.

Statistical Analysis

Descriptive statistics were calculated in Microsoft Excel for the site selection variables for all four data sets. Histograms were created for each site selection variable.

Many of the cultural affiliated sites were shared among the three cultures. Statistical comparisons of five variables across the cultural sites were conducted using the Kruskal-Wallis test. This statistical test is a non parametric analysis of variance able to compare multiple data sets of different population sizes (Zar, 1999). The Kruskal-Wallis analysis was conducted using the statistical program STATA (Carle, 2010). The variables selected for cultural comparison were slope, aspect, elevation, distance from streams, and distance from confluences.

Results

Based on the tally of cultural components found at the 405 open sites, at least one cultural period was affiliated with 23% (n=92 sites); yet 77% (n=319) of the sites did not produce any cultural affiliated artifacts.

Many sites had multiple cultural components identified at a given site (Table 1), although some sites were unique to a given period.

The Paleo-Indian culture was identified at 12 sites, with only one site being unique to this period. Archaic cultural artifacts were found at 67 sites, with 36 sites of these unique to this period. The Woodland culture was associated with 53 sites; of which 25 were unique to the Woodland period. Cultural affiliation from all three periods was found at seven sites.

Table 1. The total number of sites representing a given cultural period is shown as bold. The table also shows number of sites shared between cultures.

	Paleo	Archaic	Woodland
Paleo	**12**	10	8
Archaic	10	**67**	27
Woodland	8	27	**53**

Nearest Neighbor Index Results

The results of Near Neighbor Index (NNI) calculations for each data set are shown in Table 2. All data sets except for the Paleo-Indian sites showed significant levels of clustering. The Paleo-Indian sites had the closest NNI ratio value to zero, an indication of a more random dispersion. The NNI ratios for the Archaic and Woodland period sites were similar.

Table 2. Results from Nearest Neighbor Index, showing Observed values (Obsv), Expected values (Exp), Z score, and p-value (p).

	Paleo	Arch	Wood	Open
n	12	66	53	403
Obsv.	884.6	269.3	287.1	127.2
Exp.	1131.2	482.3	538.3	194.7
Ratio	0.78	0.56	0.53	0.653
Z	-1.44	-6.86	-6.50	-13.35
p	0.159	0.000	0.000	0.000

Ripley's K Function Results

The graphical results for the Ripley K Function analysis for each data set are shown in Figures 1, 2, 3, and 4. All four sample sets show clustering to exist up to a range of 2400 to 2700 meters as indicated where the observed values intersect the expected values. Beyond this distance, the site distribution pattern shifts towards more dispersion. None of the data sets showed statistically significant levels of dispersion.

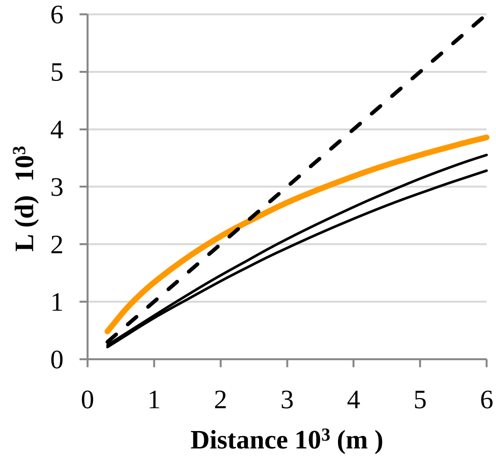

Figure 1. Ripley's K results for open sites (orange line). Expected values are shown as a dashed line; upper and lower confidence limits are shown as black solid lines.

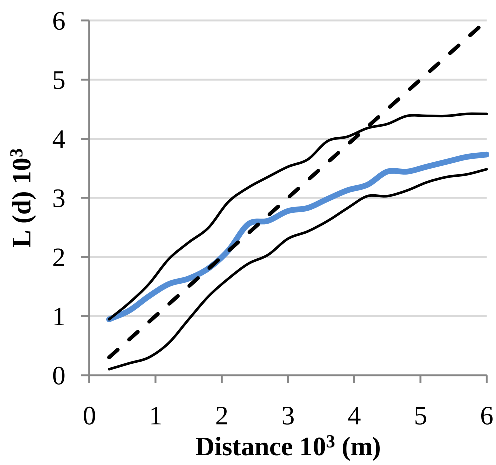

Figure 2. Ripley's K results for Paleo-Indian sites (blue line). Expected values are shown as a dashed line; upper and lower confidence limits are shown as black solid lines.

