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Landscape Visibility and Prehistoric Artifact Distribution at Pea Ridge National Military Park

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By

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Abstract

Pea Ridge National Military Park, in the north east corner of Benton County, Arkansas, is the 4,300 acre site of a crucial Civil War Battle. Human occupation of the Ozark Highland landscape, however, extends far into pre-history. A 2005 report to the National Park Service details the findings of a four year cultural resource survey of the park. The sampling strategy employed in the research design (random sample site selection and 2.5% park coverage) provides an excellent dataset to assess prehistoric land use. This dataset is not dependent on artificially defined sites, representing singular activity in a limited geographical space. Instead it allows for interpretation of patterns of land use; while artifacts may not be spatially or temporally associated, their provenience on the landscape can be assessed in relationship to various landscape elements and environmental variables. Trends in artifact location can be seen with this representative sample distribution.

The 2005 report examines artifact distribution with respect to permanent and intermittent streams. The predictive models produced from the analysis closely relate the availability of water and caloric expenditure required to travel across the landscape to a majority of the prehistoric material at the park. The report also explores seasonal expressions of land use at Pea Ridge. The goal of this project is to explore the relationship between another landscape variable, visibility, and prehistoric locations that do not conform to the models of the original study, those with higher travel costs to water. Economic models like cost-to-water are meaningful interpretations of land use, but I feel that such models preclude other elements of landscape experience. By comparing the distributions of conforming and aberrant prehistoric artifact groups against three different measurements of visibility, I hope to show that landscape perception could be a reliable predictor of prehistoric material in high cost areas.

Acknowledgements

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Table of Contents

I. Introduction

A 2005 survey report of the Pea Ridge National Military Park (PERI) details a modern strategy for statistical archaeological sampling, the analysis of the collected data, and the conclusions drawn from the analysis (Kay and Herrmann 2005a, 2005b, 2005c, 2005d). The sampling strategy is versatile, suitable for both historic and pre-historic survey in most every geographic region, surface visibility condition, and vegetation. The impacts are minimal, involving as much surface survey as possible and a specific regime of shovel tests in each sample unit without extensive, costly, and destructive excavation. The coverage is substantial and flexible; as much could be done as can be afforded. Such a survey returns a truly distributional dataset, not reliant on high density deposits or bounded site areas.

The records of material remains discovered, recorded, and recovered from the survey were digitized and assessed using Geographic Information Systems, specifically *IDRISI* and *ArcGIS*, and produced a number of intriguing interpretations. One decade removed, the sampling strategy, survey technique, and models produced stand firm. What has improved is the spatial resolution of the digital model of the space assessed in the survey. The original study was structured and conducted on a 30 meter Digital Elevation Model (DEM). Light Detection and Ranging (LIDAR) scans of Benton and Washington Counties, Arkansas, including Pea Ridge National Military Park, now exist that improve the resolution to 25 feet. Such improved resolution drastically affects the perception of the space in such an analysis (Chase et al. 2012; Harmon et al. 2006). My goal is to utilize the DEM from the LIDAR dataset to contribute to the assessment of land use at Pea Ridge.

As an extension of the original assessment I would like to test quantifiable aspects of space and landscape morphology as variables in a phenomenological assessment of land use. The debate in archaeological theory about what we can truly "know" has always baffled me. I understand the merits of the two extremes: on the one hand, what can be measured can be understood, and on the other, personal experience and individuality defy summarization (Hole, 1980; Zubrow, 2006). I, however, do not find the positivist and post-processual perspectives to be mutually exclusive. The objective/ subjective dichotomy so frequently contested in theoretical discussion is not wholly in opposition, I think. Typically, "scientific" archaeology attempts to generalize cultural manifestations into "laws," glossing over any subjective or experiential interpretation. I argue that the problem arises from generalizing specific instances of human activity, not that generalization itself precludes experiential interpretation. Rather than assessing a site of cultural activity and developing generalities about specific behavior, I would like to assess the nature of a distribution across a landscape as a range of human activity. The synthesis of deductive and inductive reasoning in model construction is not new (Kay and Allen, 2000; Kay and Herrmann, 2005a, 2005d; Redman, 1973; Schiffer and Gummerman, 1977b; Wheatley and Gillings, 2004), but the recognition of patterns in archaeological data typically revolves around physiological/ economical aspects of human land use. Measurable aspects of landscape and the location of artifacts in relation to them should allow for both "scientific" and "phenomenological" interpretations. Both physiological needs for survival and a metaphysical experience of the world can both be represented using techniques of quantified spatial analysis (Knapp and Ashmore, 1999; Llobera, 2003, 2006; Lock and Harris, 2000; Tilley, 1994; Wheately and Gillings, 2000).

Specifically, I aim to assess elements of landscape as they pertain to visibility. Perception of the environment is an integral part of land use (Gibson, 1979; Knapp and Ashmore

1999, Llobera, 2003, 2006; Tilley, 1994). Visual components of a landscape can serve both functional/ economic and experiential/ metaphysical purposes. This report is the result of an attempt to validate such a claim using variables that represent landscape visibility rather than a traditional viewshed analysis. Visibility measurements commonly used in archaeological assessments involve intervisibility of sites or the portion of the landscape visible or invisible from an observation point. Such calculations pertain to the particulars of the observation points, quite frequently monumental architecture or relatively large, dense sites (Fisher et al. 1997; Jones, 2006; Lake et al. 1998; Llobera 2006; others). While the value of assessing such visual interplay between such sites and their surroundings is apparent, there is little to suggest that intervisibility of positive prehistoric locations at PERI is significant whatsoever. Instead, I want to represent the landscape in a visual sense (as an extension of Marcos Llobera's concepts of *visualscape* and visual property: landscape elements of a visual nature [2003, 2006]) and assess the distribution of artifacts in this context.

As a secondary goal, I would like to explore visibility as a factor in land use strategy for upland areas during summer, when water is least abundant. The broad distribution of prehistoric locations beyond the caloric-cost predicted zones appears to coincide with areas of increased solar illumination during the summer months. During a hot and dry Ozark summer, what factors would encourage land use well away from limited available water? I argue that the broad distribution in upland areas confers a more expansive viewshed, making upland exploitation a valuable land use strategy in summer.

II. Project Context

Setting

Pea Ridge National Military Park is a National Park Service (NPS) landholding located in the Northeast corner of Benton County, Arkansas. The park was the site of a large American Civil War battle, but the cultural resources on the premises are not limited to the conflict. Both prehistoric and historic material remains are abundant within the park boundaries, as evidenced by this survey (Kay and Herrmann, 2005a, 2005b, 2005c, 2005d). Frequent and repeated, if not continuous human occupation at PERI is suggested with even a cursory assessment of the cultural resources present (Kay and Herrmann, 2005b-c).

Situated near the southern edge of the Springfield Plateau, a sub-region of the Ozark geologic formation, PERI is characterized by low rolling mountains with plains between. The landforms are moderately dissected by ephemeral, seasonal, and permanent streams. Typical Ozark vegetation populates the landscape: oak forest and low growth understory dominate some areas (Cozzens, 1940) while tree stands are interspersed with prairie grasses elsewhere. The topographical diversity within the park, as well as the landscape redundancy throughout the Southern Ozark region make it an ideal setting for an exploration of land use decisions (Kay and Herrmann, 2005a).

The PERI survey as a distributional dataset

The initial PERI survey was carefully crafted as a truly distributional study of the cultural resources, both historic and prehistoric, for the National Park Service. Rather than copy/pasting the research design from typical resource inventory and salvage operations, the project implemented a sampling strategy structured to address the resource management needs of the park using common archaeological discovery techniques (outlined in Kay and Herrmann, 2005a). Several research goals were stated, spanning prehistoric land use, historic settlement, the Civil War battle, and post war occupation of the region. Even with explicit goals, the data was collected in such a way to sample the resources of the entire park, allowing for application beyond the initial study (Kay and Herrmann, 2005a).

The structure of the sampling strategy is closely related to the analytical techniques and technology used to answer many of the research questions. The DEM of the park available at the time of the survey carried a 30 m resolution: the grid cells or pixels of elevation data represented 30m by 30m areas of the park. Because these were to be the units of analysis, they were utilized as the units of sampling. A 30 m grid corresponding to the 30 m DEM was projected onto the park and grid cells were randomly selected, located with GPS, and tested for cultural material. 505 30 m units (from the ArcMap point file of the survey) were randomly sampled over the course of the survey, accounting for 2.5% of the park area. Methods of testing included limited metal detection, visual assessment of the ground surface, and predominantly shovel testing and dry screening (4336 tests dug and screened with .635mm or .25 in mesh screens). The routes traveled between sample areas were also visually assessed in transit, so some opportunistic finds were documented outside the randomly selected grid cells. Shovel tests were conducted at the center of each grid cell and at 15m intervals on the perimeter, as allowed by vegetation and landscape morphology. Each positive find was recorded and spatially referenced with a GPS unit (Kay and Herrmann, 2005a).

While the sampling strategy is simply devised, I think it affords a unique perspective on and effective assessment of the cultural resources of the park. The random selection of sample cells circumvents what may be considered selection bias in both design and undertaking in many archaeological surveys. The size of the sample units addresses issues of spatial resolution and siteless-ness in distributional archaeology. The testing methods deal with the realities of the vegetation and landscape. The broad scope of the design extends the life of the data far beyond the initial survey and research questions; new analytical schemes and methodological approaches should be able to utilize the original data without questioning the validity of the data collection.

Simple transects, a common survey technique, will ideally cover an entire survey area in a uniform fashion (Goodyear, 1977; Kintigh, 1988; Krakker et al. 1983; Lightfoot, 1989; Nance, 1983; Nance and Ball, 1989). At best, this is a good way to cover an entire area with simple instruction for technicians and low impact on the archaeological record: either using visual assessment of the surface or shovel testing at set intervals. In my experience, however, transect survey is subject to both error and presumption. Following a compass bearing even slightly off course can produce uneven spacing, thus more heavily sampling some areas and more lightly sampling others. Even more dubious is the presumption introduced in transect planning: transects may be oriented to follow particular geological trends, intersect landscape features, or avoid certain areas. Some surveys even incorporate high and low probability areas, meaning wide spacing where material is not expected to be found. The method and theory of probability sampling is frequently discussed (Dunnell and Dancey, 1983; Hole, 1980; Nance, 1983; Rogge and Fuller, 1977), but questionable (Dunnell and Dancey, 1983; Hole, 1980; Nance, 1983). As archaeologists expect to find cultural materials in certain conditions, the survey may be structured to test those spots and avoid others. The tendency to find what one is looking for and disregard the unexpected projects modern presumptions about antiquity, and can adversely affect a study (Ebert, 1992; Hole, 1980; Shott, 1989). Selecting grid cells at random, regardless of geomorphology or presupposed presence or absence of cultural material avoids the prejudice of transect plotting. Locating the sample units with GPS and conducting the shovel tests within the 30m square reduce the chance that tests are inadequately spaced or inaccurately located within the sampling design.

A distributional study is framed around the concept that artifacts are important in relationship to one another beyond clustered groups that may indicate an isolated activity (Bevan and Conolly, 2002; Dancey, 1994; Dunnell and Dancey, 1983; Ebert, 1992; Nance, 1983). While such a "site" may speak to the process of, say, tool manufacture or deposition of waste at a settlement, a cluster of directly associated artifacts does little to assess larger trends of landscape exploitation, settlement patterns, or culture through time and space. A distributional survey would attempt to fill the gaps between dense clusters of cultural material, better grasping the entirety of cultural interaction with the landscape. Ebert's example study in *Distributional Archaeology* (1992) involves an extensive surface survey of a number of large contiguous study areas. 500m by 500m grid cells were selected at random, much like the PERI survey (only on a much larger scale). Ebert contends that the coverage of his study area is not important (only 25 test units were surveyed due to time constraints), but he argues that the methodology is sufficient to assess the distribution of artifacts across a region. While Ebert's (1992) study area is larger than PERI, about 185,000 acres, I contend that testing a large number of smaller areas provides better coverage of a region than a small number of larger units. While a large sample area may encompass various landscape features, they are sampled as one and variation of landscape composition is not accounted for. While a rolling plain may be surveyed intensely in a 500m area, a nearby ridge may be entirely avoided because it did not intersect one of the few survey areas. Dispersing many smaller units might more completely cover a study area, thus sampling both the ridge and the plain. The same area can be more widely distributed across a study region, without incurring extra time or monetary cost. Further, smaller sample units do not assess a geological region as a whole, but more accurately describe the landscape elements (Stafford, 1995), or local features that compose a complete landscape. A plain might be more accurately described by its components: stream, riparian zone, flood zone, swells and mounds, etcetera. Such resolution of landscape elements may provide insight into the nature of an artifact distribution.

The actual method of sampling is an important consideration in a survey as well. Ebert (1992) argues that visual survey of cultural materials on the surface provide the best and most accurate assessment of a distribution. He and others (Ebert, 1992; Kintigh, 1988, Krakker et al. 1983; Shott, 1989) argue that shovel testing relies on intersection of testing intervals with subsurface deposits; it is a method of site discovery that is rudimentary, its effectiveness in question. The defense of shovel testing as a viable method of survey and data recovery is extensive as well (Lightfoot, 1989; Nance, 1983; Nance and Ball, 1989), but still revolves largely around site discovery, something a truly distributional study should not be concerned with. The reality of the survey technique situation is multi-faceted. First and foremost, archaeological deposits are not manifested uniformly. Ebert's (1992) surface assessment was conducted in the Great Basin. Deposition in the Ozarks results in drastically different expressions: quite frequently artifacts are carried downhill or displaced downward into soil stratigraphy (Kay and Herrmann, 2005a). Post depositional forces are surely a factor in the Great Basin, but lateral displacement seems to be a larger issue than downward into the strata (Ebert, 1992). Therefore, Ebert (1992) is not concerned with documentation of buried deposits, arguing that such caches represent rare instances of sealed isolated activity, and confident that the surface artifacts will be representative of the distribution of cultural material in the region. In the Ozarks, subsurface artifacts compose a large portion of the material record. Even 100% of surface material is not representative of regional distribution. Regardless of the representativeness of a surface collection, the obstacles to obtaining one make it an unsuitable foundation for a survey. Grasses, forest undergrowth, larger trees, and organic detritus all produce a covering that is nearly visually impenetrable. The fact that a surveyor cannot see the bare earth surface severely inhibits his or her ability to spot and collect artifacts from it. The shovel test, in this case, is a necessary technique to sample subsurface deposits and collect data (Kay and Herrmann, 2005a).

