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RESEARCH REPORT

Geoarchaeological Modeling of Late Paleoindian Site Location in the Northwestern Great Lakes Region

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ABSTRACT
Full-time occupation of recently deglaciated landscapes in the northwestern Great Lakes by late Paleoindian groups marks a key milestone in the colonization of the region, yet settlement-subsistence systems of these colonizing populations remains poorly understood. Here we apply geoarchaeological modeling and early Holocene environmental reconstruction to analyze environmental settings of known late Paleoindian sites in Michigan's Upper Peninsula. Our results reveal significant settlement patterning associated with this early Holocene record, highlighting the spatial correlation between site locations and high ground adjacent to hilly terrain and inland lakes – prime locations for monitoring the movement of large game. The analysis highlights a core area with a high likelihood for undiscovered late Paleoindian sites in the northwest corner of Marquette County and suggests the possibility of a north-south travel corridor into the region from upper Wisconsin along the Michigamme River.

KEYWORDS
Paleoindian; paleoenvironmental reconstruction; archaeological site suitability; predictive modeling; spatial correlation

1. Introduction

Research on early Paleoindian adaption in North America typically invokes historical narratives that commence in the Holocene, some 11,700 calendar years ago (cal yr BP), when climatic warming and receding continental glaciers enabled temperate flora and fauna to advance northward across the Great Lakes (Grimm and Jacobson 2003). Mobile migrating Paleoindians soon followed, typically in search of prey to feed families and tribes (Robinson et al. 2009; Seeman et al. 1994). Recently, with some controversy, new approaches have countered such narratives by arguing that social and political factors, other than searches for sustenance, may have contributed to Paleoindian settlement routes and sites (Speth et al. 2013). Ethington (2007, 466) has reconceived historical interpretation "as the act of reading places, or *topos*," and in this paper we discuss a place-based geographical information science (GIScience) statistical model which considers topology, terrain, and environment as factors to identify undiscovered sites of late Paleoindian colonization in the Upper Great Lakes region. Given the limitations of previous research, questions concerning the timing of colonization, potential routes of ingress into the region, and whether colonizers focused on particular landforms remain unresolved. The GIScience model discussed in this paper holds the potential to aid archaeologists working in commensurate North American latitudes, terrains, and environments to develop site identification and fieldwork strategies. Michigan's Upper Peninsula and adjacent portions of northern Wisconsin were characterized by open spruce parklands dotted with numerous small lakes, rivers marshes, and wetland areas. Early Holocene climatic amelioration associated with the development of these biotic communities undoubtedly played a role in the influx of mobile late Paleoindian groups into the region (Brubaker 1975; Brugam, McKeever, and Kolesa 1998; Booth, Jackson, and Thompson 2002). Although evidence from this period documents the presence of late Paleoindian peoples throughout the Lake Superior basin, poor organic preservation and a sparse archaeological record impede better understandings of the settlement-subsistence systems of these early groups (Anderton, Regis, and Paquette 2004; Buckmaster and Paquette 1988; Carr 2004, 2008; Dawson 1983; Fox 1975; Hawley et al. 2000; Meinholz and Kuehn 1996; Rusch and Penman 1984; Salzer 1969).

We employ a predictive archaeological GIScience model to speculate on these questions and investigate the spatial association between samples of known late Paleoindian site locations in Marquette County, Michigan within an early Holocene geophysical and environmental context (Arakawa and Nicholson 2009;

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Buckmaster 1985, 1989; Buckmaster and Carr 2004; Buckmaster and Paquette 1988; Espa et al. 2006; Finke, Meylemans, and Van de Wauw 2008; Greiser 1985; Jochim 1976; Judge and Sebastian 1988; Maschner and Stein 1995; Warren and Asch 2000; Verhagen and Whitley 2012) (Figure 1).

Our speculative, predictive GIScience model was designed to narrow down locations which may possess high probabilities for the discovery of late Paleoindian sites across an expansive study area. Increasing the sample size of early Holocene archaeological sites would certainly offer further insights into the mobility and practices of this population and how they interacted with a rapidly changing environment in the early Holocene. This type of speculative, predictive modeling in GIS represents one potential avenue toward overcoming serious logistical challenges to conducting Paleoindian archaeological fieldwork in this and other regions.

A similar research approach has been successfully applied to Archaic sites in the nearby Pictured Rocks National Lakeshore (Legg and Anderton 2010), and authors such as Duke and King (2014), Krist (2001) and Nelson (2015) demonstrate the increasing role of predictive modeling approaches in Paleoindian studies in Michigan and elsewhere. Archaeological probability maps, in combination with existing paleoenvironmental evidence, aim to identify locations that correlate with late Paleoindian site locations in the study area (Blewett et al. 2014; Breckenridge et al. 2012; Curry and Petras 2011; Drzyzga, Shortridge, and Schaetzl 2012; Loope et al. 2014). In addition, the speculative strategies discussed and applied in this paper outline a potential low-cost-high-yield GIScience archaeological approach to late Paleoindian site analysis on near ice edge occupations, which may further our understandings of early-period colonization in these northern environments.

2. Study area

Consisting of 4684 km^2 of land area, Marquette is the largest of Michigan's 83 counties. Marquette County is naturally bounded to the north and east by the Lake Superior shoreline and glacial-margin lands. The area is centrally important to the northern Great Lakes and offers a variety of different environments associated with a number of late Paleoindian sites located within a few kilometers of one another. The area is ideally situated for the construction of speculative predictive models which help us understand how late Paleoindian groups colonized recently deglaciated landscapes in these northerly latitudes. The county is characterized by bedrock outcrops and panoramic views of poorly drained basins and broad outwash plains. Generally, thin Pleistocene deposits blanket the undulating Precambrian bedrock (Regis 1997) and support maple, birch, oak, and mixed conifer forests. As is the case with the overwhelming majority of northern Great Lakes forests, logging companies clear-cut most of Marquette County's lands in the nineteenth and twentieth centuries. Since that time, anthropogenic and natural reforestation has resulted in heavy second- and third-generation regrowth. While most of the study area is free from development, this dense regrowth, coupled with a short summer field season, extreme winter temperatures, and deep lake-effect snowfall, combine to present substantial obstacles to ongoing archaeological field surveys.