With respect to the confidence envelopes, only the Paleo-Indian observed values plotted completely within the upper and lower limits, indicating no statistical significance in the results.

Popularity Index Results

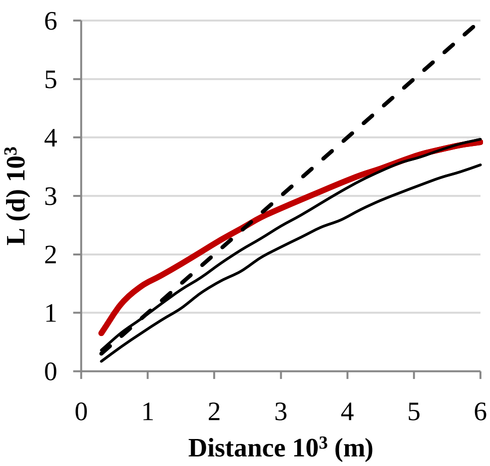

Figure 3. Ripley's K results for Archaic sites (red line). Expected values are shown as a dashed line; upper and lower confidence limits are shown as black solid lines.

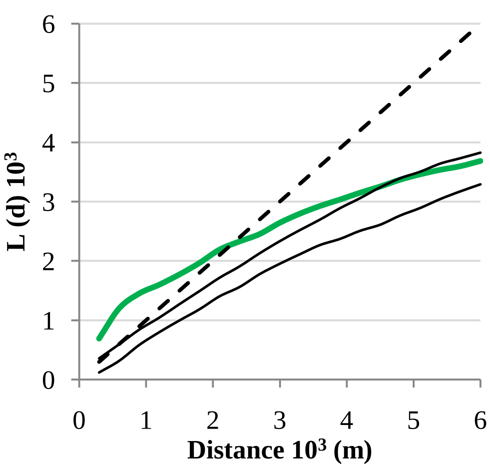

Figure 4. Ripley's K results for Woodland sites (green line). Expected values are shown as a dashed line; upper and lower confidence limits are shown as black solid lines.

Of the 405 open sites, twelve percent of the sites (n=53) were associated with only one cultural sub-period and seven percent (n=27) were affiliated with two sub-periods. Three cultural sub periods were identified at 1.2 % (n=5) sites. The percent of sites with greater than three sub-periods was 3.5% (n=14), with a maximum of 7 cultural sub-periods represented at one site.

Hot Spot Analysis Results

Table 3 shows the percent distribution of Z score values for the two hot spot analyses. Approximately 6% of the points produced statistically significant Z score values. Maximum values were 5.1 and 4.2 for the density and popularity index analyses, respectively.

Table 3. The Z score Hot Spot results as percent of points (n=405) based on the density of sites and based on popularity index.

Z Score Range	Density	PopIndex
< 1	83.5%	81.7%
1 – 1.96	10.1%	12.3%
>1.96	6.4%	5.9%

Z score values near zero indicate no concentration of either high or low values (Mitchell, 2005). Thirty percent of the density based hot spot analysis had Z score values between -0.5 and +0.5. The popularity index analysis had 36% point values within this range.

Negative values did not exceed the 95 % significance level for either analysis. The minimum values were -1.20 for the density based analysis and -1.36 for the popularity index.

Graphical results for the Hot Spot Analyses are shown in Figure 5 and Figure 6. Areas in red are statistically significant (Z score > 1.96), showing high density of sites and high popularity index values. Yellow areas are Z score values greater than 1, but less than 1.96. These reflect areas of high use or density, but the results are not statistically significant. Z score values less than 1 are shown in green, reflecting low site densities and/or less popularity across cultures.

