8-2024

Paths of Least Resistance: A Geospatial Analysis of the Integration of Mississippian Communities in the Northwest Arkansas Ozarks

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PATHS OF LEAST RESISTANCE:

A GEOSPATIAL ANALYSIS OF THE INTEGRATION OF MISSISSIPPIAN COMMUNITIES IN THE NORTHWEST ARKANSAS OZARKS

by

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AN HONORS THESIS

Submitted in partial fulfillment of the requirements for the degree of Bachelor of Arts in Anthropology.

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Fayetteville, Arkansas

April 15, 2024

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Chapter 1. Introduction and Background

The Ozark Mountains have been home to Native Americans for thousands of years, and understanding both the political and community organization of its inhabitants has been a longstanding research area explored by archeologists (Sabo et al. 1990). During the Mississippi period (ca. AD 1050-1500), native groups in the Ozarks built mound-and-plaza centers and occupied bluff shelters, or sandstone over-hangs wind-carved into bluff lines. A few small single or few household hamlets are also recorded in this region (Kowalski 2023; Sabo et al. 1990). While the variety of site types is documented, community structure or understanding how these sites may have articulated in a larger settlement system remains unknown. This research asks, can we infer some aspects of community organization through a geospatial analysis? In this thesis, I conduct a least cost analysis to identify clusters or patterns in site locations that might suggest interacting communities. I use site location data and site types and calculate distance between sites to make inferences about community organization in the Ozarks during the Mississippi period.

Physiography and Historical Background

The Ozark Mountains can be divided into three subregions that stretch from Eastern Oklahoma, through Northwest Arkansas, Southern Missouri, and include the southeast corner of Kansas: the Boston Mountains, Springfield Plateau, and Salem Plateau. Its topography can be generally characterized as rolling in most of the Springfield and Salem Plateaus, and rugged in the Boston Mountains and along the border between the two plateaus (Adamski et al. 1995). Karst features are abundant in the region and include bluffs, caves, sinkholes, and narrow river valleys (Adamski et al. 1995). Caves and overhanging bluffs were widely utilized and occupied by Native Americans throughout history. Commonly referred to as bluff shelters, these caves and overhanging bluffs are of utmost significance to archaeologists, as they are known to preserve perishable materials remarkably well, lending insight as to their uses, the lives of their inhabitants, and contemporary cultural practices (Rees and Brandon 2017). The river valleys are relatively narrow and are home to three mound-and-plaza centers and two known hamlets or small non-mound Mississippi period sites.

Prior to and during the Mississippi period, Native American societies in the Eastern Woodlands of North America saw a shift from horticulture to intensive agriculture and increasingly complex political organization (Anderson and Sassaman 2012; Sabo et al. 1990). However, the inhabitants of the Ozark Mountains, often referred to as "bluff-dwellers" were long thought to have lagged in this development, and archaeologists like Willey and Phillips (1958) asserted that people in the region lacked the advanced technology and complex social organization of neighboring regions (Rees and Brandon 2017). While populations in the Ozarks likely remained more mobile than those of neighboring regions, occupying bluff shelters well into the Mississippi period—as shown through the presence of diagnostic shell-tempered pottery—it is now theorized that during the Woodland Period (ca. 500 BC-AD 1050), these populations settled the river valleys, establishing more permanent residences. They continued to use shelters for temporary occupations, such as camps for hunting, storage sites, and nut collecting and processing (Rees and Brandon 2017; Trubowitz 1983). During the Mississippi period, Native Americans in the Ozarks also used bluff shelters for ceremonial and ritualistic purposes as their long history of use might have connected them to their ancestors (Rees and Brandon 2017).

Conversely, mound construction was a new phenomenon in the region after AD 1050 (Kowalski 2023) and sites consisted of large earthen works, often built for ceremonial and religious purposes. The prevailing thought is that other than a small caretaking population, mound centers in the Ozarks were not permanently occupied; rather, they were the settings for ritual activities like feasts and ceremonies attended by local groups and communities (Regnier et al. 2019; Sabo et al. 1990). Mounds within sites appear to have served a variety of functions. Mounds may have been the location of mortuary rituals or served as the platforms for religious structures or chiefs' residences. In the Ozarks of Northwest Arkansas, mound summit architecture is characterized by Harlan-style charnel houses, structures distinct from residences that were deliberately built then burnt, symbolizing imagery of death and the movement of souls to the afterlife (Kay and Sabo 2006).

Even though the Ozarks are surrounded by hubs of Mississippian culture and numerous mound sites that served as densely packed villages or civic-ceremonial centers, there is a distinctive lack of these kinds of archaeological sites within Northwest Arkansas. Other Mississippian landscapes boast networks of integrated mound sites and polities with sites structured in political hierarchies (Kowalski 2019; Livingood 2012). In the Ozarks of Northwest Arkansas, three mound centers are recorded: Collins (3WA0001), Huntsville (3MA0022), and Goforth-Saindon (3BE0245) (Figure 1). These mound centers are similar in size and layout, each with 4-5 mounds surrounding a plaza area. The similarity in size between these centers suggest that none rose to a position of power over the other mound sites in the region (Kowalski 2023). These mound centers were likely built at the same time after AD 1000 and served as ceremonial centers, evidenced by the presence of Harlan-style charnel houses on mound summits, at least at Goforth-Saindon and Collins (Carmelita 2016; Kay and Sabo 2006; Sullivan and McKinnon 2013). These sites probably did not support residential populations, indicated by very low artifact recovery in the off-mound areas, drawing labor for their construction from the hinterlands, most likely groups that utilized nearby bluff shelters.