3. Early Holocene environment

Few detailed surficial geologic maps exist for the Upper Peninsula of Michigan. Regional mapping was conducted by Leverett (1929), Thwaites (1943), Farrand and Bell (1982), and Peterson (1986), but these lack sufficient detail to understand the complexity of local landscape morphology. The availability of detailed elevation data allowed Regis (1997, 2015) and Walters (2013) to interpret the Laurentide Ice Sheet (LIS) retreat from the Upper Peninsula through the Lake Superior basin. Radiocarbon dating by Hughes and Merry (1978), Pregitzer et al. (2000), Derouin, Lowell, and Hajdas (2007), and Walters (2013) set chronological parameters on the timing of the retreat (Figure 2). This places a natural upper boundary on the earliest potential dates for human occupation of the Upper Peninsula.

The LIS buried two major forest beds in its advances and retreats across the region. The Two Creeks Forest near Two Rivers, Wisconsin (which defines the Greatlakean advance maximum) and dates from the Ishpeming and Green Hills moraines in Marquette County provide a starting point for the northward retreat of the ice margin through the Upper Peninsula of Michigan (Regis 1997; Walters 2013). Many ^{14}C dates from the Two Creeks forest bed and gytta from the Ishpeming/Green Hills moraines average about 13,000 cal yr BP. The LIS retreated northward, with as many as six minor re-advances before the ice margin was located in the Lake Superior basin. The most significant and best dated of these is the Gwinn Moraine (12,100 cal yr BP), a few kilometers distal to the Marquette Moraine. After retreating from the Gwinn Moraine, the LIS re-advanced one last time onto the present Upper Peninsula to about 10–15 km south of the modern Lake Superior shoreline. The Gribben forest (black spruce and white cedar), about 10 km south of Marquette, Michigan grew in proximity to the ice margin as the LIS retreated into the Lake Superior basin (the Gribben Interstadial) (Lowell et al.

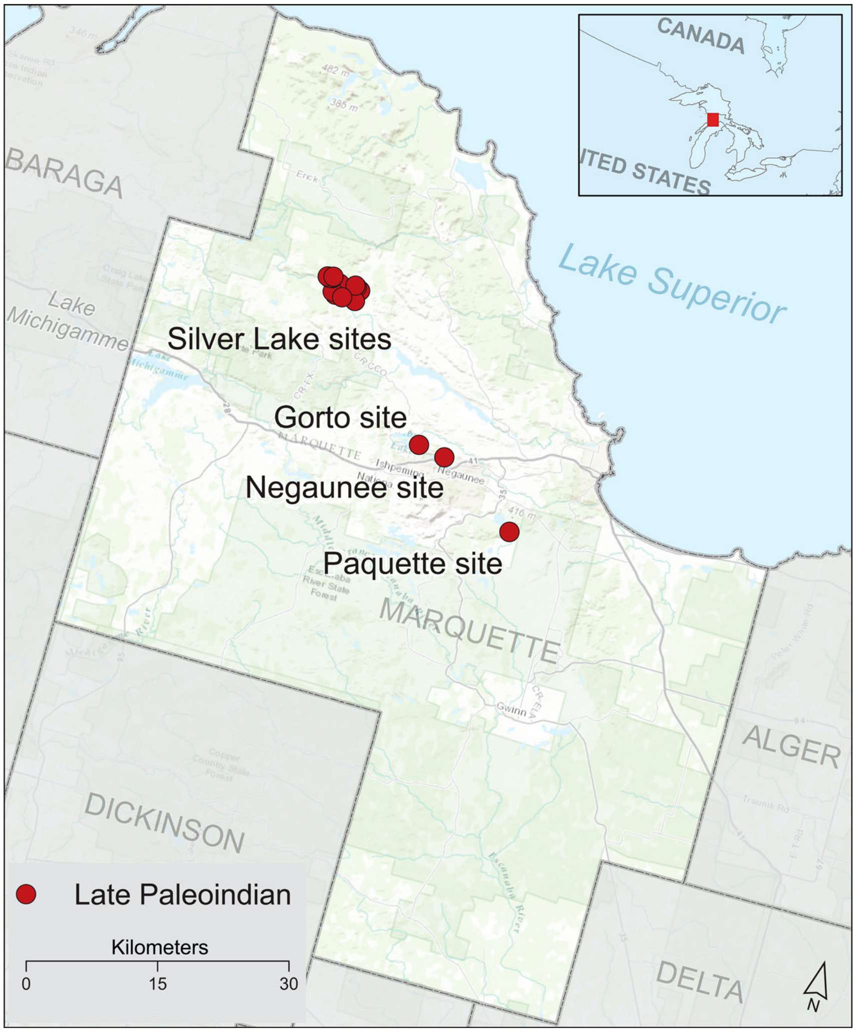

Figure 1 Previously recorded late Paleoindian site locations within Marquette County, Michigan.

1999). This forest was subsequently buried by the last advance (the Marquette stadial) of the LIS's Superior lobe (about 11,600 cal yr BP). Tree ring counts suggest the forest grew for over 70 years (Hughes, pers. comm.). Many meltwater streams carried outwash southwards from the Marquette ice margin and buried the forest in 10+ meters of sediment, persisting long enough to accumulate into easily recognizable, large, thick outwash plains. This last advance likely persisted for several hundred years before the LIS finally retreated for the last time into the Lake Superior basin. Cores containing gytta were obtained from Goose Lake by Walters (2013), and the most recently deposited material near the top of the core was dated to 10,900 cal yr BP. Thus, the entire landscape was deglaciated by about 10,900 cal yr BP (Walters 2013).

In Marquette County, several broad outwash plains developed during the retreat of the LIS and re-advance of the Marquette ice margin. The oldest is the Ishpeming Outwash Plain (Two Creeks age), and the youngest are the Yellow Dog Plains and the Sands Outwash Plains (each formed by the Marquette advance). There are several other minor outwash plains distal to the Marquette Moraine and proximal to the Ishpeming/Green Hills Moraine. The outlets were active during and shortly after their development and drained meltwater south and westward. Depressions, some formed by abandoned stagnant ice blocks and kettles occupying bedrock depressions, created lakes that late Paleoindian people appeared to favor (for example, the Silver, Deer, and Goose Lake sites). The shape of modern lakes, however, is generally different and larger than lakes which occupied those basins during Paleoindian times.