The density based hot spot analysis (Figure 5) shows two statistically significant areas. The analysis based on the popularity index (Figure 6) shows three areas of significance. Both analyses show hot spots occurring near stream confluences.

The locations of yellow areas show some association with confluences, with most being located around the statistically significant areas (red). However, a few of these areas appear not to be associated with the major stream confluences.

Stream Size Preference Results

The open sites were assessed for proximity to a particular stream size. Forty-six percent (n=187) of the sites were closer to the Kickapoo River than any other stream. Low flow and/or intermittent streams were the second most popular with 32% of sites (n=128) in closest proximity.

Twenty-two percent (n= 90) of sites were located along one of 6 of the major streams. The values for these streams were as follows; 8% for Weister Creek, Warner Creek 5%, Billings Creek 4%, Indian Creek 3% and the Jug Creek Valley with 2 %. Plum Run, a stream on the south side of the study area had less than 1% (n=3) of the sites in closest proximity. No sites were located closer to Hay Creek, the northern most tributary, than other streams.

Site Selection Variable Results

Eight variables were selected as possible variables for influencing site selection. All were plotted in histograms to visualize the distribution. Most distributions were non-parametric and skewed towards the left. The distribution for aspect was the most uniform.

Elevation

The distribution of sites based on elevation is shown in Figure 7. The values range was from 243 m to 364 m. The average elevation was 269 m. The median value was 265 m, with 53% of the sites located between 250 m to 270 m. Less than 1% of the sites were located above 330 m.

Figure 5. Hot spot analysis based on density. Red areas are statistically significant (>1.96). Yellow areas are greater than 1 but not significant. Green shows Z score values less than 1. Black triangles are stream confluences. Scale is 1:160,000.

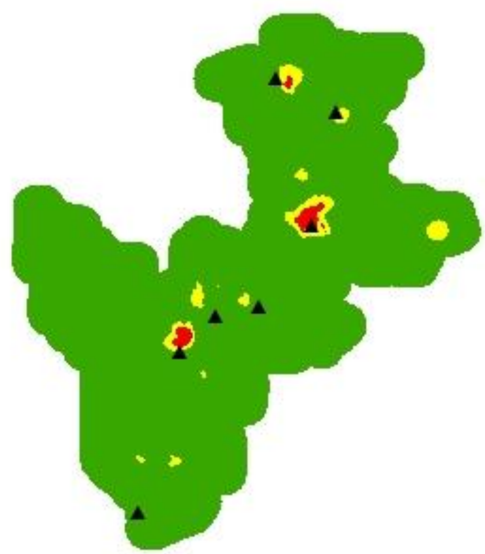

Figure 6. Hot spot analysis based on popularity index. Red areas are statistically significant (>1.96). Yellow areas are greater than 1 but not significant. Green shows Z score values less than 1. Black triangles are stream confluences. Scale is 1:160,000.

Aspect

Figure 8 shows the distribution of sites based on aspect. Fifty-eight percent of the sites were located between 135^0 and 315^0, showing a preference of site locations on south and west facing slopes. Thirty percent of the sites were on south-southeast and south-southwest facing slopes (135^0-225^0). The northeast direction (0^0-45^0) consisted of 17% of the sites.

Figure 7. Percent distribution of open site locations based on elevation.

Slope

The slope value distribution is shown in Figure 9. The average slope and median values were 7.7 degrees and 6 degrees, respectively. The range of values was from 0 to 33 degrees. 85% of the sites were located on slopes less than 15 degrees.

Distance to the Kickapoo River

Site distances from the Kickapoo River ranged from 0 m to 3387 m. The average distance was 443 m and the median value was 206 m. Twelve percent of the sites were within 50 m of the Kickapoo River and 11% of sites were located 1200 m or greater distances from the river. The distribution of open sites based on distance from the Kickapoo River is shown in Figure 10.

Distance to Streams

The distribution of sites based on distance from any stream is shown in Figure 11. Values ranged from 0 m to 557 m. The average value was 128 m and the median was 101 m. Ten percent of the sites were located within 25 meters of any stream within the study area.