The emphasis on regional scale investigation and random sample collection of the PERI survey make it an ideal dataset with which to explore visual elements of landscape and the relationship of archaeological distributions upon them.

III. New Data

LIDAR derived DEM

The simple consistency in the research design for the PERI survey not only does well to address the specific questions posed in the original study, but extends the life of the data for further inquiry. Through application of the prehistoric artifact locations to more recently available elevation data, I will address some of the predictive modeling from the original study and evaluate some aspects of landscape visibility. Using the improved resolution of the LIDAR derived DEM, I hope to emphasize the *visualscape* (Llobera, 2003, 2006) as a predictive variable of land use. The LIDAR model improves the resolution of landscape elements, which in turn improves the overall interpretation of regional landscape morphology and ultimately land use (Bevan and Conolly, 2002; Chase et al.2012; Harmon et al. 2006).

Although originally conceived in relation to the 30 meter DEM (Figure 1a) available at the time of the study (Kay and Herrmann, 2005a), the GPS coordinates of the positive shovel tests allow them to be disconnected from the large grid cells and plotted onto a higher resolution model of the park. Using the LIDAR model, which represents surface elevation in 25 foot by 25 ft (approximately 7.62 m by 7.62 m) grid cells (Figure 1b), provides a much more fine grained representation of the land surface at PERI and a more accurate assessment of the artifacts in relation to the landscape and each other. A 30 m grid cell in an elevation model holds one elevation for the 900 m^2 it covers. A 25 ft grid cell represents about 1/15 the area, so each 30 m grid cell is subdivided and the elevation approximated about 15 times in the higher resolution model. When taken from the abstraction of a computer screen to the real world, the advantage is quite clear: the 7.62 m square around an observer is much more representative of the local elevation, slope, relief, aspect, et cetera than the surrounding 30 m square. Resolution is

Figure 1a: PERI DEM 30m Cells

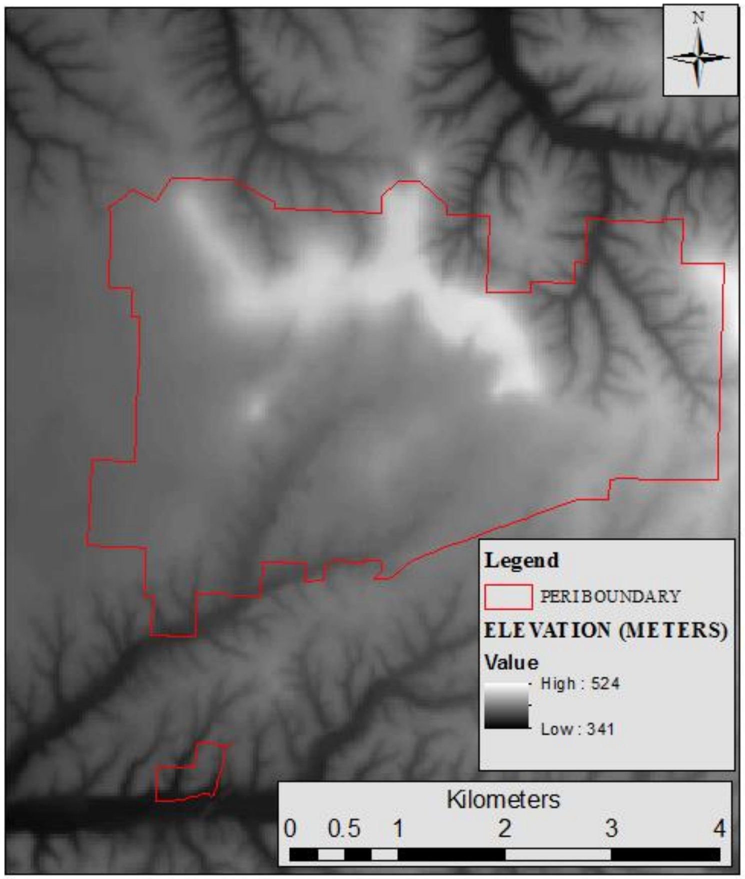
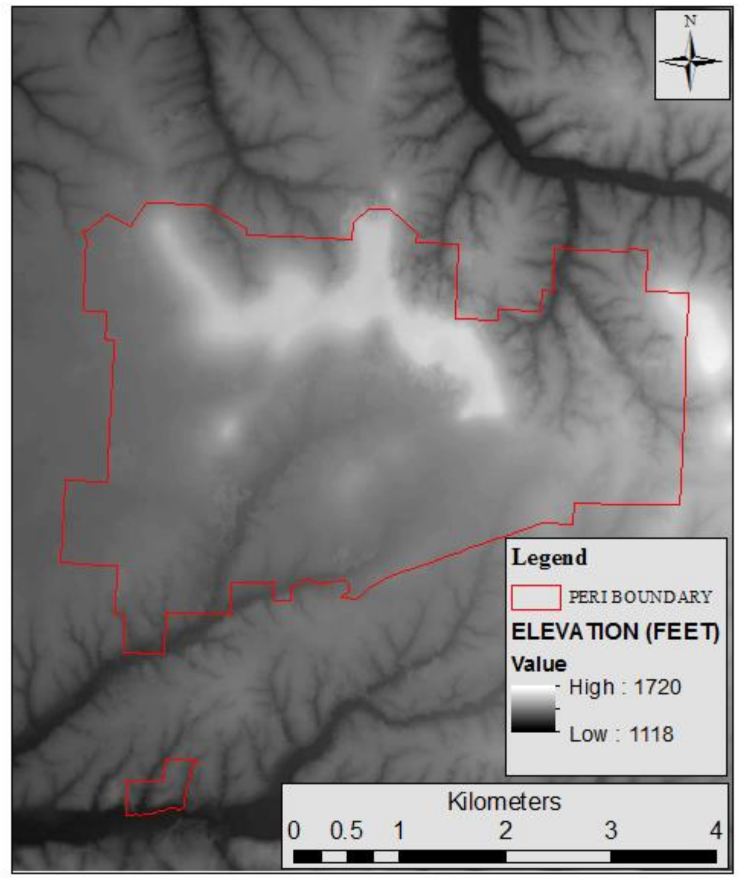


Figure 1b: PERI DEM 25 ft Cells



especially important in variable terrain, a steep slope may be smoothed over and reduced in severity because elevation is the approximation over 900 m^2 rather than 58.06 m^2. While 25 ft grid cells are still an approximation (Lock and Harris, 2000; Wheatley and Gillings, 2000, 2004; Zebrow, 2006), they are a better approximation than the 30 m cells used in the original PERI study.

The predictive models in the original survey are derived from the cost of travel across a landscape and the distance one travels from water. Multiple techniques for calculating the cost of travel or "cost surfaces" were utilized, the merits and shortcomings of each are outlined in detail in the NPS report (Kay and Herrmann, 2005d). No matter the technique, the starting point for each cost surface is the park DEM. An elevation model is a primary layer, and from it, any GIS can derive other useful layers (Burrough and McDonnell, 1998; Wheatley and Gillings, 2004). Comparing a cell's elevation with the elevations of its neighbors, for instance, a slope value can be assigned to it. Slope is a primary value in many of the cost surface calculations. The cost of travel across a 30 m grid cell can be estimated, but basing that calculation on one slope value is an invitation for error. The slope of the ground surface can change drastically over 37 m (the average distance traveled when moving through the center across a square with 30 m sides, a value used in calculating travel costs) (Kay and Allen, 2000; Kay and Herrmann, 2005d). Constraining the estimation to 8.576 m (the average distance through the center of a square when the sides are 25 ft) reduces the effects of the surface approximation, providing a more accurate cost surface.

The finer resolution should not only better approximate cost surfaces, but provide a more accurate basis for calculation of elements of landscape visibility. A viewshed is a raster layer in which cell values represent whether they are obstructed or visible from a source cell or observation point (Fisher et al. 1997; Jones, 2006; Wheatley and Gillings, 2000, 2004). Line of site (LOS) calculation is central to most techniques of viewshed (Fisher et al. 1997; Jones, 2006; Llobera, 2003; Tschan, 2000). Other functions of visibility can be calculated using different parameters of LOS, but the principle remains. With a finer resolution DEM, localized terrain variation is more accurately depicted; the better a true landscape is represented, the better visibility can be assessed.

Data considerations

In the interest of full disclosure, there are a few issues to address prior to the discussion of predictive modeling and land use assessment. While the following points do require consideration, I see them more as areas of potential improvement beyond the scope of this project rather than caveats to the success of this study. Quite frankly, the time constraints imposed by happenstance and deadline prevented me from pursuing some avenues of potential improvement; they are realistic goals, just not within the time frame I faced.

The first is the cell size of the new DEM, in two parts. The first of these is the unit of measure. The Landair Mapping LIDAR scan in 2004 was conducted at 7 m intervals (Tullis, personal communication, March 2015) but the DEM derived from it has 25 ft cells. The Geostor description indicates elevation values in meters, but values indicated in the layer itself appear to be in feet. The source of the discrepancy is unclear. Perhaps the historic nature of the battlefield merits imperial units rather than metric, but this is entirely speculation, and would not explain the use of both in the same layer. A simple multiplication operation in ArcMap (elevation values *.3048) should rectify the situation by converting all elevation values to meters (Lockhart March, 2015; Kvamme, March 2015, personal communications). The second is the actual cell dimension. This project was conceived under the supposition that LIDAR data existed that could produce a sub-meter elevation model. As previously mentioned, the LIDAR data collected in 2004 utilized 7 m spacing, making smaller cell sizes no more than interpolated subdivisions. It seems as though high-caliber, sub-meter LIDAR data of Benton County is being or has been collected, but is not yet available (Van Beek, Feb, 2015, Cothren, March, 2015, personal communications). Availability of this data would certainly merit its use (Zubrow, 2006), but as of now, 25 ft cell size is the highest resolution I have access to.

The next issue to consider is the bare earth approximation. LIDAR scans produce point clouds of un-differentiated class. This means the laser returns unsorted elevation measurements of bare earth, roads, low vegetation, buildings, trees, and any other objects present in the scan. Those points require digital sorting (Chase et al. 2012). The DEM available through Geostor was classified by an automated process, which seems to have produced some anomalies in the resulting elevation model. These few instances are small though, occurring where the laser may not have fully penetrated the canopy or passed over a building. While an imperfect scan of the bare earth surface, I believe it is an accurate enough approximation of the landscape: indeed more representative of local elevations than the 30 m layer previously used.

Third is the delimitation of the study area. Pea Ridge is a 4,300 acre land holding including the main park and a small parcel of land south of the western half of the park (National Park Service, 2015). I have restricted my assessment to the confines of the park, but included some area outside the park for the calculation of landscape variables. The survey data was collected from and is an assessment of the cultural resources of the National Park Service land holding at Pea Ridge Battlefield. When carried into prehistory, this boundary is arbitrary, but it does define the current property, and should be the primary concern of this study. The initial PERI assessment deals only with the park property, for consistency's sake I will do the same.

Such arbitrary regional definition should not inhibit the success of the study, as the sampling strategy is well defined and justified (Lipe, 1977). I calculated the landscape variables using a portion of the Benton and Washington County DEM that includes the entirety of the park as well as a buffer approximately 10,000 feet in each cardinal direction from the park boundary. I included this buffer to mitigate the edge effects of assessing the landscape within a bounded area; I will elaborate in the proceeding section detailing the assessment method.

An issue most pertinent to the visibility operations, is vegetation. The bare earth elevation model is representative of the landscape with no vegetation present. While trees, brush, and grasses between an observer and an observation most certainly interfere with said observer's ability to observe (Gearey and Chapman, 2006; Tschan, 2000), assessing that interference is an undertaking far beyond the scope of this study (Gearey and Chapman, 2006; Bevan and Conolly, 2002). Therefore, I have chosen to disregard vegetation as a factor in my study. Thirteen thousand years (the approximated span of human occupation of the Ozarks [Kay and Herrmann, 2005a-c]) is a relatively short time, geologically speaking. In terms of a biotic community, it is many, many lifetimes. I can assume that the landscape has changed only modestly over the course of human occupation (Kay and Herrmann, 2005a-c); likewise, I can assume that the vegetation has changed drastically. Simple factors of human interaction with the environment like the clearing and plowing of fields for agriculture and wildfire prevention have caused remarkable change in the plant life at PERI even in the last few hundred years (Marvin Kay, personal communications 2014-2015). Prehistoric locations of tree stands, forests, and prairies, as well as the densities and heights of the plants would be nearly impossible to model at any point in time, much less over the entire course of human occupation. Some intensive prehistoric vegetation and pollen analysis might inform some level of weighting or some kind of filter through which to estimate visibility (Geary and Chapman, 2006; Wheatley and Gillings, 2000), but such an undertaking is well out of reach for this project.