During the late Paleoindian period, Marquette County would have become ice free when the LIS began its final retreat into the Lake Superior Basin. The Gribben phase was the last time these inland lake basins were covered by the ice sheet (Carr 2008). It is speculated that Paleoindian peoples probably entered the Upper Peninsula immediately following the final retreat of the

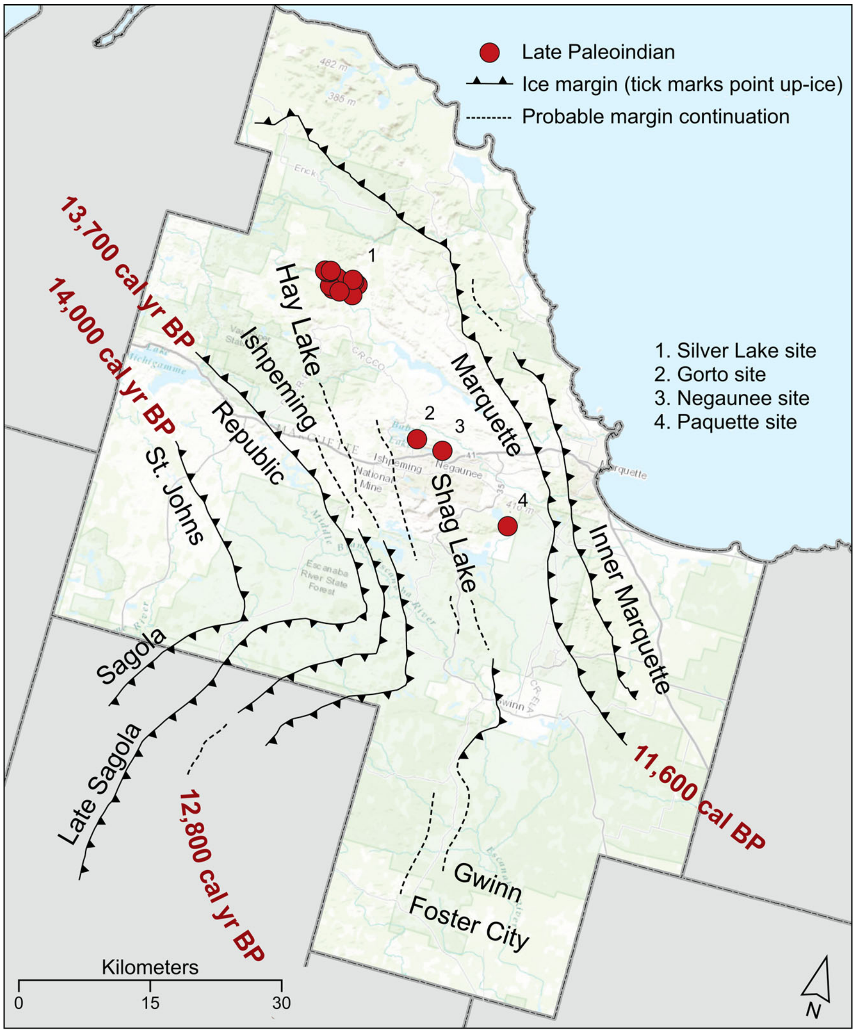

Figure 2 Dated positions of ice margin in Marquette County.

LIS after the Marquette re-advance. From the pioneering work conducted at identified late Paleoindian sites, available evidence suggests that populations migrated into the Upper Peninsula at the outset of the Holocene, left archaeological signatures in several separate locations, and brought lithic materials from some 300 km southwest (Carr 2008). Despite a paucity of direct evidence, the triangulation of site locations, paleoenvironmental proxies, and limited but existent paleontological evidence suggests that caribou herd migrations were a pull factor for early groups in search of prey in more northerly latitudes (Lemke 2015; Long 1986; Long and Yahnke 2011; West 1978).

4. Late Paleoindian site sample, Marquette County, Michigan

Early Holocene archaeological research in central Marquette County was galvanized in the mid-1980s by the discovery of the late Paleoindian Negaunee site (20MQ32), a lithic workshop and quarry that contained large ovate bifaces and several flake scatters (Buckmaster 1985). By the end of the 1980s, substantial late Paleoindian evidence was also discovered at the Gorto site (20MQ39). This was the result of a local mining company's excavation in the Deer Lake Basin that exposed the original shoreline and previously submerged site. Investigations at Gorto revealed a cache of Cody Complex projectile points on the surface of the exposed lakebed (Buckmaster and Paquette 1988; Clark 1989). These points unequivocally associate the area with late Paleoindian peoples and were manufactured almost exclusively on Hixton silicified sandstone (HSS), which outcrops 350 km to the southwest in Wisconsin. These bifaces were fragmented, discolored, and exposed to thermal shock. Evidence of post holes in the middle of the artifact cluster led archaeologists to suggest the artifacts sat on a platform prior to being burned – possibly in association with ritual activity at the site (Buckmaster and Paquette 1988). Soon after discovery and emergency excavation, refilling of the impounded basin by the local mining company terminated further archaeological exploration in the area.

The third discovery of late Paleoindian evidence at the Paquette site (20MQ34) was identified on a small terrace at the north end of the outlet to Goose Lake. This site extended evidence of late Paleoindian people approximately 15 km southeast of the Gorto site. While conducting excavations, archaeologists unearthed a campsite, hearth feature, and several scatters of fire-cracked rock (Buckmaster 1989).

In a fourth area a few kilometers to the northwest of Deer Lake, late Paleoindian artifacts were discovered in the Silver Lake Basin, after the basin emptied unexpectedly due to a burst levee at the headwaters of the Dead River. The exposed area was thoroughly combed by a pedestrian survey, and archeologists found the densest collection of late Paleoindian artifacts in Michigan's Upper Peninsula (Buckmaster and Carr 2004). The artifacts ranged from flakes and scrapers to Agate Basin projectile points, all manufactured from HSS (Carr 2004).

5. Site location modeling

Three main assumptions underpin our speculative predictive modeling approach. First, the physical environment and geomorphological conditions influenced late Paleoindian settlement patterns in the northwestern Great Lakes and that at least some of these paleoenvironmental data exist in currently available sources. Second, significant information can be gleaned from geomorphological and paleoenvironmental studies, which can lead to the potential reconstruction of environmental conditions dating to the late Paleoindian period. Third, although many factors bias the preservation, discovery, and dating of late Paleoindian sites in this region, known site records to a certain extent offer insight into where people were situated during this period. Subsequently, relationships between known late Paleoindian sites and environments can be modeled and extended to speculate on additional, potential, and undiscovered locations late Paleoindian sites in this region.

In constructing the site location model, data were organized to perform forward stepwise logistic regression analysis. This procedure compared environmental parameters at locations with known late Paleoindian sites to potential locations that do not have evidence of late Paleoindian settlement. Statistical analysis was performed in SPSS (Version 23), and spatial information was visualized using ArcGIS software (Version 10.3).