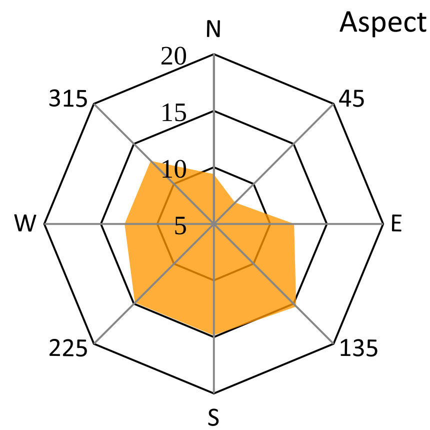

Figure 8. Percent distribution of open site locations based on aspect.

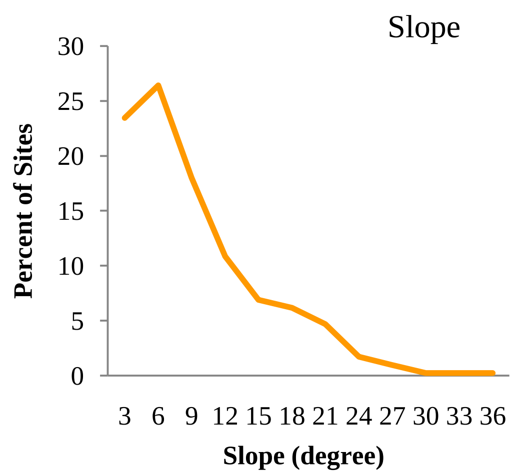

Figure 9. Percent distribution of open site locations based on slope.

Distance to Confluences

Figure 12 shows the distribution of sites based on distance from a stream confluence. The range of values was 81 m to 3657 m. The average value was 907 m and the median was 706 m. Four percent of the sites were within 200 meters of a confluence within the study area.

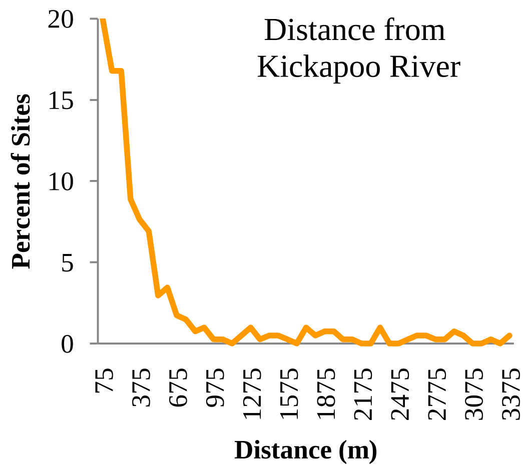

Figure 10. Percent distribution of open site locations based on distance from the Kickapoo River.

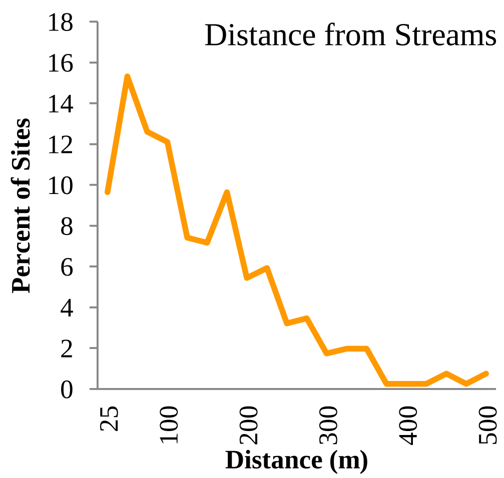

Figure 11. Percent distribution of open site locations based on distance from any stream.

Distance from Rock Shelters

The range of distance values of site locations from a rock shelter was 0 m to 2744 m. The average value was 437 m and the median was 262 m. Twenty-five percent of the sites were within 100 meters of any rock shelter. The distribution is shown in Figure 13.