IV. Assessment

Landscape visibility as a factor of land use

The predictive models produced from the original PERI study closely relate water availability to prehistoric artifact distribution across the park. The models are derived from a series of cost of travel assessments utilizing the park elevation data and plotted stream courses to calculate the expenditure of energy while traveling across the landscape, away from water. The models are based on the human physiological need for water and the generalization that settlement decisions will be made to satisfy that need without great cost. The generalization is duly confirmed, it is reported that various iterations of the model accounted for significant percentages of the prehistoric assemblage collected in the survey over a relatively small percent area of the park: the areas near water (Kay and Herrmann, 2005d). The statistical "drop off" of artifact locations noted at distances greater than 200 meters from permanent and intermittent streams (Kay and Herrmann, 2005d:22), however, does not mean that the entire distribution is explained by minimal effort in travel to water. The portion of the distribution aberrant to the cost-distance predictive modeling merit re-visitation. I would seek to explain these prehistoric locations not as sites that do not conform to an expected settlement strategy, but as expressions of land use not so simply characterized by efficiency and physiological need (Tilley, 1994).

The prehistoric locations discovered in the PERI survey are representations of human land use, not necessarily "sites" by the common notion of human settlement and activity (Kay and Herrmann, 2005d:37). While some of the cultural material may have been extracted from a dense cluster of artifacts suggestive of a camp or settlement, some traditionally conceived site, the artifacts themselves are not indicative of such activity. The distribution recorded and analyzed in this study merely represents the full range of land use at PERI, both spatially and temporally (Kay and Herrmann, 2005d). The variety of models developed for the initial study deal with the energy cost expenditure of traveling away from water. This is a highly functional approach to land use but does not encapsulate the entirety of human spatial needs. Land use, while relatable to water availability, cannot be fully summarized by it. I want to change the nature of the questions being asked about land use. Landscape perception, I believe, is another crucial factor in land use strategy. The aesthetic of an environment, connection to a landscape, and associations of time and place are common sentiments. While such metaphysical and experiential phenomena may be difficult to quantify, I think that certain measurable environmental and landscape features may serve as proxies, or at the least, inform this study as to what kinds of characteristics may have an influence on land use decisions. Using the toolset available in the open source Geographic Information System (GIS) *SAGA*, I have produced several data layers representative of the landscape that diverge from a biological needs assessment of land use.

The somewhat metaphysical sense of place is to a great degree interpreted through sight (Gibson 1979; Llobera2003, 2006; Tilley, 1994). Perception of a location is in no way limited to the visual sense (Zubrow, 2006), but humans are visual creatures and I believe that visibility is a critical factor in how humans conceive of a landscape and how they act upon it. Through assessments of visibility and landscape openness, I here attempt to demonstrate that a somewhat intangible concept like perception can be quantifiable through tangible elements of the *visualscape* (Llobera, 2003, 2006), and that it can be used to assess an artifact distribution.

In the context of the PERI survey, it can be said that the prehistoric locations satisfactorily explained by their cost of travel to water lie within a certain zone (calculated a number of times using different methods), and those not explained lie outside it. I will divide the artifact distribution by their inclusion in or exclusion from the zone, dubbed conforming and aberrant, respectively. As the conforming locations may be satisfactorily explained by water availability, I believe that the aberrant locations may be explained by landscape visibility.

The procedures that follow document my attempts to assess variables of landscape in terms of perception, as well as the predictive model constructed from the variables and a statistical assessment of the difference between conforming and aberrant prehistoric locations.

Cost surfaces

The first stage of the assessment requires creating the zone that satisfactorily separates conforming and aberrant prehistoric locations and creating a location class for each. For this zonal creation I wanted to produce a cost surface consistent with the original PERI survey on the improved resolution of the 25 foot DEM. I used a shapefile of the intermittent streams as my water source. I did not use permanent water, because the only permanent water at PERI is Winton Spring, which does not account for much water in the park (Kay and Herrmann, 2005B). The intermittent streams were frequently used in the previous assessment, so I will use it as the basis for mine. The caloric values 71 and 163.5 are also derived from the PERI report, being the cost values from intermittent and permanent streams beyond which there was noted a statistically significant decline in artifact density.

The ultimate version of the cost surface involves manipulation of McDonald's transport cost calculation, and Brannan's inclusion of weight and rate of travel. I extracted these descriptions and calculations from the PERI report, which are in turn cited from Kay and Allen's 2001 Taney County report. From the PERI report (Kay and Herrmann, 2005d):

$$\textbf{Cost (in Calories)} = \mathbf{37 * (7*(Slope) +50)/1000m}$$

And: Cost (in Calories carrying 10kg) = ((.5*slope) +10)*(unencumbered cost)/100 + unencumbered cost

To apply the formula to the 25 ft DEM, I had to manipulate the equation, accounting for the reduced distance across each cell and the conversion of feet to meters. I also removed what appears to be an extraneous parenthesis at the end of the unencumbered cost calculation. As explained in the PERI report, the distance (37 meters in the unencumbered cost formula) is representative of the average distance traveled in a straight line, from edge to edge, and across the center of a cell. It is equal to the diameter of a circle of the same area of the cell (Kay and Allen, 2000; Kay and Herrmann, 2005d). A 25 ft square is 625 square ft, and the diameter of a circle with that area is 28.2095 ft. Times .3048 (for the metric conversion) yields a distance of 8.5982 m. Imputing the (metrically converted) DEM into the slope function of *ArcGIS*, I created the slope layer at a 25 ft resolution. My calculation for the unencumbered cost surface is:

Cost (calories) = 8.5982 * (7 * (Slope) + 50) / 1000m

The resultant cost surface shows the caloric cost to travel across each individual cell, ranging from 0.4299 calories to 1.1734 calories. To introduce the impedance of carrying a weight, I inserted the slope and unencumbered cost layers into the adapted encumbered cost formula, which is unaltered from the PERI report. The range of caloric values resulting from this calculation is 0.4729 to 1.3632 calories.

While these values represent energy expenditure in traveling across an individual cell, they do not provide the cumulative cost of moving across the landscape away from streams. I used the Cost Distance tool from *ArcGIS*' Spatial Analyst Tools extension to accomplish the accumulation. The intermittent streams shapefile provided my input feature. I used both the unencumbered and the encumbered cost raster and maximum distances (in this case not actual distance but caloric values) of both 71 and 163.5 calories in multiple attempts to create a satisfactory cost distance buffer around the streams. In the cost distance calculation of greatest extent, the unencumbered cost raster with a 163.5 calorie maximum, the cost distance only accounted for 14.6341% of the prehistoric artifact count (48 of 328 artifacts). This is far less than the 52% accounted for in the PERI report, and was calculated using intermittent streams, not just the permanent Winton Spring (Kay and Herrmann, 2005d).

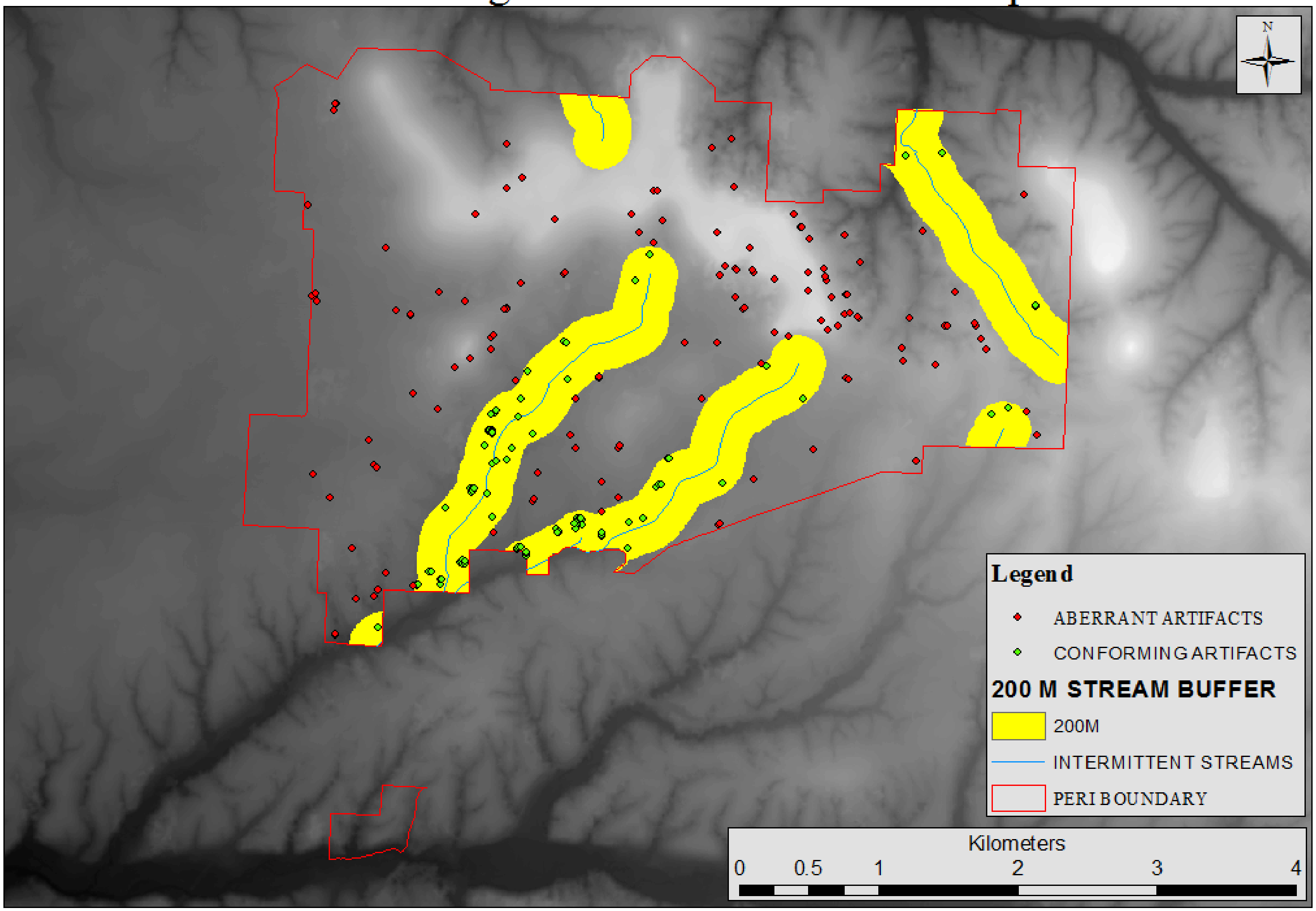
Needless to say, this process did not allow for the satisfactory recreation of the cost distance models from the 2005 PERI report. Perhaps the discrepancy stems from the multi-GIS platform use. The cost surfaces from 2005 were created and assessed in *IDRISI*, and I used *ArcGIS*. I did import the new DEM and necessary stream and artifact layers into *IDRISI*, but attempts to render them together were met with errors and projection problems. I could not calculate a cost surface without the streams, which would not render on the cost surface raster or elevation model. Regardless of reason, the cost distance models were not usable. In lieu of cost distance zones, I created a 200 meter buffer around the intermittent streams. The PERI report notes that this is the distance within which there is a "statistically significantly greater concentration of prehistoric remains" (Kay and Herrmann 2005d:38). While the caloric cost distances from the streams would be more finely tuned to the landscape if calculated properly, the 200 meter buffer will serve as a proxy since I was unable to reproduce the calculation. Resorting to the simple distance layer is frustrating, but acceptable, I feel, as the 71 and 163.5 calorie cost values were derived from assessment within the 200 meter zone. The simple distance measurement accounts for about 20% of the park area, more extensive than the reported coverage of the caloric cost distance layers independently (14% and 5%, respectively), but the combined model accounts for 17% of the park, very near my coverage.

Prehistoric location groups

For the sake of this study, all prehistoric locations within the 200 meter buffer will be considered locations that conform to the PERI report model. All those outside the buffer will be considered locations that are aberrant to the model (Figure 2). By creating a polygon of the 200 meter buffer I extracted the conforming prehistoric locations from the point file of prehistoric artifacts. Likewise, I created a polygon of the entire park minus the 200 meter buffer to extract the aberrant prehistoric locations. The artifact counts in the separated feature classes reaffirm my decision to use the 200 meter stream buffer as a proxy. Of the 328 artifacts recovered, 149 fall within the 200 meter distance to streams buffer. This represents 45% of the collection, the same 45% accounted for by the combined 71 and 163.5 calorie zone (Kay and Herrmann, 2005d). Again, my inability to recreate a caloric cost distance layer consistent with the original study is disappointing, but does not seem to have interfered with identifying two distinct groupings of artifacts: those that fit the model and those that do not.

The points I extracted into two groups represent individual artifacts recovered in the PERI survey. The total 328 artifacts were split into 150 conforming and 177 aberrant. The analysis portion of this project required transformation from discrete point data to continuous raster data, each cell indicating presence or absence of prehistoric material. I transformed the point files into raster layers in *ArcMap* using cell values and spatial extent of the 25 ft. DEM clipped to the park boundary. There are a number of instances of multiple artifacts coming from one shovel test. In these cases, the new raster layer does not create multiple cells with presence recorded, but one cell with the frequency or total count of artifacts present. I took each cell to

Figure 2: 200 m Buffer, Streams,
Conforming and Aberrant Artifact Groups



represent a prehistoric location with no regard to the amount of artifacts present. After the conversion there were 100 conforming and 131 aberrant prehistoric locations represented.