All spatial layers were represented in a 10-×-10-m cell size. To build the data set, we plotted known late Paleoindian site and artifact locations ($n = 25$) from the six late Paleoindian site locations listed in state archives. Centroids for previous archaeological surveys conducted in Marquette County ($n = 97$) formed non-site locations at places where archaeological surveys were conducted, but no evidence of late Paleoindian sites was discovered (Figure 3).

Independent environmental variables were assembled from several data sources, including soil type, altitude, aspect, and slope. A 10-m digital elevation model (DEM) from the National Elevation Dataset (http://seamless.usgs.gov) was the primary source of surface topography. Adjustment for isostatic rebound dating to the early Holocene was made at a rate of 0.3 m/km along a baseline bearing N15° E (Futyma 1981; Loope et al. 2014). For aspect, ArcGIS generated a raster surface with cell values representing compass directions in degrees. To prepare these values for statistical algorithms, compass directions were coded into four quadrants (0–90; 90–180; 180–270; 270–360) and then into categorical variables (Hardy 1993). The ArcGIS slope operation calculated the greatest change in height between individual grid cells and their neighbors. The values resulting are further calculated as percent slope. A field visit to each of the site areas identified that they were typically located in close proximity to steep slopes and hilly terrain. To incorporate this type of terrain within our analysis, we assembled a spatial layer that indicated the distance to hilly terrain (identified by slopes of 20 per cent or greater). Straight-line distance operations in the ArcGIS Spatial Analyst module were applied to generate a raster surface of distance to hilly land across the study area.

Commensurate with ordinary least squares regression, the forward stepwise logistic regression procedure produces an intercept value (α) and positive or negative regression coefficient for each significant variable (Hosmer and Lemeshow 2000). The intercept value (α) and regression coefficients (Bi) are then applied to a logistics regression equation:

$$p(B) = \frac{1}{1 + e[-(\alpha + B_1X_1 + B_2X_2 + \ldots B_iX_i)]} \quad (1)$$

Applying this formula to separate spatial layers in ArcGIS generated a probability for each study area cell. Cells were further reduced to only high probability values with those at 0.90 and above and refined further for cartographic generalization.

The final cartographic model was linked to the results of the estimated paleoenvironmental reconstructions. These estimates, combined with the results of the

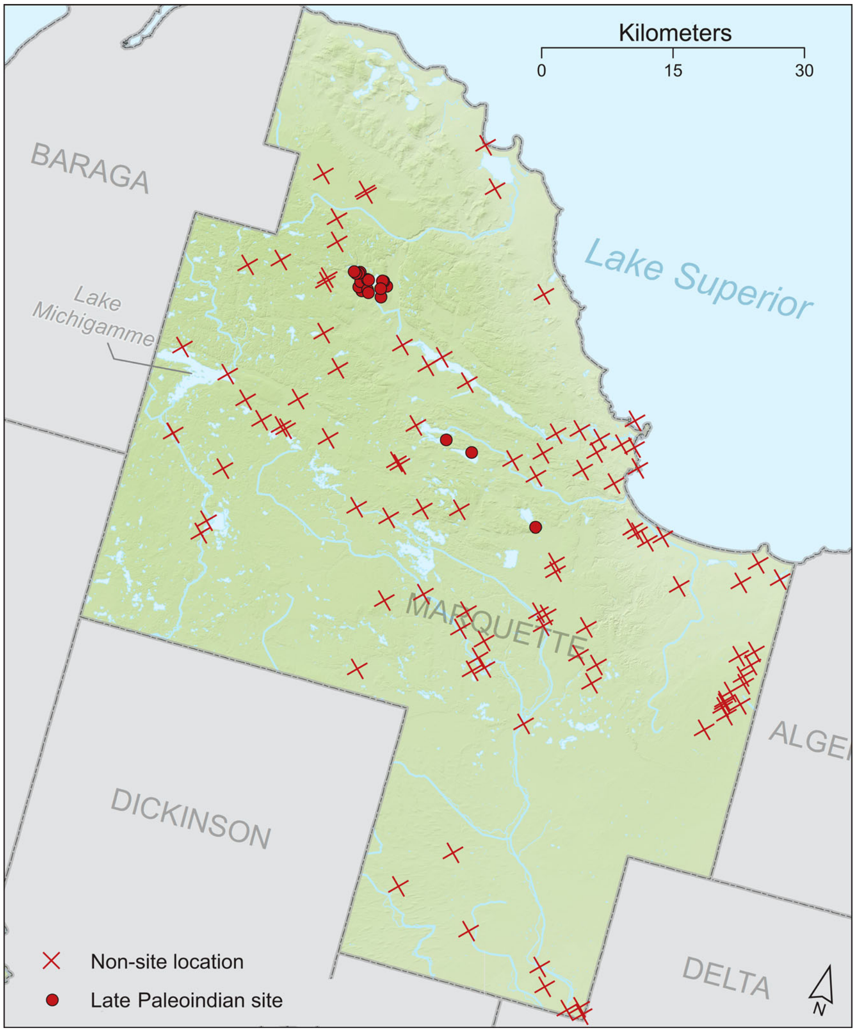

Figure 3 Location of surveys with and without evidence of late Paleoindian sites.

modeling process, reduced potential areas for archaeological settlement to a few key areas within the county.

6. Results and discussion

The results of the modeling process were significant ($r^2 = 0.392$; $P < 0.001$; Cox and Snell 1989) suggesting a moderately weak relationship between the model and the dependent variable. The outcome is displayed on a late Paleoindian site probability map (Figure 4). From east to west across Marquette County, the overall pattern indicates that sites tend to be located on high, relatively flat ground, close to hilly terrain. Low site probabilities are found within 13–16 km of Lake Superior and across the south and eastern portion of the county. These lowland areas, with relatively flat topography, correlate poorly with known late Paleoindian sites.

The central and western portions of the study area, on the other hand, represent a core area comprised of terrains and environments with strong similarities to those having known late Paleoindian sites. Located at the southwestern end of this core area, one place of interest for high late Paleoindian site potential is Lake Michigamme. Given that all known late Paleoindian sites in this study area are situated within or near existing lakes, Lake Michigamme, or lakes dotting the core area, a high probability exists to identify undiscovered late Paleoindian sites.