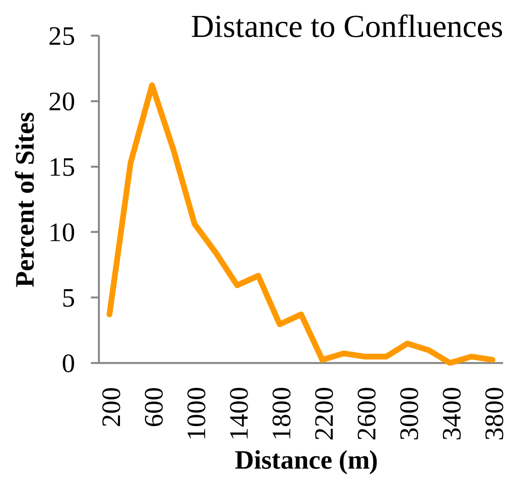

Figure 12. Percent distribution of open site locations based on distance from a major stream confluence with the Kickapoo River.

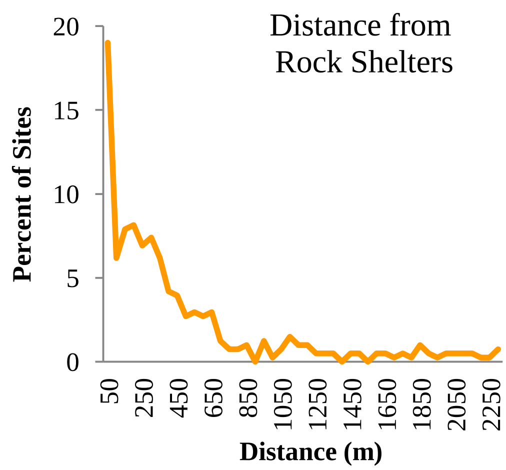

Figure 13. Percent distribution of open site locations based on distance from a rock shelter.

Distance from Cliffs/Steep Areas

Figure 14 shows the distribution of sites from areas of slopes exceeding 20 degrees. The values ranged from 0 m to 648 m, with the average value of 120 m. The median value was 95 m. Nineteen percent of the sites were within 25 m of a steep area.

Comparisons across Cultures

The results for the Kruskal-Wallis test are shown in Table 4. The results showed that the variation among the distances to confluences and the distances to streams was significant ($p<0.05$). The difference among the cultures was more pronounced for distance from confluences than the distance from streams. The values among the other tested variables did not show any significant difference.

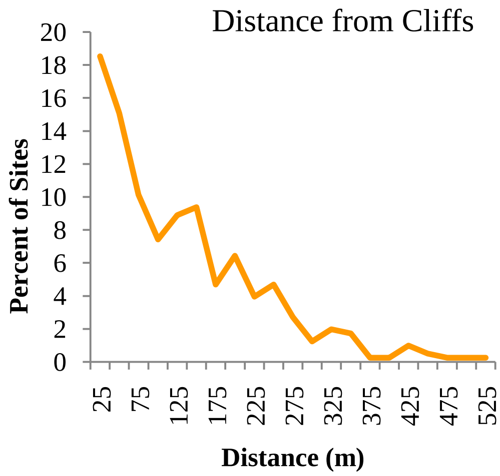

Figure 14. Percent distribution of open site locations based on distance from a steep area or cliff.

Table 4. P value results from Kruskal-Wallis test for five selected variables are shown. Significant (<0.05) values are shown as bold.

Aspect	0.9134
Elevation	0.9596
Slope	0.2552
Confluence	**0.0001**
Streams	**0.0217**

Discussion

One of the goals of this study was to investigate the distribution of archaeological sites within UKVAD. The overall distribution of open archaeological sites within the study area showed a pattern of clustering based on the Nearest Neighbor Index (NNI) and Ripley's K-Function analysis.

NNI and Ripley's K-Function analysis for the Archaic and Woodland cultured affiliated sites showed statistically significant clustering. Both data sets showed clustering to occur up to 2700 meters. Beyond this distance, the sites became more randomly distributed.

The Paleo-Indian sites did not show significant levels of clustering. This was likely the result of a limited number of sites (n=12) with this cultural affiliation. According to the output from the *Ripley's K-Function* tool, data sets should contain greater than 30 sample points for the analysis (ESRI, 2010).