Variables of landscape visibility

The next stage is producing the landscape visibility layers upon which I will assess any differences in conforming and aberrant prehistoric locations. The production of these layers was carried out using *ArcGIS* and *SAGA* GIS, an open source program with many unique modules developed for landscape assessment not available in the larger platforms. Particularly of interest in *SAGA* are the landscape openness and sky view modules. While not directly visibility measurements, I believe they offer a perspective of the environment that influence human visual construction and perception of landscape. Phenomenological and landscape archaeology contend that the landscape is only one perception of reality, even that how an individual sees his or her surroundings is a construction of their experience, how he or she uses and moves through it (Knapp and Ashmore, 1999; Llobera, 2003, 2006; Tilley, 1994; Wheatley and Gillings, 2000). If landscape is merely a construction of space, then assessing topographic features should stand as an interpretation of landscape perception. Using these tools in *SAGA*, I will represent in a quantifiable way how open or visible the environment is from the perspective of any point in the park, and hopefully that an open environment may be an important factor in upland land use.

The three variables developed in *SAGA* were all calculated using the same segment of the Benton and Washington County DEM described earlier. The full model consists of about 105 million cells, the area I needed to assess only about 5.4 million. The segment was extracted from the larger DEM to reduce calculation time, processing the full extent would have been an unnecessarily long procedure. To combat edge effect (Wheatley and Gillings, 2000, 2004), I used an area buffering the park boundaries, so that each cell within the study area would be calculated with equal parameters. I chose the extent of the segment and the radial limit of my variable calculations based on the PERI boundary proximity to the edge of the dataset. The park is located in the north east corner of Benton County; between 3 and 3.5 km separate the northern boundary from the County line. The DEM segment was extracted to approximate a 3 km (or greater) buffer. Each module I used in *SAGA* requires a radial limit. I used the same 3 km to maximize my search radius, while keeping the search areas consistent between cells.

Landscape openness

The concept of "landscape openness" is an assessment of whether a point is either dominant/ convex on a landscape or enclosed/ concave within it (Yokoyama et al, 2002). Two measurements, zenith and nadir, are taken along the eight cardinal compass directions to assess the convexity or concavity of any particular point on the landscape, within a specified radius. The zenith measurement is the maximum vertical angle along a compass direction that is obstructed by landscape features within the radial limit. In other words, the angle from the observation cell to the highest grid cell within the measurement radius that lies along the compass bearing. The positive openness score of a grid cell is calculated with the average of the zenith scores along all 8 compass bearings. High values indicate convexity; the origin cell rises above the surrounding landscape. Nadir is calculated similarly, except it is the maximum angle measured that can be measured below the earth surface, within the radius along the compass bearing. Again the 8 measurements are averaged for a grid cell's nadir score. Higher nadir scores indicate concavity; the surrounding landscape features tend to rise above and enclose the origin cell. Figure 3 below, from Yokoyama et al (2002) better illustrates the concept.

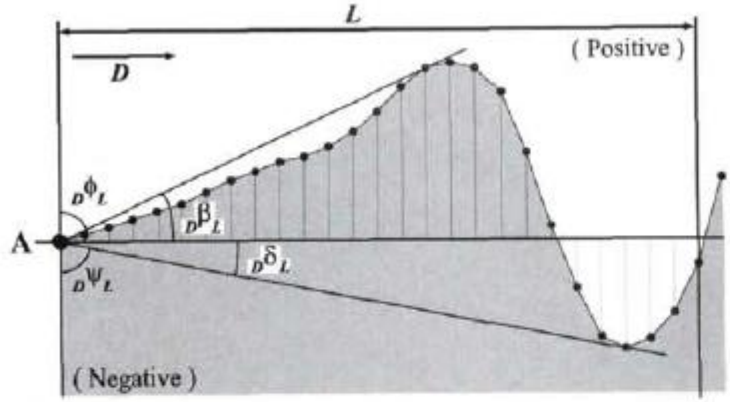


Figure 3: a graphic representation the zenith and nadir angles from Point A, along compass bearing D, within radial limit L (From Yokoyama et al, 2002:258)

Described as an image processing technique (Yoloyama et al. 2002:257), openness provides an alternative method to landscape representation in GIS. While not directly a visibility measurement, openness is conceived of in a very perceptual manor. The line of site concept used to measure a viewshed is a critical factor in the conceptualization of openness, particularly positive or convex openness: zenith angles are essentially LOS measurements to the highest surrounding points. Its developers even refer to positive openness as "openness of the terrain to the sky" inhibited by surrounding landscape features (Yokoyama et al. 2002:259). While LOS is not a factor of the below ground nadir angle calculations, it follows the same principle straight line calculations to the lowest surrounding points (Yokoyama et al. 2002:258). Contextualizing a landscape not only by immediate local relief but by the relief of features more distant is important to a study of landscape perception. The dominance of a landscape feature and the viewshed it affords may be closely related landscape attributes.

The *SAGA* module "landscape openness" performs the operations on each grid cell, using a user specified radial limit and the standard 8 cardinal compass directions. The module outputs both a positive openness and negative openness layer. Both positive and negative openness are expressed as positive value, and are used by the developers of "landscape openness" more to indicate convexity (positive) or concavity (negative) (Yokoyama et al. 2002).

Visible Sky

Within the Sky View Factor (SVF) module in *SAGA* is a parameter called visible sky. SVF is a figure representing the relationship between visible area of the sky and buildings or urban structures (Souza et al. 2003:1228). Obvious lack of urban environment in prehistory make this measurement un-usable, but it relies on the calculation of visible sky from points on the landscape. *SAGA* describes the parameter as "the unobstructed hemisphere given as a percentage" (*SAGA* GIS, 2015). Imagine the sky is a hemisphere over the observer. The percentage of that hemisphere that is not obstructed by surrounding topography is the resulting value for the observer cell. This value, while still not measuring an observer's view of the surrounding landscape, is a visual variable. An expansive view of the sky would indicate an expansive view of the land. Prominent topographical features should return greater visible sky percentages than features nestled in the relief. While conceptually related to positive landscape openness (Yokoyama et al. 2002) visible sky measures sky as inhibited by topography rather than a location's prominence in relation to surrounding landscape features. The SVF module outputs both the SVF and Visible sky layers, but I only retained visible sky.

Once the three variables were calculated in *SAGA*, I exported the layers to *ArcMap* via Ascii text files. Communication between the multiple platforms of analysis I utilized was streamlined by conversion from raster format to Ascii; all the programs recognize the file format and include modules to convert to and from it as necessary. In *ArcMap* I extracted the pertinent data from these layers using the park boundary as a mask. As previously stated, my variables needed to be calculated on as large a scale as possible, but the assessment of their effectiveness was constrained to the PERI study area. From *ArcMap* I exported the three PERI constrained landscape visibility variables, the aberrant prehistoric locations as a dependent variable, the conforming prehistoric locations, and the entire record of prehistoric locations as a mask. In *IDRISI* (contained within *TerrSet* as the *IDRISI GIS Analysis* toolset) I conducted the assessment of the variables.

Assessment of the landscape visibility variables

Each layer (positive openness [Figure 4], negative openness [Figure 5], and visible sky [Figure 6]) represents a variable of landscape visibility which I believe contributes to land use decisions in areas not easily characterized by the availability of or efficient travel to water, as defined in the original PERI study. Expression of this hypothesis for each specific variable would be:

H_0 = There is no statistical difference in the mean values of conforming and aberrant locations for variable x.

H_1 = Aberrant locations will display a higher mean value than conforming locations with respect to positive terrain openness.

H_2 = Aberrant locations will display a lower mean value than conforming locations with respect to negative terrain openness.

H_3 = Aberrant locations will display a higher mean value than conforming locations with respect to visible sky.

Preliminary visual assessment of each variable leads to no certain conclusions. The graphic representation of positive openness (Figure 2) seems to indicate distinct landscape