Derived from a Chippewa phrase that means "Large Lake," Lake Michigamme covers approximately 1620+ hectares across Marquette and Baraga Counties, and is one of the biggest inland lakes in Michigan. This lake features many islands and rock beds with a southern outlet at the Michigamme River. The river flows southward and forms the northern section of the Menominee River catchment, which drains southward into Lake Michigan. Given the topography of this area, it is possible that late Paleoindian peoples entered the Menomonee River catchment and may have followed prey and rivers northward reaching Lake Michigamme, which acted as a

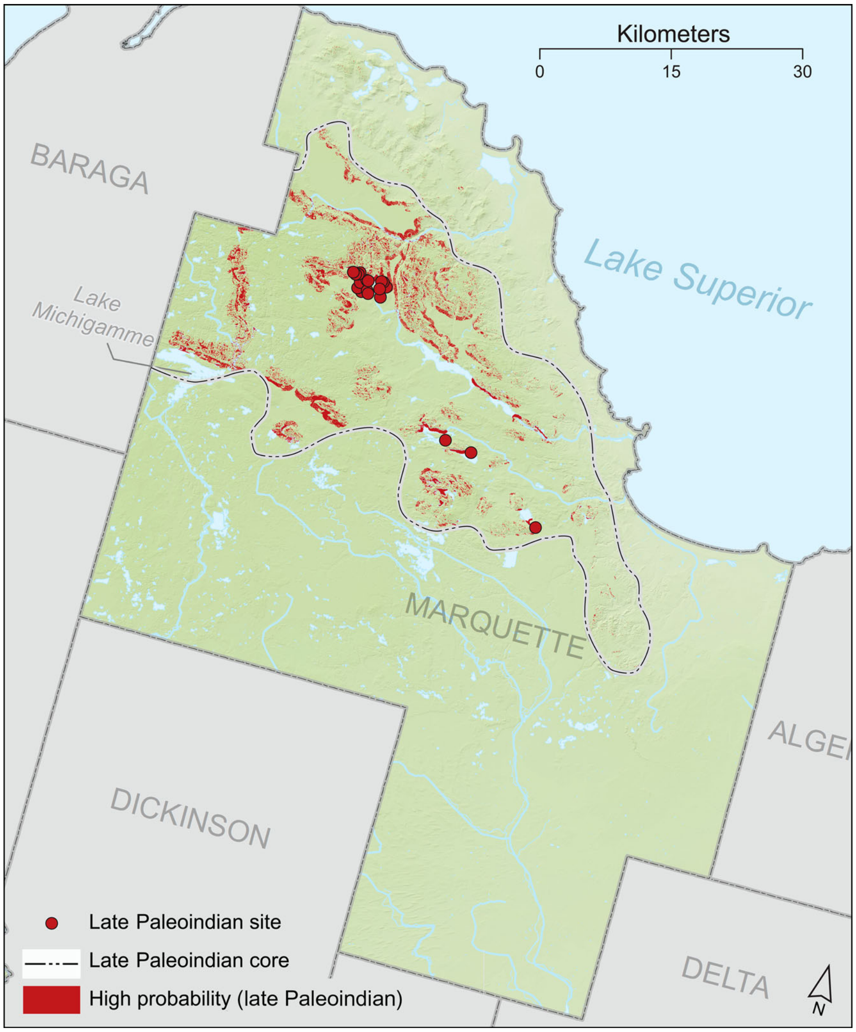

Figure 4 Site probability map featuring areas with high probability for Paleoindian settlement.

possible junction portal into this core area. Further analysis of the Menominee River catchment would be necessary to understand this theory better, as these lakes' waterways and catchment areas did not factor directly into our modeling process.

Smaller lakes, such as the Van Riper Lakes and those in the Craig Lake State Park in the northern portion of Michigamme Township are situated in areas and proximate locations that contain high probabilities for late Paleoindian settlement. In particular, the Van Riper Lakes, located between Silver Lake and Lake Michigamme, are areas worth targeting for the discovery of additional late Paleoindian evidence. These lakes are found in and near areas of high probability and situated between Lake Michigamme and known sites of the Silver Lake basin. Throughout the core area, the landscape offers a range of topographic settings, numerous water bodies, and many locations that could have concentrated animal migration and behavior which would have drawn hunter-gatherer interest and activities.

While the resulting map offers many areas to target for field work, the limited reliability of these results must be noted. The availability of Paleoindian archaeological records in this region, for example, is affected by many elements. Issues related to site preservation and chronology drastically impact archaeological traces in this area. In terms of formation processes and site preservation, for instance, the presence of buried forests introduces the possibility that Paleoindian deposits were also covered. It is quite likely that the large, thick outwash plains that accumulated south of the ice front may well have inundated not just forests, but any evidence of near ice front occupation by Paleoindians was well. Such deeply buried sites pose a very different problem for site discovery, and there is simply no evidence to say the area was not utilized. Additionally, the absence of lowland sites may be the result of aquatic inundation. Numerous sites (similar to the ones detailed in our analysis) may be underwater. Patterns of upland Paleoindian settlement should be speculated with caution, as these patterns may be underpinned with site preservation bias.

7. Conclusions

P. J. Ethington claims: “The past cannot exist in time; only in space. Histories representing the past represent the place (*topoi*) of human action” (2007, 466). Employing known late Paleoindian sites from Marquette, Michigan’s largest county, we demonstrated that the application of a place-based predictive GIScience archaeological model holds the potential to identify other locations where late Paleoindian settlement may have occurred and where sites may have existed during the early Holocene in the Upper Peninsula.

Our research shows that both previously recorded late Paleoindian areas with high probability for site identification tend to be found on places characterized by raised, flat ground, near hilly or steep sloping terrain, often within or in close proximity to inland lakes – which served as prime locations for monitoring the movement of large game herds, such as caribou (Carr 2012; Lemke 2015). Early Holocene foragers in the Upper Peninsula may have exploited the possibility that woodland caribou prefer nursery habitat near lakes and marshes during spring and summer calving (Carr, Rodgers, and Walshe 2007; Carr et al. 2011; White et al. 1975). Outwash plains immediately to the north of the study area may have also been productive caribou calving grounds during the period, which in turn would have been a factor in motivating late Paleoindian seasonal group migration into the region (Bergerud, Ferguson, and Butler 1990; Cannon and Meltzer 2004; Carr 2012; Gramly 1982; Johnson et al. 2002; Storck 2004; White and Trudell 1980). While these are speculative possibilities, it is important to note that few faunal remains are available to support this conclusion and there exists a substantial debate on the importance of caribou to the late Paleoindian people in the Great Lakes regions (Lemke 2015).