Hot Spot Analysis

The hot spot analyses results showed a clustering near stream confluences (Figures 5 and 6). The analysis based only on density revealed two confluences as hot spots. Yet for the popularity index weighted analysis, three hot spot areas were revealed. Between the two analyses, one stream confluence was a common hot spot between the two analyses. Both hot spot analyses suggest the importance of stream confluences for site selection.

Areas of high use and density (yellow) were mostly located near confluences as well. Generally, these are "buffers" around the statistically significant areas. This decrease in density and popularity may be a result of an increase in distance from the confluences.

Yellow areas not associated with stream confluences may reflect proximity to other resources not present in the current landscape. These could include former ponds or small lakes, or a vegetation food sources.

Stream Size Preference

The preference of sites closer to the Kickapoo River than other sites was not surprising since it is the largest water resource in the study area. The higher percentage along the small intermittent streams may be a factor of the abundance of these streams rather than an actual preference. Alternatively, the preference to these smaller streams may reflect the small valley size, offering more protection.

Plum Run had the fewest number of sites in close proximity. This stream was located at the study area's southern most edge. These results were most likely a factor of edge effects rather than lack of resources along this stream compared to other streams.

Site Selection Variables

Elevation

The elevation distribution of archaeological sites revealed a slight preference to elevations between 250 and 270 m. Comparing range of elevation along the valley (240 m -253 m) with the average (269 m) and median values (265 m) indicated that most sites were slightly above the floodplain, but below the upland terrace level (275 m), as described by Holtz and Boszhardt (1998). These values probably reflect that lower elevations were closer to water sources.

Slope

The majority of the sites were located on slopes less than 15 degrees, as suggested by Holtz and Boszhardt (1998). Surprisingly 14% of the sites yielded slope values greater than 15 degrees, with a maximum value of 34 degrees. This upper range of values was most likely associated with the accuracy of the 10 m DEM. Sites located on slopes 20 degrees might occur on small, generally flat areas near, above, or below a cliff or steep slope. In support of this, 10% of the sites were located within 10 m of an area exceeding 20 degrees.

Aspect

The distribution of aspect showed a preference of sites located on south and west facing slopes. This was likely due to the greater amount of sun exposure on these slopes. Such slopes would have been ideal during colder climates and seasons. However, the presence of sites located on northern facing slopes further suggests prehistoric use of the area through all seasons.

Distance from Water Resources

Clustering of sites along streams is expected (Fletcher, 2008). This was illustrated by the Hot Spot analyses (Figures 5 and 6) occurring near confluences and through the histograms based on water resources (Figures 10, 11 and 12). 90% of sites were located within 250 m any stream.

Although only a low percentage of sites (4%) were located within 200 m of a stream confluence, the hot spot analysis shows the importance of confluences in site selection. The dynamic nature and high sedimentation rates of confluences (Best 1988; Bradbrook, Lane, Richards, Biron, and Roy, 2001; Howard *et al*., 2008) may have destroyed or buried many of the sites, thus further limiting archaeological information.

In addition, the importance of the particular four confluences with the higher density and popularity is unclear. Compared to the others, these confluences may have had unique resources, such as a rich vegetation food source or an abundance of game migration paths.

Distance from Rock Shelters and Steep

Areas

The histograms show site locations were close to rock shelters and steep areas. These results may have been influenced by the distribution of these resources rather than a site selection process. A Nearest Neighbor Index evaluation was conducted on the 91 rock shelters within the study area. The results showed a clustered distribution (p=0.0000). Visual inspection revealed that many rock shelters were close to streams. Therefore, the close proximity between rock shelters and open sites may not be based on site selection but rather due to the close proximity of rock shelter sites to water sources.

The occurrence of sites close to steep areas may result from their abundance and wide distribution. Cliff faces occur along the river channel as well as just below the ridge line. Furthermore, the minimum value (20 degrees) for steep areas defined in this study may have been to low. Therefore, the steep areas may have been too broad or widely distributed. A narrower range of slope may have better isolated cliffs as a resource.