Figure 4: Positive Landscape Openness, Conforming and Aberrant Artifact Groups

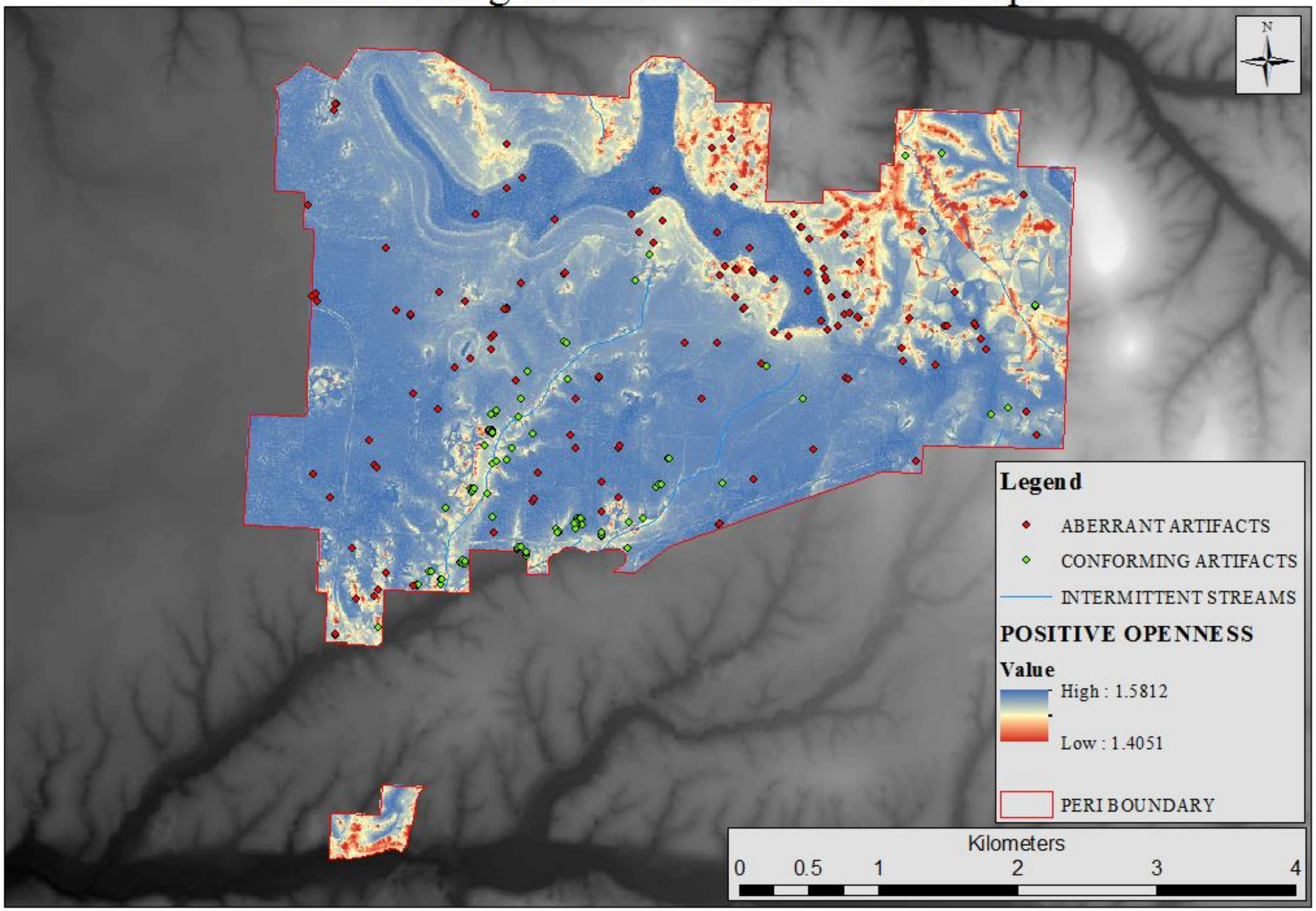


Figure 5: Negative Landscape Openness, Conforming and Aberrant Artifact Groups

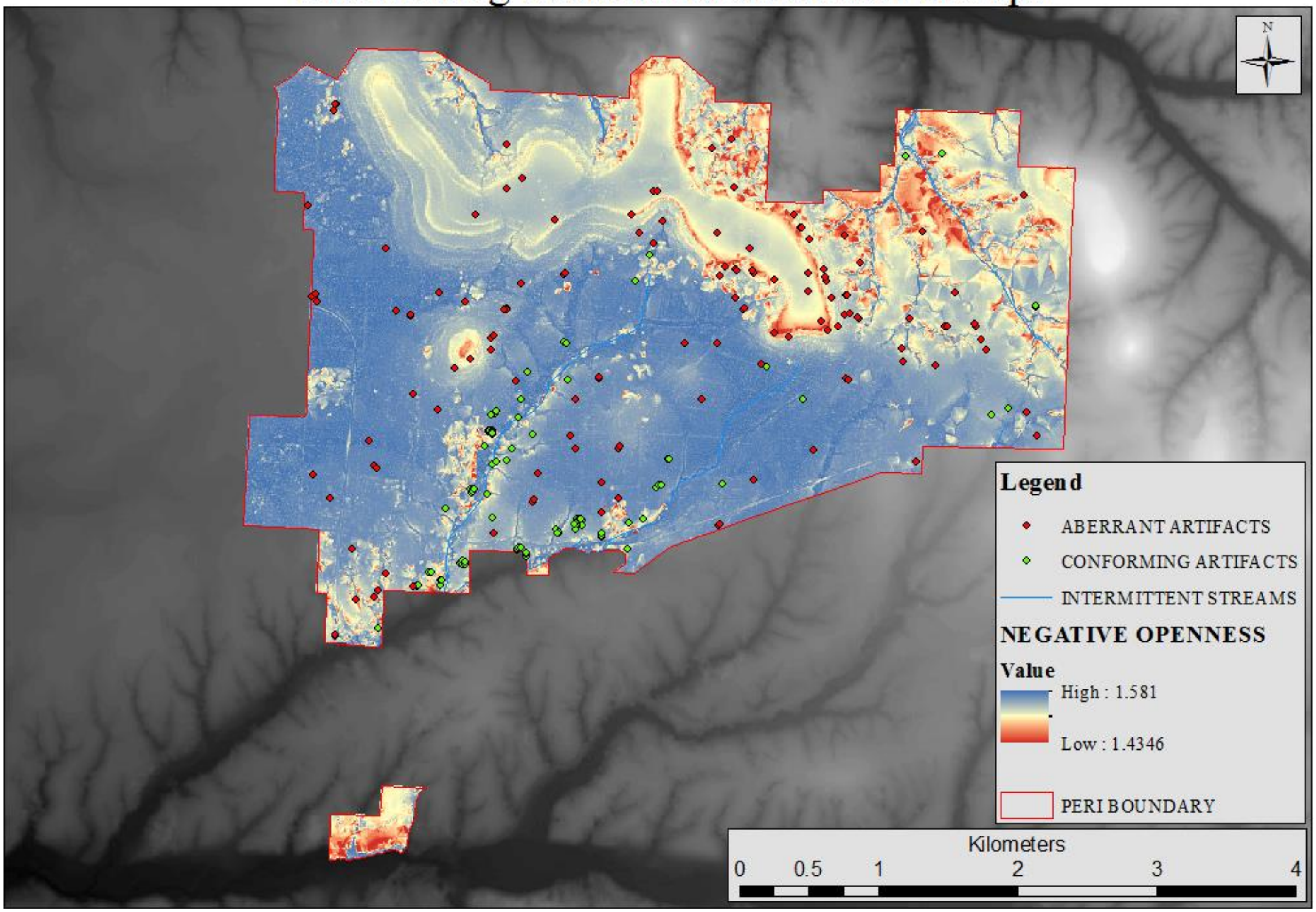
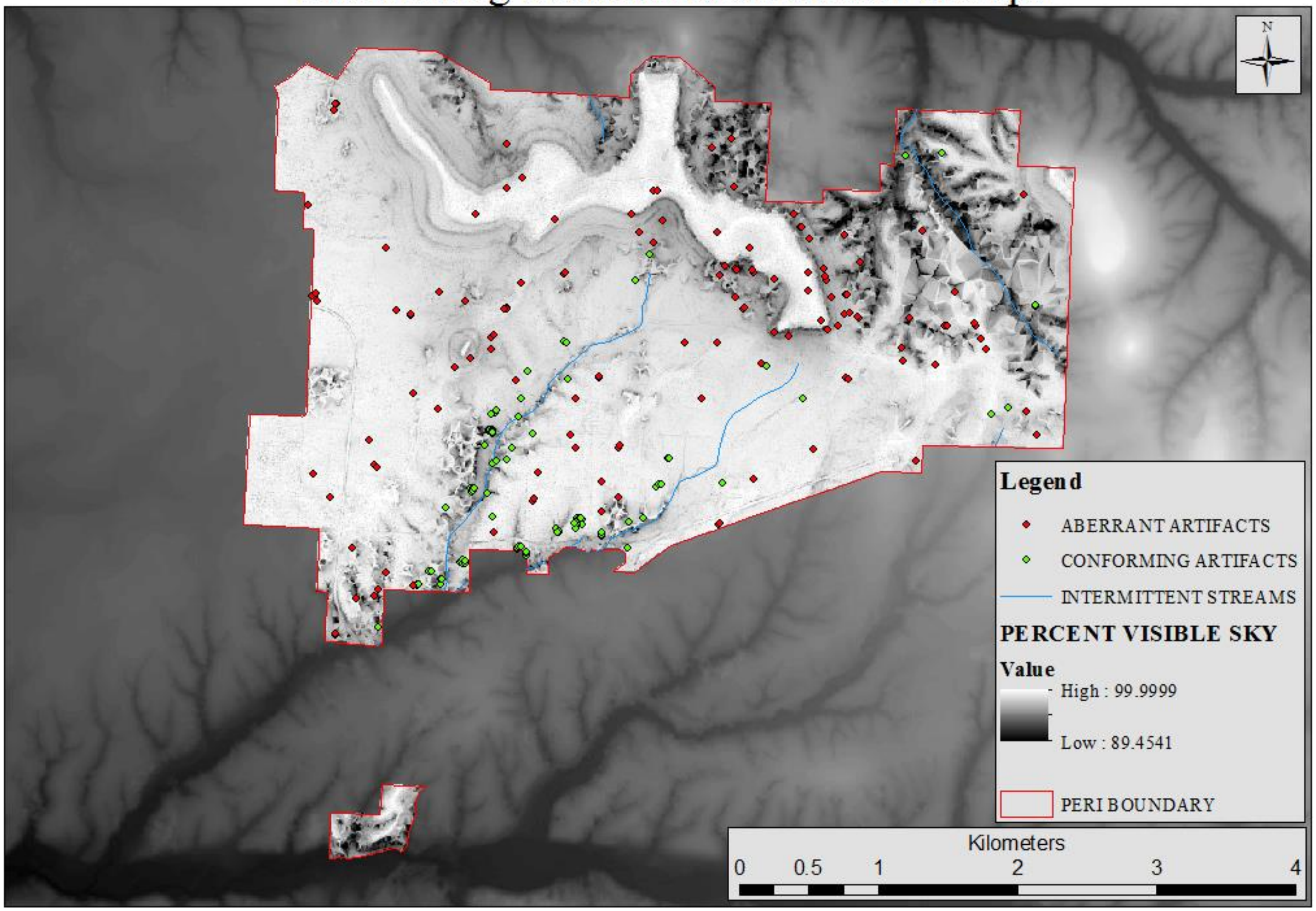


Figure 6: Percent Visible Sky,
Conforming and Aberrant Artifact Groups



features dramatically more open to the surrounding, particularly the top of Elkhorn Mountain, Little Round Mountain, and the plains between them. The actual range of zenith values for the park, however, is 1.4051 to 1.5812.

Likewise, the negative terrain openness graphic (Figure 5) shows that the mountains are not being closed upon, while the open areas in between, particularly the intermediate level streams, are concave to the rises around them. However, the value range for nadir scores is similarly narrow (1.4346 to 1.5810).

Neither of these variables numerically suggest highly variable terrain, or that any of the prominent features of the park are any more open to the surrounding than the lower plains or streambeds. The apparent distinction between convex and concave features in the graphic iterations of the variables is likely a result of the color values being stretched to fit the very narrow range.

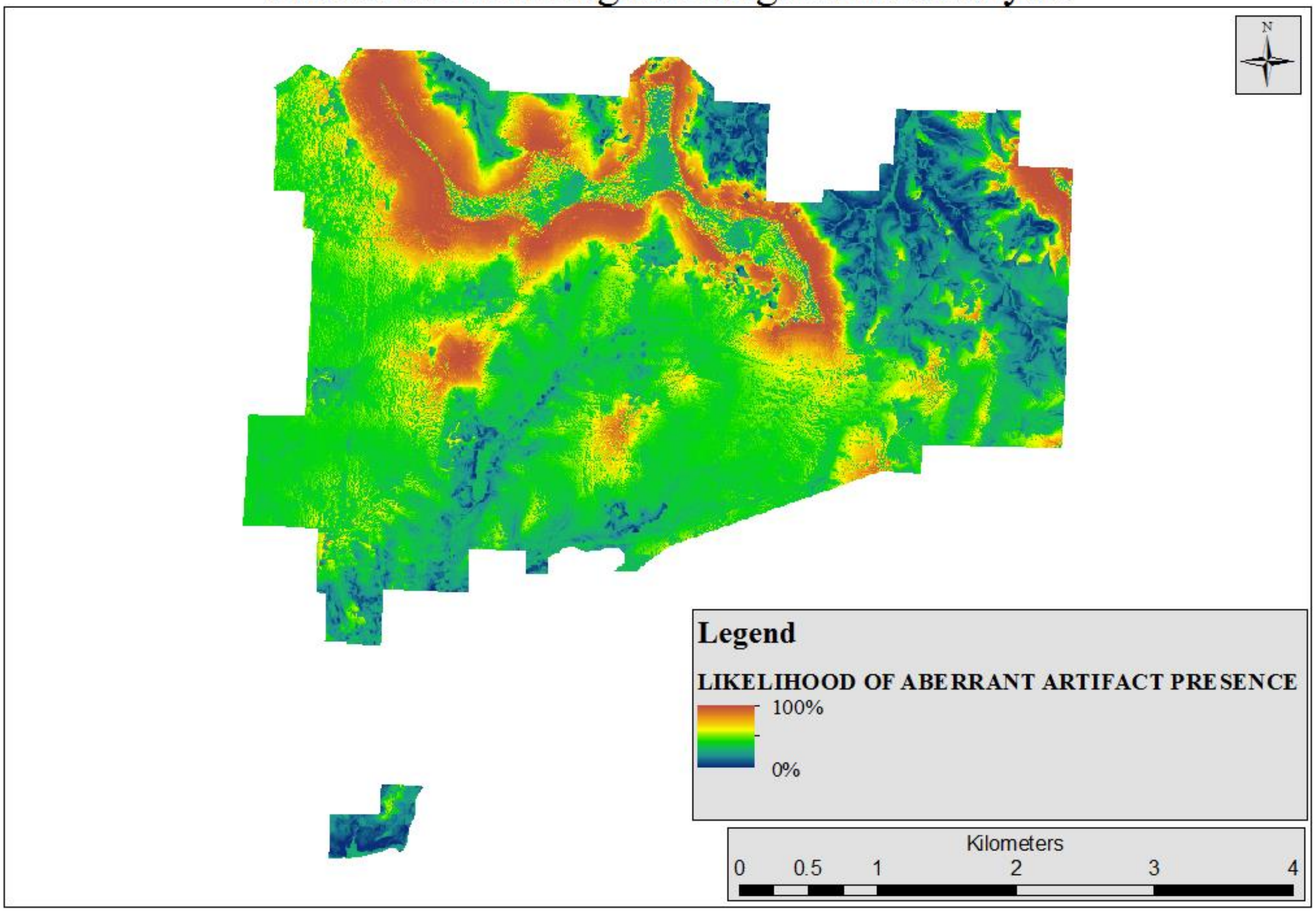
The visible sky variable follows a similar trend. The graphic (Figure 4) shows distinct areas of enclosure, along the lower elevations of Elkhorn Mountain and through the intermittent stream courses. The data range is 89.4541% to 99.9999%, quite a bit more broad than the zenith and nadir value ranges, but not so broad to expect much difference in mean values.

A statistical distinction between aberrant and conforming group means for any variable would indicate that that particular variable might have an impact on site selection. Using *IDRISI*'s query function, I extracted values of each variable at instances of prehistoric artifacts, divided into aberrant and conforming locations. The six resulting queries are represented as histograms with descriptions of central tendency and deviation in Appendix A. Using R statistical software, I performed t-tests on the complimentary sets to determine any statistically significant differences in the location groups. The results of the t-tests are also presented in Appendix A. At a confidence level of .05, I can decisively accept the null hypothesis. There is no statistical difference between group means in landscape openness or visible sky. The ranges of zenith and nadir scores and visible sky percentages are too narrow for any significant variation. As narrow as the scores seem to be across the park, the realized range of values at the prehistoric locations were even more limited.

Landscape visibility regression model

While the simple statistics of central tendency display no significant difference between locations that fit the cost distance model and those that do not, perhaps the variables of landscape visibility may still serve in a predictive model. The goal of such a regression is to assess the predictive value of the variables against conforming locations, not against negative sample units or variation due to randomness in the environment. I am attempting to model land use through landscape visibility, counterbalancing a physiological/ economic assessment of water availability. In *IDRISI*'s logistic regression function, *LOGISTICREG*, I built a regression model with the three landscape visibility variables as independent. I input the aberrant locations as the dependent variable, and all prehistoric locations as the masking feature. The resulting regression equation is not remarkably powerful, but does demonstrate some utility. The results of the regression are listed in Appendix B. The predictive raster of PERI (Figure 7) emphasizes some of the topographic features I had expected to stand out. The perimeter and bluff edges of Elkhorn Mountain, the slopes of Little Round Mountain, and some lower swells in the plains between are more favorably predicted than the lower areas that still fall outside the cost distance model. The sample case assessment with an adjusted threshold returns 77% true positive prediction and an ROC of .7479, far better than random prediction. Again, the model is not

Figure 7: Predictive Model
Produced from Logistic Regression Analysis



massively powerful, but seems to have a solid predictive function for aberrant sites.

Seasonality and Viewshed

Within the stratified cost surface model developed in the original study emerges the idea that values of solar illumination, variable by season, may influence land use strategy (Kay and Allen, 2000; Kay and Herrmann, 2005d). Indeed, the assessment at PERI indicates that areas of the park exposed to solar illumination greater than average through the summer corresponded to a subset of the distribution more widely disbursed than the full sample. Conversely, areas of the park with illumination values above average in the winter corresponded to a subset of the distribution more concentrated about the intermittent and permanent watercourses (Kay and Herrmann, 2005d). The cold and wet/ hot and dry dichotomy indicated by the apparent seasonal distributions seems counterintuitive; would it not be more economical in warmer, dryer periods to utilize parts of the landscape more near to flowing water? In winter, would the cooler temperatures and more available water not allow for more extensive movement about the landscape? Glacial climate trends affecting the region like the Younger Dryas (Kay and Herrmann, 2005b:2) might be employed to explain discrepancies in land use. Perhaps the cooler climate did not preclude the upland, costly travel areas from summer exploitation. Again, however, lack of temporal association of most of the artifacts prevents such time specific analysis. Speculation aside, climatological assessments would be a divergence from the thrust of this project.

Following the assertions made earlier, I argue that the broad dispersal of artifacts countering common logic of land use may be associated with the advantageous viewsheds such artifact locations confer. To formalize that statement:

H_0 = aberrant locations associated with summer land use will provide no greater a viewshed than either aberrant locations associated with winter land use or conforming locations associated with summer or winter land use.

H_1 = aberrant locations associated with summer land use will provide a greater viewshed that aberrant locations associated with winter land use or conforming locations associated with summer or winter land use.