The location of known sites also suggests a possible north/south seasonal migration corridor into the center of the county by way of the Menominee River catchment. People possibly followed animal herd migrations along river and lake chains within the catchment, with evidence of settlement activities clustering in the northern end of this seasonal range where more intensive foraging may have taken place. An overland entrance into Michigan’s Upper Peninsula is only possible from present-day Wisconsin to the southwest, and the Menominee River provides a natural corridor for groups moving up from this direction toward Marquette County. Archaeological evidence from central and northern Wisconsin indicates that the dugout canoe may have been introduced to the region during the early Holocene (Engelbrecht and Seyfert 1994). Therefore, it is possible that at least some of this movement may have been carried out along river and lake chains with the aid of rudimentary aquatic transport technology; however, direct evidence to support this speculation is currently lacking (Jodry 2004; Lambert and Loebel 2015; Morrow 2014).

While late Paleoindian evidence may also exist outside of the high ground and lakes basins area of this study, these sites offer a strategic starting point to focus future field survey efforts. Our approach demonstrates that the construction of localized, speculative, predictive archaeological models provide a potential avenue to identify high probability locations for the existence of late Paleoindian sites scattered throughout the northwestern Great Lakes. Though not definitive, it is our hope that our speculative model serves as only one step of many in fleshing out the sparse archaeological record associated with the late Paleoindian period in the Upper Great Lakes region, and beyond.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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John M. Lambert is currently undertaking a PhD in the Department of Anthropology at UC Davis, California. His research interests focus on Pleistocene/early Holocene archaeology of the Western Great Lakes and Upper Mississippi Valley; hunter-gatherer mobility, subsistence, and site structure; stone tool technologies; human behavioral ecology; geographic information systems (GIS).

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Charles B. Travis is currently an Assistant Professor of Geography with the Department of History at the University of Texas, Arlington; he is also a visiting research fellow at the School of Histories and Humanities at Trinity College the University of Dublin. As an editorial board member of the journal *Literary Geography*, his book publications include: *The Digital Arts and Humanities: Neogeography, Social Media and Big Data Integrations and Applications* (Springer Press: 2016), *Abstract Machine: Humanities GIS* (Esri Press: 2015), *History and GIS: Epistemologies, Reflections and Considerations* (Springer Press: 2012) and *Literary Landscapes: Geographies of Irish Stories, 1929–1946 (2009)*. Charles' work also appears in the *International Journal of Humanities and Arts Computing, Annals of the Association of American Geographers, International Journal of Geographical Information Science, Historical Geography* and other peer-reviewed publications.

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References

Anderton, John B., Robert S. Regis, and James Paquette. 2004. "Geoarchaeological Context for Late Paleoindian Archaeology in the North Central Upper Peninsula of Michigan, USA." In *The Late Palaeo-Indian Great Lakes: Geological and Archaeological Investigations of Late Pleistocene and Early Holocene Environments*, edited by Lawrence J. Jackson, and Andrew Hinshelwood, 251–274. Quebec: Canadian Museum of Civilization.

Arakawa, Fumiyasu, and Christopher M. Nicholson. 2009. "Prehistoric Resource Procurement in the Central Mesa Verde Region: A Study of Human Mobility and Social Interactions Using GIS." *International Journal of Humanities and Arts Computing* 3 (1–2): 85–100.

Bergerud, A. T., R. Ferguson, and H. E. Butler. 1990. "Spring Migration and Dispersion of Woodland Caribou at Calving." *Animal Behaviour* 39 (2): 360–368.

Blewett, William L., Scott A. Drzyzga, Laura Sherrod, and Hong Wang. 2014. "Geomorphic Relations among Glacial Lake Algonquin and the Munising and Grand Marais Moraines in Eastern Upper Michigan, USA." *Geomorphology* 219: 270–284.

Booth, Robert K., Stephen T. Jackson, and Todd A. Thompson. 2002. "Paleoecology of a Northern Michigan Lake and the Relationship among Climate, Vegetation, and Great Lakes Water Levels." *Quaternary Research* 57 (1): 120–130.

Breckenridge, Andy, Thomas V. Lowell, Timothy G. Fisher, and Shiyong Yu. 2012. "A Late Lake Minong Transgression in the Lake Superior Basin as Documented by Sediments from Fenton Lake, Ontario." *Journal of Paleolimnology* 47 (3): 313–326.

Brubaker, Linda B. 1975. "Postglacial Forest Patterns Associated with Till and Outwash in North-Central Upper Michigan." *Quaternary Research* 5 (4): 499–527.

Brugam, Richard B., Kathleen McKeever, and Lawrence Kolesa. 1998. "A Diatom-inferred Water Depth Reconstruction for an Upper Peninsula, Michigan, Lake." *Journal of Paleolimnology* 20: 267–276.

Buckmaster, Marla M. 1985. "Two Aceramic Sites in Marquette County: A Preliminary Statement." Paper presented at the Annual Meeting of the Midwest Archaeological Conference, East Lansing, Michigan.

Buckmaster, Marla M. 1989. "A Report on the Early Component at the Paquette Site, Marquette, Michigan." *The Wisconsin Archaeologist* 70: 430–462.

Buckmaster, Marla M., and Dillon H. Carr. 2004. "After the Flood: Exploring the Late Pleistocene and Early Holocene in the Upper Great Lakes." Paper presented at the Joint Midwest and Southwest Archeological Conferences, St. Louis, Missouri.

Buckmaster, Marla M., and James Paquette. 1988. "The Gorto Site: Preliminary Report on a Late Paleoindian Site in Marquette County, Michigan." *The Wisconsin Archeologist* 69 (3): 101–124.

Cannon, Michael D., and David J. Meltzer. 2004. "Early Paleoindian Foraging: Examining the Faunal Evidence for Large Mammal Specialization and Regional Variability in Prey Choice." *Quaternary Science Reviews* 23: 1955–1987.

Carr, Dillon H. 2004. "Deer Lake Revisited: Evaluating the Early Holocene Occupation of Michigan's Upper Peninsula." *Michigan Archaeologist* 50 (52): 61–73.

Carr, Dillon H. 2008. "From Silver Lake to Deer Lake: Variability in the Early Holocene Human Occupation of Michigan's Upper Peninsula." *The Wisconsin Archeologist* 90: 31–46.

Carr, Dillon H. 2012. "Paleoindian Economic Organization in the Lower Great Lakes Region: Evaluating the Role of Caribou as a Critical Resource." PhD diss., Department of Anthropology, Michigan State University, East Lansing.