Comparing the Cultured Sites

The results from the Kruskal-Wallis analysis indicated that the values based on distance from confluences and the distance from streams were significantly different among the cultural affiliated sites. Comparing the median values, the Paleo-Indian sites had a greater median value (3047 m) than either the Archaic (825 m) or Woodland sites (853 m). This indicated the Paleo-Indian sites were further away from confluences than the other two. The median values for the Archaic and Woodland sites were similar.

However, the median values among the cultured site based on distance from streams varied more among the three cultural affiliated data set; Paleo-Indian 221 m, Archaic 117 m and Woodland 85 m. Again, this confirmed that the Paleo-Indian sites were further away from streams when compared to the other cultures. Yet, the median values for the Archaic sites and the Woodland site did not show much similarity.

These differences based on water resources for the culture sites could be a result of changes in stream channel locations over the years. For example, the Paleo-Indian sites may have been further from streams and confluences, based on current stream locations, but were significantly closer during the time of site occupation. Small oxbow lakes and meander scars along the current Kickapoo River and the larger tributaries indicated stream channel migration. These processes undoubtedly have occurred throughout time.

A second possible explanation was the stream flow or discharge volume during each of the periods could have varied significantly. The climatic record indicates Paleo-Indian period was relatively cooler, having occurred shortly after the Pleistocene Ice Age. The Archaic period was a warm and dry period known as the Altithermal (Theler and Boszhardt, 2003). Both of these climate trends would have influenced stream flow and possibly channel width.

Despite these possible reasons, the paucity of Paleo-Indian sites did not provide an extensive amount of information to make any definitive conclusions.

Future Studies

This study explored the distribution of open sites within a portion of the Upper Kickapoo Valley Archaeological District, mainly within the Kickapoo Valley Reserve. The study considered each site as a habitation site and that each site was chosen by prehistoric people. Furthermore, the artifacts found at a given site were assumed to indicate the site was used, at minimum, for a short duration of time (i.e. one night).

Future studies should consider using a wider data set extent of the archaeological sites in the UKVAD. The irregular boundary of the study area may have had an effect on the distribution results.

A more detailed investigation of components found at each site could isolate the sites actually used for habitation. Fire cracked rock is a key feature suggesting habitation uses (Holtz and Boszhardt, 1998). Also, statistical studies may consider the similarity and differences among the sites unique to the Archaic and Woodland periods, as well as the sites shared between these periods.

This study used 20 degrees as the minimum value for a steep area. The resulting areas could have been too broad and not specific enough to capture the actual resource of a cliff face. Further studies could re-evaluate this resource with a narrower range.

Conclusions

This project identified the distribution of open archaeological sites in UKVAD as having a clustered distribution pattern. Based on physical environmental factors, trends were shown to favor lower elevations and gradual slopes. The site locations also showed a preference for south-southwest facing slopes.

Analysis based on proximity to resources concluded that the sites were closer to water resources. The proximity to some resources may be a factor of the abundance and/or the distribution of these resources, rather than an intentional selection process.

Comparisons of variables based on cultural affiliation show similarity between the topographic variables. Distances to water resources revealed some differences based on culture.

Acknowledgments

Dr. Connie Arzigian at Mississippi Valley Archaeology Center (MVAC) at University of Wisconsin - La Crosse assisted with project goals and ideas as well as access to archaeology documents. Also, I thank Dr. Jim Theler at MVAC for considering the project as a “good idea”. I thank the Wisconsin State Historical Society for permission to use the archaeological data. Betsy Finlay at the Historical Society processed the permission request. Dr. Adam Carle at the Cincinnati Children’s Hospital Medical Center in Cincinnati, OH gave valuable discussion and assistance with statistics. I thank Marcy West and the staff at the Kickapoo Valley Reserve for GIS data, archaeology documents, and moral support. Former and current SMU students, Chip Brown and April Ammann (respectively), reviewed the document and offered comments. SMU faculty and fellow students furnished inspiration, education, guidance, and laughter. And I thank Gina Rae, of the restaurant formerly known as Gina’s Pies Are Square in Wilton, WI, for her patience, understanding, and support through another degree.

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