Using techniques from the PERI report (Kay and Herrmann, 2005d), I will create a data layer of PERI indicating the areas associated with above average seasonal illumination and compare the respective viewsheds of the artifact distributions within the zones. I have limited my assessment to the summer and winter seasons. The original report assessed the summer and winter equinox as well, but there were few locations strongly associated with those seasonal zones. Both the PERI report and mine include sizeable subsets with an indeterminate seasonal association. I have excluded them from this assessment.

The first step in relating artifact distribution to seasonal land use is to create an aggregate layer for seasonal solar illumination. The resulting layer is a categorical raster with 4 potential values: summer association, winter association, both summer and winter, and neither summer nor winter. This raster is compiled after a multi-step process from a number of derived hillshade raster layers. To identify area associated with summer, I created hillshade layers from the 25 ft DEM using azimuth and sun angle values that represent five different times of day: one hour after sunrise, mid-morning, noon, mid-afternoon, and one hour before sunset. For consistency's sake, these times of day and their associated azimuth and angel values were copied directly from the original PERI study (Kay and Herrmann, 2005d:27). To combine these layers, I reclassified them into binary, 0 = low illumination, 1 = high illumination layers. The decision values for each time of day were selected by querying the values from one cell with moderate illumination throughout the day, neither excessively shaded nor excessively illuminated. These five binary rasters were summed to create a 0-5 value cumulative summer radiance layer. A zero value would indicate low illumination all day, a five would indicate moderate to high illumination all day. The same process was exploited to create a cumulative winter radiance layer (similar to the cumulative radiance rasters from the PERI report [Kay and Herrmann, 2005d]). I reclassified these layers into binary, and combined the two, producing the aggregate layer. I considered the zones of no seasonal association and those of both summer and winter association as equally indeterminate. I converted the zones of high seasonal radiance (summer and winter) into two separate polygons (Figure 8), which I used to extract the artifact locations into four groups: conforming winter locations, conforming summer locations, aberrant winter locations, and aberrant summer locations.

Again using the 25 ft DEM, I calculated the cumulative viewshed for each of the four subsets of the distribution. A cumulative viewshed as calculated in *ArcMap* produces a binary raster of cells either "visible" or "invisible" to one or more of the observation points, using the line of site principle (Llobera, 2003, 2006; Tschan, 2000; Wheatley and Gillings, 2000). Each cell does contain a value of "times seen". These values can be displayed with an ordinal scheme, showing areas of high and low visual prominence, but the assessment will primarily come from the area of the park visible from at least one observer. The assessment that follows deals with the percentage of the park area represented by each season, the percentage of the artifact distribution associated with each season, and the percentage of the park area visible from each subset. Tables 1 and 2 below compile these quantifications.

Figure 8: Areas of High Seasonal Illumination,
Conforming and Aberrant Artifact Groups by Season

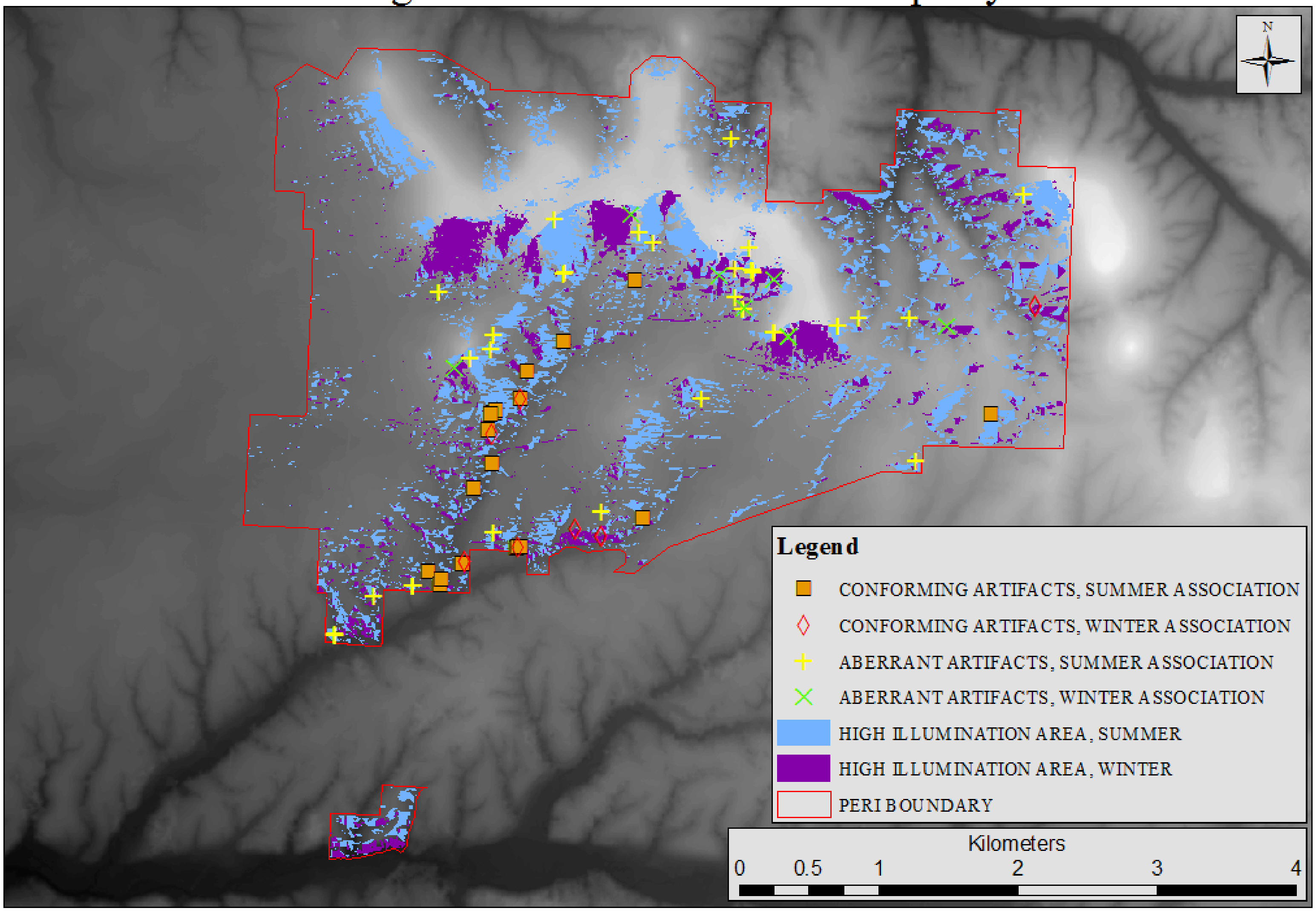


Table 1: Seasonal zones represented as percent area of park and percent of artifact distribution

Seasonal Association	Percent of Park	Total Artifacts # / %	Conforming Artifacts # / %	Aberrant Artifacts # / %
Summer	**15%**	**67 / 20%**	**23 / 15%**	**44 / 25%**
Winter	**7%**	**20 / 6%**	**11 / 7%**	**9 / 5%**

Table 2: Viewsheds represented as visible percent of park

Observing From	Percent of park visible
Aberrant prehistoric locations, summer association	**57%**
Aberrant prehistoric locations, winter association	**43%**
Conforming prehistoric locations, summer association	**26%**
Conforming prehistoric locations, winter association	**18%**
All prehistoric locations, summer association	**60%**
All prehistoric locations, winter association	**49%**

According to my calculations of seasonal radiation, the zones classified as summer accounts for 15% of the park area and 20% of the total artifact distribution. The winter zones make up 7% of the park, and account for 6% of the total distribution. Neither of these observations seem to indicate a disproportionate concentration of artifacts into a summer or winter zone. However, incorporating the categorical distinction of high and low travel costs, patterns of seasonal association begin to emerge. Forty-four of the aberrant artifacts fall within a summer zone, accounting for 25% of the aberrant distribution. The apparent dispersion of aberrant artifacts in zones of the park associated with summer radiance would corroborate the assertions of the original PERI study. Only 9 aberrant artifacts, 5% of the aberrant distribution, fall into the winter radiance zone. To me this does not indicate a categorical avoidance of upland areas in winter, but it does reflect the more concentrated distribution associated with winter from the PERI survey. Twenty-three artifacts conforming to the cost-distance model, 15% of the conforming distribution, fit within the summer zones, and 11, or 7% fit within the winter zones. Neither of these observations indicate preference or avoidance of seasonally specific zones. I would chalk it up to the success of the cost-distance model; efficient travel to water seems to accurately predict prehistoric land use, regardless of season.

It is quite plausible that visibility and seasonality are correlated variables of land use. Exploitation strategies vary throughout the year, and different activities require different perception of the landscape. Without evidence of the ritual significance of particular landscape features, source locations for natural material resources, game tracking tactics, inter-group dynamics, or any other possible explanation for exploitation of the visual landscape, it is hard to say why these trends seem to emerge, but I can say that these trends are evident. Observation from the aberrant prehistoric locations associated with summer land use accumulates a viewshed of 57% of the park. When compared to the 26% of park visibility from the conforming locations of summer association, it is quite plausible that a more expansive viewshed confers some advantage to the upland areas. The apparent correspondence is echoed with the prehistoric locations in winter zones: 43% of the park is visible from aberrant winter locations, while only 18% is visible from the conforming winter locations. This observation is a bit intuitive, the upland areas account for a greater land area in the park, their openness to the surrounding landscape and greater elevation immediately suggest a more expansive viewshed. Perhaps more telling than the upland/ lowland distinction is the viewshed comparison of summer and winter zones. Winter associated observation points return more restricted viewsheds, 49% of the park as compared to 60% of the park from summer associated locations (Figures 9 and 10). I am not mistaking correlation for causation, but these viewshed area calculations do reflect the broad dispersion of artifacts associated with summer land use and the concentration of locations associated with winter land use. Ultimately, I would reject the null hypothesis. Aberrant prehistoric locations associated with summer land use do appear to confer a more extensive viewshed to observers than the alternative sets of prehistoric locations. To reiterate, this is not an attempt at full explanation, but the documentation of observations that visibility may have an influence on seasonal land use.