Carr, N. L., A. R. Rodgers, S. R. Kingston, and D. J. Lowman. 2011. "Use of Island and Mainland Shorelines by Woodland Caribou during the Nursery Period in Two Northern Ontario Parks." *Rangifer* 31 (Special Issue No. 19): 49–62.

Carr, N. L., A. R. Rodgers, and S. C. Walshe. 2007. "Caribou Nursery Site Habitat Characteristics in Two Northern Ontario Parks." *Rangifer* 27 (4): 167–179.

Clark, Caven P. 1989. "Plano Traditional Lithics from the Upper Peninsula of Michigan." *The Midwest Archaeologist* 35: 88–112.

Cox, David R., and Joyce E. Snell. 1989. *Analysis of Binary Data*. 2nd ed. London: Chapman & Hall.

Curry, Bandon, and Justine Petras. 2011. "Chronological Framework for the Deglaciation of the Lake Michigan Lobe of the Laurentide Ice Sheet from Ice-walled Lake Deposits." *Journal of Quaternary Science* 26 (4): 402–410.

Dawson, Kenneth C. A. 1983. "Cummins Site: A Late Paleo-Indian (Plano) Site at Thunder Bay, Ontario." *Ontario Archaeology* 39: 3–31.

Derouin, Sarah A., Thomas V. Lowell, and Irka Hajdas. 2007. "Landscape Evolution and Deglaciation of the Upper Peninsula, Michigan: An Examination of Chronology and Stratigraphy in Kettle Lake Cores." *Journal of Great Lakes Research* 33 (4): 875–886.

Drzyzga, Scott, Ashton M. Shortridge, and Randall J. Schaetzl. 2012. "Mapping the Phases of Glacial Lake Algonquin in the Upper Great Lakes Region, Canada and USA, Using a

Geostatistical Isostatic Rebound Model." *Journal of Paleolimnology* 47: 357–371.

Duke, Daron, and Jerome King. 2014. "A GIS Model for Predicting Wetland Habitat in the Great Basin at the Pleistocene–Holocene Transition and Implications for Paleoindian Archaeology." *Journal of Archaeological Science* 49 (1): 276–291.

Engelbrecht, William E., and Carl K. Seyfert. 1994. "Paleoindian Watercraft: Evidence and Implications." *North American Archaeologist* 15: 221–234.

Espa, Giuseppe, Roberto Benedetti, Anna De Meo, Ugo Ricci, and Salvatore Espa. 2006. "GIS Based Models and Estimation Methods for the Probability of Archaeological Site Location." *Journal of Cultural Heritage* 7: 147–155.

Ethington, P. J. 2007. "Placing the Past: 'Groundwork' for a Spatial Theory of History." *Rethinking History* 11 (4): 465–493.

Farrand, William R., and Danny L. Bell. 1982. "Quaternary Geology of the Upper Peninsula of Michigan." Department of Environmental Quality, Geological Survey Division, University of Michigan.

Finke, Peter A., Erwin Meylemans, and Johan Van de Wauw. 2008. "Mapping the Possible Occurrence of Archaeological Sites by Bayesian Inference." *Journal of Archaeological Science* 35: 2786–2796.

Fox, William A. 1975. "The Palaeo-Indian Lakehead Complex." Paper presented at the Canadian Archaeological Association Meeting, March, Ontario.

Futyma, Richard P. 1981. "The Northern Limits of Glacial Lake Algonquin in Upper Michigan." *Quaternary Research* 15: 291–310.

Gramly, Richard M. 1982. "The Vail Site: A Paleo-Indian Encampment in Maine." *Buffalo Society of Natural Science Bulletin* 30: 1–183.

Greiser, Sally T. 1985. "Predictive Models of Hunter-gatherer Subsistence and Settlement Strategies on the Central High Plains." *Plains Anthropologist* 30: 1–134.

Grimm, Eric C., and George L. Jacobson. 2003. "Late-Quaternary Vegetation History of the Eastern United States." *Developments in Quaternary Sciences* 1: 381–402.

Hardy, Melissa. 1993. *Regression with Dummy Variables, Sage University Series on Quantitative Applications in the Social Sciences*. Newbury Park, CA: Sage.

Hawley, Martin F., Patrick Ladwig, Norman M. Meinholz, and Vicki L. Twinde. 2000. "By the Water's Edge: Phase I and Archaeological Survey and Phase II Evaluation of Sites along the STH 178, Chippewa County, Wisconsin." In *Research Report in Archaeology, Museum Archaeology Program*. Madison: State Historical Society of Wisconsin.

Hosmer, David W., and Stanley Lemeshow. 2000. *Applied Logistic Regression*. New York: Wiley.

Hughes, John D., and W. J. Merry. 1978. "Marquette Buried Forest 9850 Years Old." Paper presented at the 144th Annual Meeting of the American Association for the Advancement of Science.

Jochim, Michael A. 1976. *Hunter-gatherer Subsistence and Settlement: A Predictive Model*. New York: Academic Press.

Jodry, Margaret A. 2004. "Envisioning Water Transport Technology in Late-Pleistocene America." In *Paleoamerican Origins: Beyond Clovis*, edited by Robson Bonnichsen, Bradly T. Lepper, Dennis J. Stanford, and Michael R. Waters, 133–160. College Station: The Center for the Study of the First Americans, Texas A&M University.

Johnson, Chris J., Katherine L. Parker, Doubglas C. Heard, and Michael P. Gillingham. 2002. "A Multiscale Behavioral Approach to Understanding the Movements of Woodland Caribou." *Ecological Applications* 12 (6): 1840–1860.

Judge, James W., and Lynne Sebastian. 1988. *Quantifying the Present and Predicting the Past: Theory, Method, and Application of Archaeological Predictive Modeling*. Washington, DC: US Government Printing Office.

Krist, Frank J. 2001. "A Predictive Model of Paleo-Indian Subsistence and Settlement." PhD diss., Department of Anthropology, Michigan State University, East Lansing.

Lambert, John M., and Thomas J. Loebel. 2015. "Paleoindian Colonization of the Recently Deglaciated Great Lakes: Mobility and Technological Organization in Eastern Wisconsin." *PaleoAmerica* 1 (3): 284–288.

Legg, Robert J., and John B. Anderton. 2010. "Using Paleoshoreline and Site Location Modeling in the Northern Great Lakes: Geoarchaeological Approaches to Prehistoric Archaeological Survey in the Pictured Rocks National Lakeshore." *Geoarchaeology* 25: 772–783.

Lemke, Ashley K. 2015. "Great Lakes *Rangifer* and Paleoindians: Archaeological and Paleontological Caribou Remains from Michigan." *PaleoAmerica* 1 (3): 276–283.

Leverett, Frank. 1929. "Moraines and Shore Lines of the Lake Superior Basin, U.S." *Geological Survey Professional Paper* 154-A: 1–72.

Long, Charles A. 1986. "Pleistocene Caribou in Central Wisconsin." *Transactions of the Wisconsin Academy of Science, Arts and Letters* 78: 12–13.

Long, Charles A., and Christopher J. Yahnke. 2011. "End of the Pleistocene: Elk-Moose (Cervalces) and Caribou (Rangifer) in Wisconsin." *Journal of Mammalogy* 92 (5): 1127–1135.

Loope, Walter L., Harry M. Jol, Timothy G. Fisher, William L. Blewett, Henry M. Loope, and Robert J. Legg. 2014. "A Previously Unrecognized Path of Base Flow and Elevated Discharge from Lake Minong to Lake Chippewa Across Eastern Upper Michigan." In *Coastline and Dune Evolution along the Great Lakes*, edited by Timothy G. Fisher and Edward C. Hanson, 1–13. Boulder, CO: Geological Society of America.

Lowell, Thomas V., Graham J. Larson, John D. Hughes, and George H. Denton. 1999. "Age Verification of the Lake Gribben Forest Bed and the Younger Dryas Advance of the Laurentide Ice Sheet." *Canadian Journal of Earth Sciences* 36 (3): 383–393.

Maschner, Herbert D. G., and Jeffery W. Stein. 1995. "Multivariate Approaches to Site Location on the Northwest Coast of North America." *Antiquity* 69: 61–73.

Meinholz, Norman M., and Steven R. Kuehn. 1996. "The Deadman Slough Site (47-Pr-46)." In *Archaeology Research Series, No. 4*. Madison: State Historical Society of Wisconsin.

Morrow, Juliet E. 2014. "Early Paleoindian Mobility and Watercraft: An Assessment from the Mississippi River Valley." *Midcontinental Journal of Archaeology* 39 (2): 103–129.

Nelson, Matthew R. 2015. "Paleoindian Predictive Model for Yellowstone National Park." MA thesis, Department of Anthropology, University of Montana, Missoula.

Peterson, Warren L. 1986. *Late Wisconsin Glacial History of Northeastern Wisconsin and Western Upper Michigan*. USGS Numbered Series 1652. Alexandria, VA: US Geological Survey.

Pregitzer, Kurt S., David D. Reed, Theadore J. Bornhorst, David R. Foster, Glenn D. Mroz, Jason S. McLachlan, Peter E. Laks, Douglas D. Stokke, Patrick E. Martin, and Shannon E. Brown. 2000. "A Buried Spruce Forest Provides Evidence at the Stand and Landscape Scale for the Effects of Environment on Vegetation at the Pleistocene/Holocene Boundary." *Journal of Ecology* 88: 45–53.

Regis, Robert S. 1997. "Late Pleistocene Glacial History of Central Marquette and Northern Dickinson Counties, Michigan." PhD diss., Geology & Mining Engineering & Sciences, Michigan Technological University, Houghton.

Regis, Robert S. 2015. "Late Pleistocene Laurentide Ice Sheet Recession across the Central Upper Peninsula of Michigan." Paper presented at the Annual Meeting of the Association of American Geographers, Chicago.

Robinson, Brian S., Jennifer C. Ort, William A. Eldridge, Adrian L. Burke, and Bertrand G. Pelletier. 2009. "Paleoindian Aggregation and Social Context at Bull Brook." *American Antiquity* 74 (3): 423–447.

Rusch, Lynn A., and John T. Penman. 1984. *Transportation Archaeology in Wisconsin: The 1983 Field Season*. Madison: Wisconsin Department of Transportation.

Salzer, Robert J. 1969. "An Introduction to the Archaeology of Northern Wisconsin." PhD diss., Department of Anthropology, Southern Illinois University.

Seeman, M. F., G. Summers, E. Dowd, and L. Morris. 1994. "Fluted Point Characteristics at Three Large Sites: The Implications for Modelling Early Paleoindian Settlement Patterns in Ohio." In *The First Discovery of America: Archaeological Evidence of the Early Inhabitants of the Ohio Area*, edited by W. S. Dancey, 77–93. Columbus: Ohio Archaeological Council.

Speth, John D., Khori Newlander, Andrew A. White, Ashley K. Lemke, and Lars E. Anderson. 2013. "Early Paleoindian Big-game Hunting in North America: Provisioning or Politics?" *Quaternary International* 285 (8): 111–139.

Storck, Peter L. 2004. *Journey to the Ice Age: Discovering an Ancient World*. Seattle: University of Washington Press.

Thwaites, Fredrik T. 1943. "Pleistocene of Part of Northeastern Wisconsin." *Geological Society of America Bulletin* 54: 87–144.

Verhagen, Phillp, and Thomas G. Whitley. 2012. "Integrating Archaeological Theory and Predictive Modeling: A Live Report from the Scene." *Journal of Archaeological Method and Theory* 19: 49–100.

Walters, Kent A. 2013. "Laurentide Ice Sheet Retreat during the Younger Dryas: Central Upper Peninsula of Michigan, USA." MS thesis, Department of Geology, University of Cincinnati, Cincinnati.

Warren, Robert E., and David L. Asch. 2000. "A Predictive Model of Archaeological Site Location in the Eastern Prairie Peninsula." In *Practical Applications of GIS for Archaeologists: A Predictive Modeling Kit*, edited by Konnie L. Wescott and Joe R. Brandon, 5–32. Philadelphia, PA: Taylor and Francis.

West, Robert M. 1978. "Late Pleistocene (Wisconsinan) Caribou from Southeastern Wisconsin." *Transactions of the Wisconsin Academy of Science, Arts and Letters* 66: 50–53.

White, R. G., B. R. Thomson, T. Skogland, S. J. Person, D. E. Russell, D. F. Holleman, and J. R. Luick. 1975. "Ecology of Caribou at Prudhoe Bay, Alaska." In *Ecological Investigations of the Tundra Biome in the Prudhoe Bay Region*, edited by J. Brown, 150–210. Fairbanks, AK: University of Alaska, Fairbanks.

White, Robert G., and Jeanette Trudell. 1980. "Habitat Preference and Forage Consumption by Reindeer and Caribou near Atkasook, Alaska." *Arctic and Alpine Research* 12 (4): 511–529.