Figure 9: Viewshed
Observed from Summer Associated Prehistoric Locations

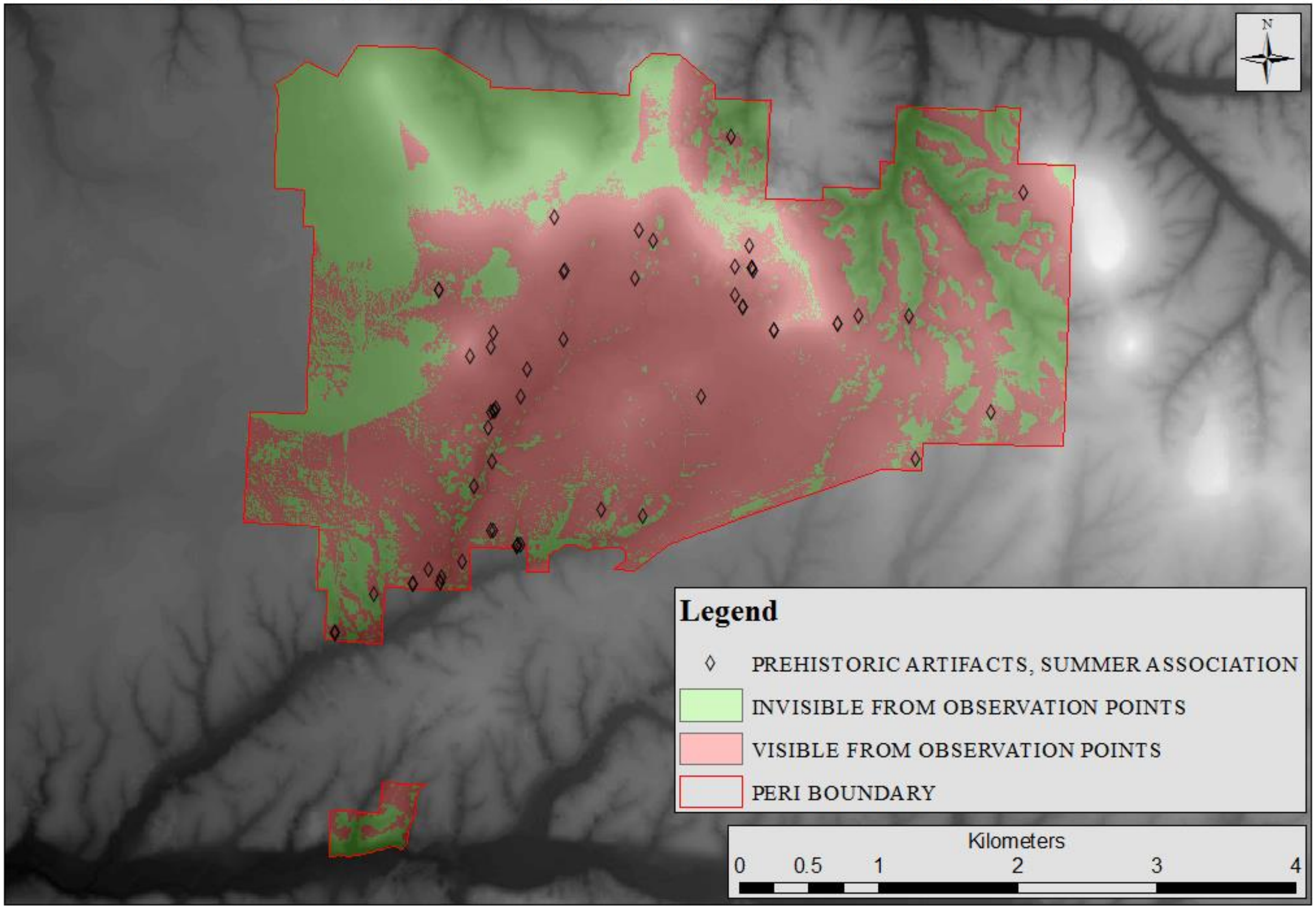
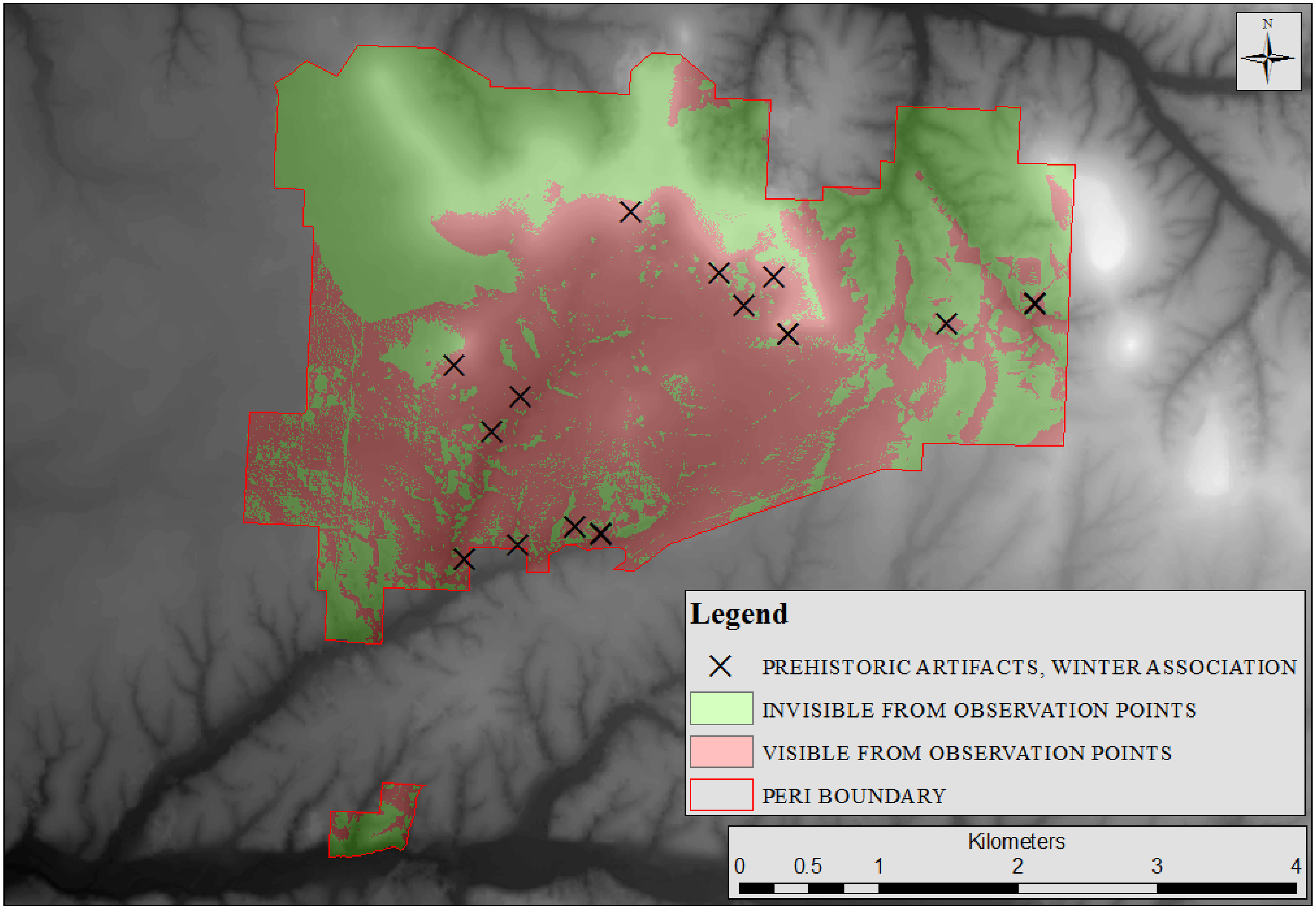


Figure 10: Viewshed
Observed from Winter Associated Prehistoric Locations



V. Discussion and Conclusions

Post assessment considerations

The varied results of this assessment are complicated to distill. The finding of no significant difference between aberrant and conforming location groups for any of the assessed variables calls to question the variables' effectiveness here, but I argue that the relative success in a predictive application, as well as a successful recombination with seasonal land use demonstrate some level of utility. Both in this study and more broadly, I think elements of visibility, openness to the sky, and topographic presence on the landscape are variables that could produce powerful models of land use. When combined with other quantifiable aspects of environment such as cost of travel to water and solar illumination, these landscape visibility variables may contribute to understanding of both the physiological and phenomenological human experience.

Evaluating some issues that arose during the analysis portion of this project will help unpack what may have affected the success of this experiment and why I think landscape visibility could be developed into a powerful tool of land use assessment. I will attempt to deal with these issues in ascending order of severity.

Of minor concern is the issue of prehistoric locations as compared to prehistoric artifacts. I have used both throughout to indicate independently valid expressions of human activity. In the regression and difference between groups analyses, locations with one artifact present were weighed equally to those with multiple. The lack of temporal control (Kay and Herrmann, 2005a, 2005d) perhaps means that artifacts occupying the same "location" do not represent the same instance of activity and therefore should receive weight as independent artifacts, rather than as one location. The redundancy of particular values may have altered the analysis, but the instances of multiple artifact presence were relatively few, and most likely would not have had a dramatic influence.

I have already justified my exclusion of vegetation, here I would like to consider it as an important variable in landscape perception. Again, assessment of prehistoric vegetation is an endeavor of tremendous magnitude (Gearey and Chapman, 2006), but vegetation is a key component of the environment (Bevan and Conolly, 2002, Tschan, 2000). I do not think that its exclusion is so egregious to this study, but the visual impact of Oak forest giving way to rolling grassland (and other expressions of Ozark flora) should be considered moving forward.

Another issue of exclusion is viewshed itself as a variable in the regression assessment. It seems that a study of visibility would do well to utilize the tools of viewshed available in any number of GIS platforms. I did in fact run a viewshed assessment of the conforming and aberrant prehistoric locations. The results however were so un-telling and obvious that I did not even consider them as a viable variable. The dispersion of aberrant locations about the park created a nearly complete "visible" section of the park, leaving only a few somewhat anomalous patches "invisible." A visual assessment of the cumulative viewshed emphasized the visually prominent areas of the park like Little Round and Elkhorn Mountains, while the northern slope or "backside" of Elkhorn remained relatively invisible. However, the cumulative viewshed function assumes contemporaneity, and becomes cumbersome and un-practical with the inclusion of too many points, the aberrant and conforming viewsheds were nearly indistinguishable. I would have liked to conduct a total viewshed of the park, one where each cell is treated as an observation point, and the percentage of the park visible from each cell is stored as that cell's value (akin to visibility models discussed in Lake, Woodman, and Mithen

[1998] and Lee and Stucky [1998]). I think the results of such a viewshed would have been more than helpful in this study of landscape visibility. Such a calculation, however, would have required programming well beyond my capability and time well out of hand for this project. Another useful viewshed layer may have assessed directionality. I suspect that many of the aberrant location values were stunted by their locations on the sides of hills. The bench below Elkhorn summit is rife with cultural material (Kay and Herrmann, 2005d) and commands a respectable viewshed of the plain below, but not behind it. Such topographic features likely influenced land use decisions, however, this is a problem suited for another assessment.

Of deeper methodological and theoretical concern is the “black box” (Wheatley and Gillings, 2004) effect of some GIS tools. I contend that a topographic measurement such as landscape openness is a viable form of assessing landscape perception. The narrow range of values for the openness scores in my assessment are disappointing. Landscape diversity may have come into play. The demonstrations of openness in Yokoyama and colleagues (2002) are calculated on volcanic landscapes and regions with severe elevation changes. Elkhorn and Little Round are called mountains, but the relief at PERI is not so drastic. Whatever the cause for small, hard to interpret values, the point is I am unsure of it. One criticism frequently leveled at GIS and its practitioners is the use of technology because it is there, despite a lack of understanding of the true power and operation of the tools (Wheatley and Gillings, 2000, 2004; Zubrow, 2006). *SAGA* is an open source GIS with many contributors, most of whom are not full time GIS developers (saga-gis.org, 2015). The tools are not always well explained, the algorithms and processes are there and functional, but not readily apparent to the causal user. My understanding of topographic openness from its developers did not completely elucidate the calculation process in *SAGA*. The only reliable citation on the process is Yokoyama and colleagues (2002). As previously mentioned, I still believe that visual landscape is an important factor in land use (Llobera 2003, 2006). I also think that factors of the visual landscape could be more thoroughly examined in future efforts.

Conclusion

A result of no small consequence is the successful re-deployment of decade old survey data. The reuse of shovel test records from a 4,300 acre NPS land holding stands as a testament to the thoughtful construction of the original undertaking. The statistical relevance of the sample was well known (Kay and Herrmann, 2005a), but the flexibility of the dataset is remarkable. While the variables I chose to represent landscape visibility did not produce much more than a suggestive predictive model, the fact that they were assessed using data which was collected with no regard to visibility or landscape openness demonstrates that a truly distributional dataset can eschew the particular, the anecdotal, and the specific to answer questions of broad applicability.

I hope that by assessing differences (or lack thereof) in landscape visibility across a region, I have put some analytical weight behind an idea as intangible as perception of place and conception of landscape. The effort is not to "correct" a physiological assessment with a metaphysical explanation, but to serve as an alternative perspective on land use not offered by such economically based models (Tilley, 1994). A multi-faceted approach seems to produce a more holistic interpretation of land use, one less prone to criticism of reductionism, determinism, or lack of analytical merit.

My goals were to demonstrate broad utility of well-designed research initiatives and to provide a counterpoint to the water transport economy model by explaining upland prehistoric land use with an assessment of landscape visibility. I think these goals have been realized, despite some setbacks with data availability and compatibility, as well as confirmation of my first null hypothesis. The data set stood up to alternative application. I think that the introduction of visual landscape to the model of prehistoric land use at the Pea Ridge Military Park at the very least begins to combine a more phenomenological perspective with the traditional economic understanding. As an aside, landscape visibility quite likely has had an effect on land use in more recent history. Examining the strategic use of landscape, topography, and visibility during the Civil War battle at Pea Ridge could dramatically influence the understanding of the progression and outcome of that chapter of the conflict. Such study is beyond the reach of this endeavor. With some adjustment, however, I believe the techniques of landscape assessment utilized here could find practical application in the context of the Battle at Pea Ridge. Likewise, adapted procedure for assessment of seasonal expression of prehistoric material at PERI and a continued effort to tweak the metrics of landscape visibility could open the door for some intriguing interpretations of land use at the park, and more broadly, the Ozark Highlands.

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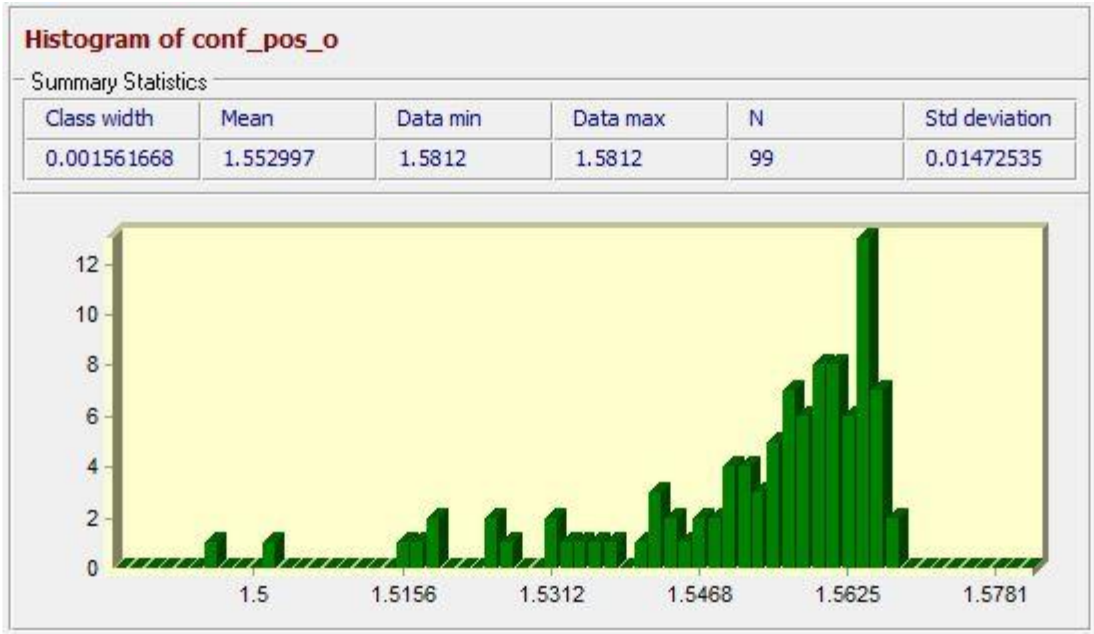
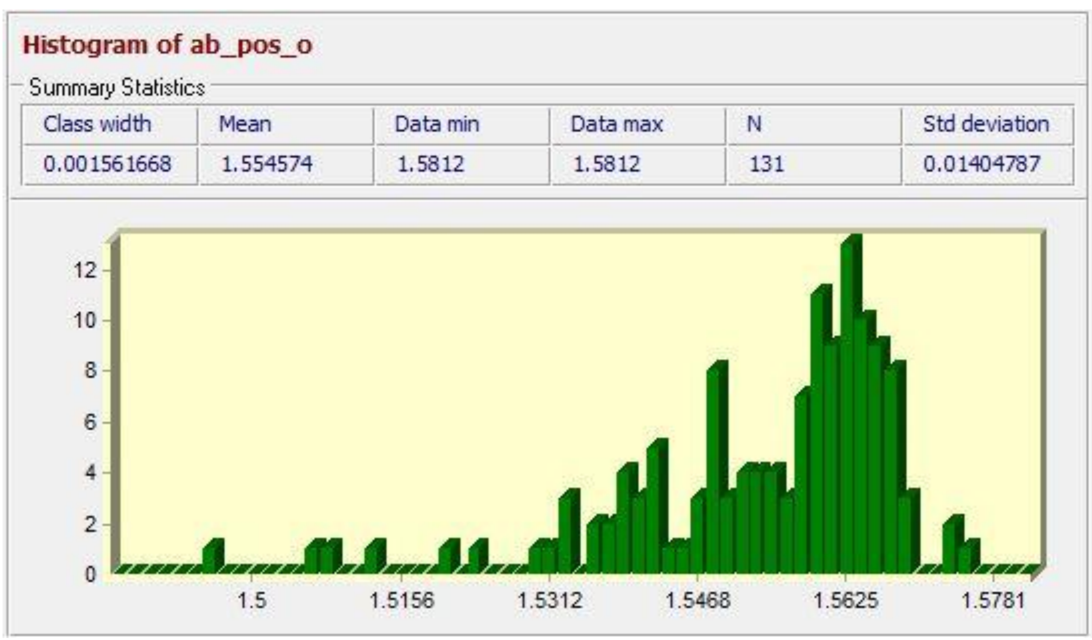
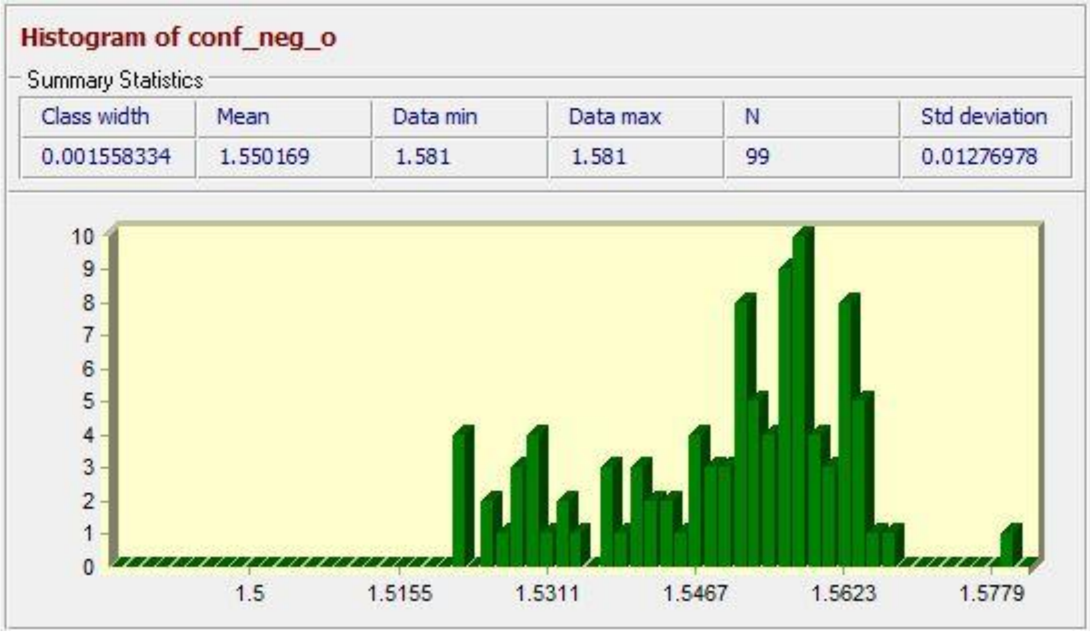
Appendix A: Histograms of landscape visibility variables and between groups t-test residuals from *R Statistical Software.*



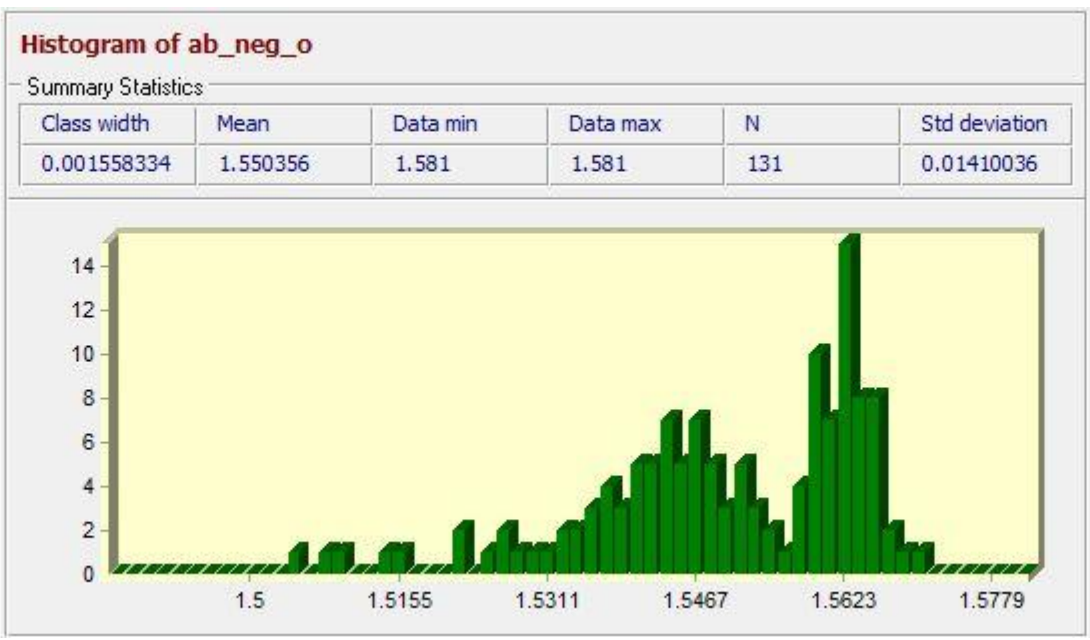
Histogram distribution of positive openness values at conforming prehistoric locations.



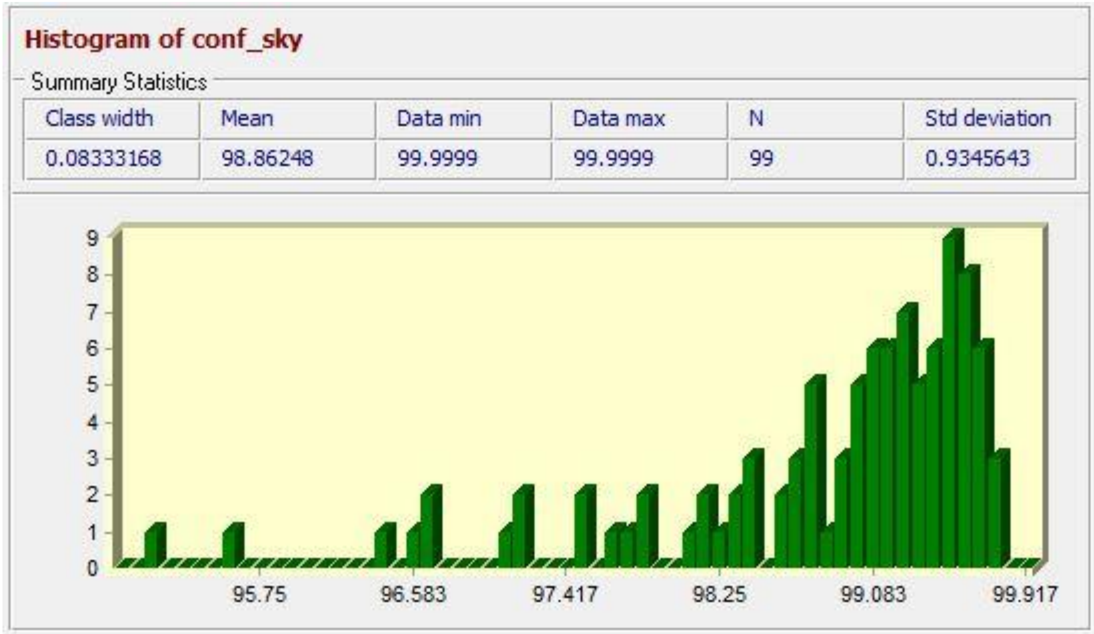
Histogram distribution of positive openness values at aberrant prehistoric locations.



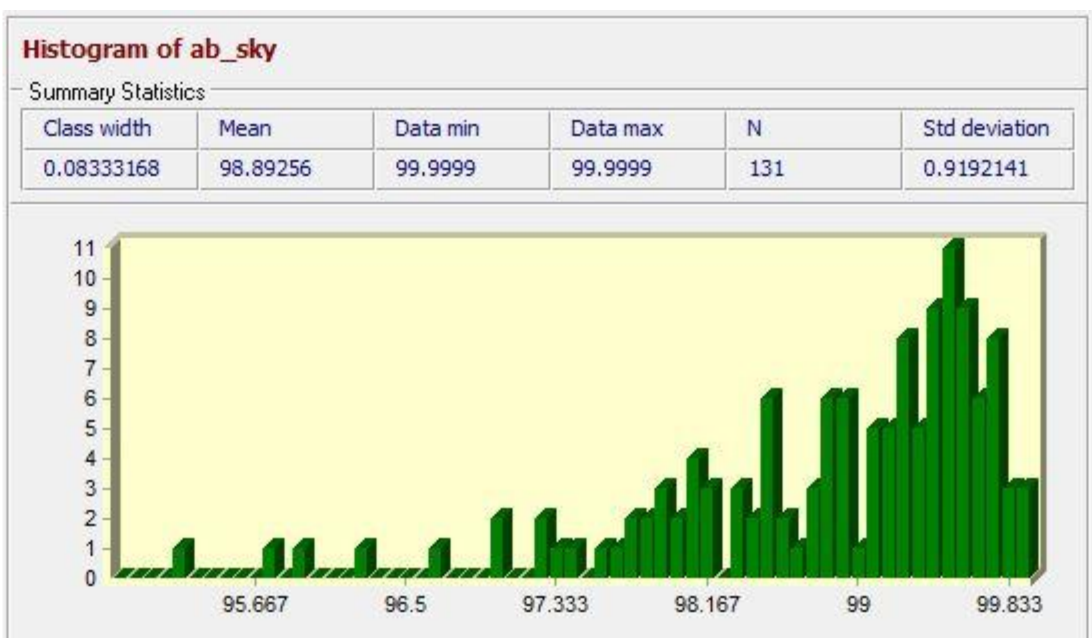
Histogram distribution of negative openness values at conforming prehistoric locations.



Histogram distribution of negative openness values at aberrant prehistoric locations.



Histogram distribution of visible sky percentages at conforming prehistoric locations.



Histogram distribution of visible sky percentages at aberrant prehistoric locations.

t.test for positive openness

Welch Two Sample t-test

data: ab_pos_o and con_pos_o

t = 0.8237, df = 205.52, p-value = 0.4111

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

-0.002197879 0.005352034

sample estimates:

mean of x mean of y

1.554574 1.552997

t.test for negative openness

Welch Two Sample t-test

data: con and ab

t = -0.1057, df = 220.555, p-value = 0.9159

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

-0.003673203 0.003299122

sample estimates:

mean of x mean of y

1.550169 1.550356

t.test for visible sky

Welch Two Sample t-test

data: ab and con

t = 0.1057, df = 220.555, p-value = 0.9159

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

-0.003299122 0.003673203

sample estimates:

mean of x mean of y

1.550356 1.550169

Appendix B: Predictive model regression residuals from LOGISTICREG module in *IDRISI*

Regression Equation:

logit(AB_B) = 48.1420 + 22.2302*neg_o + 928.5599*pos_o 14.4544*sky

Individual Regression Coefficient:

Intercept/Variables	Coefficient
Intercept	-48.1420
neg_o	22.2302
pos_o	928.5599
sky	-14.4544

Regression Statistics:

Number of total observations	231
Number of 0s in study area	124
Number of 1s in study area	107
Percentage of 0s in study area	53.6797
Percentage of 1s in study area	46.3203
Number of auto-sampled observations	231
Number of 0s in sampled area	124
Number of 1s in sampled area	107
Percentage of 0s in sampled area	53.6797
Percentage of 1s in sampled area	46.3203
-2logL0	318.9818
-2log(likelihood)	275.0594
Goodness of fit	258.1503
Pseudo R^2	0.1377
Chi-square (*df=3*)	43.9224

Means and Standard Deviations:

Variables	Mean	Standard deviation
neg_o	-41.7422	657.9879
pos_o	-41.7386	657.9881
sky	55.1649	664.3923
AB_B	0.4632	0.4997

Classification of Sample Cases & Odds Ratio:

Observed	Fitted-0	Fitted-1	Percent correct
0	110	14	88.7097
1	54	53	49.5327

Odds ratio = 7.7116

Reclassification of Sample Cases & ROC (sample based computation when applicable):

1) Select a new threshold value such that, after reclassification, the number of fitted 1s matches the number of observed 1s in the dependent variable.

New cutting threshold = 0.4205

Classification of Sample Cases & Odds Ratio by Using the New Threshold:

Observed	Fitted-0	Fitted-1	Percent correct
0	88	36	70.9677
1	36	71	66.3551

Adjusted odds ratio = 4.8210, true positive = 77.17%, false positive = 29.03%

2) ROC* result with 100 thresholds (sample based computation when applicable):
ROC = 0.7479

* ROC = 1 indicates a perfect fit; and ROC = 0.5 indicates a random fit.