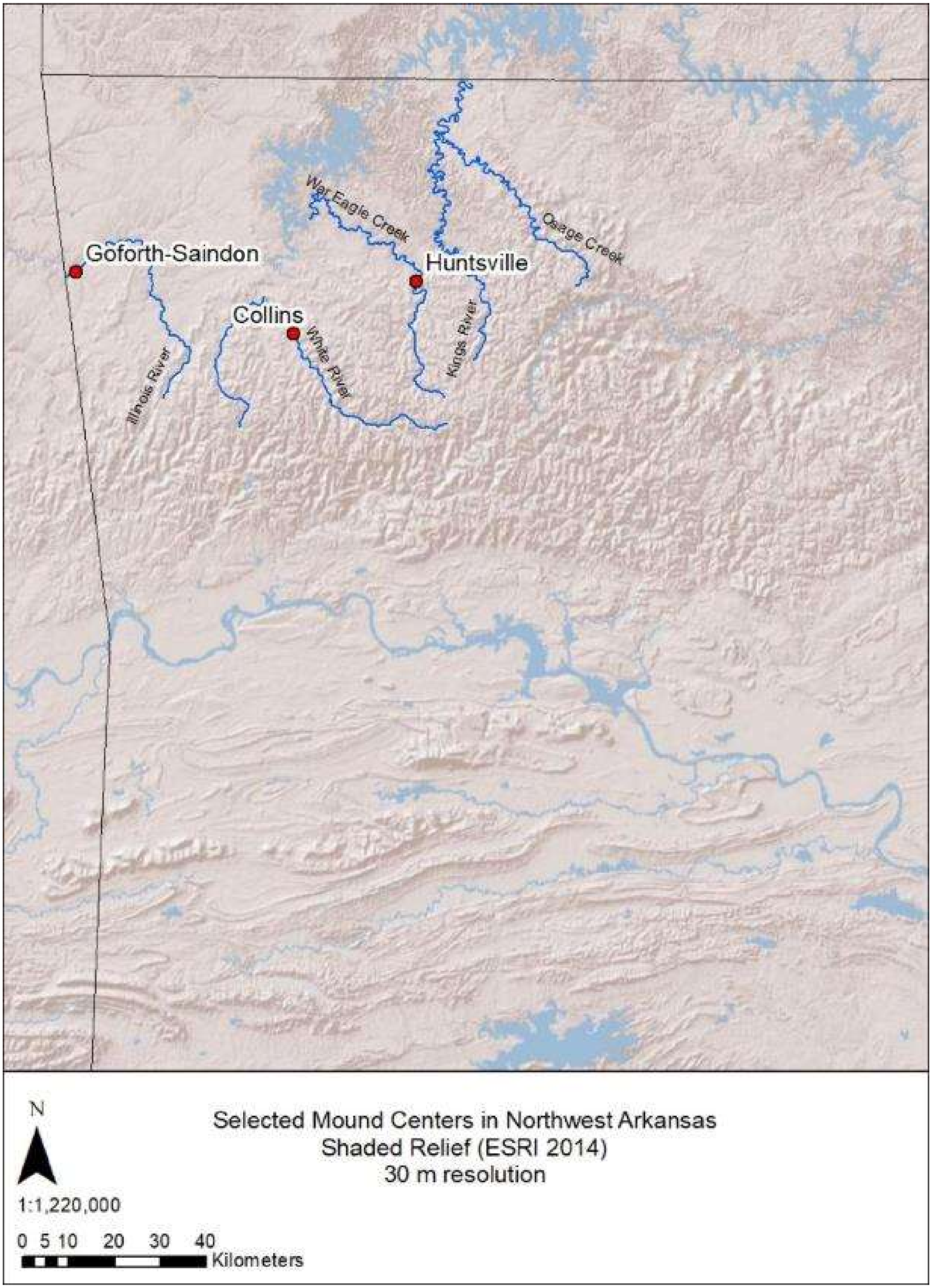

Figure 1. Mound centers in Northwest Arkansas.

This research seeks to analyze the spatial patterning or association of bluff shelters and mound centers in the Ozarks of northwest Arkansas during the Mississippi period to examine the structure of the surrounding communities. First, are the mound centers located far enough apart on foot that we can reasonably expect they are integrating different communities—something suggested by the similarities in site size? Are bluff shelters distributed similarly in the vicinity of each mound site? Does locational patterns of bluff shelters differ between mound sites? Do these patterns support the idea that these mound centers functioned independently from each other, or are these three communities integrated?

To answer these questions, a geographic information system (GIS) was utilized to implement geospatial processes, primarily least-cost analysis. A GIS is a computer-based tool that allows a user to collect, store, analyze, and visualize geographic data by combining both spatial and non-spatial data (ESRI 2023). Least-cost analysis is one of many spatial analysis techniques that can be performed using a GIS. In archaeology, it is used to identify the most efficient routes people might have used to move across a landscape based on the assumption that human behavior is rational (White 2015). Paths are created across a cost surface, a raster in which each cell or pixel is assigned a value that represents the energy expenditure—or cost— needed to cross the area of land corresponding to that cell. In this study, cost surfaces consider elevation and water resources. Paths generated by the GIS are calculated by finding the route with the least cumulative cost across a cost surface from one point to another, meaning the path will start at the location of a bluff shelter and end at its corresponding mound site by moving across the cost surface through adjacent cells that cause the least amount of energy expenditure to travel through. In landscapes with significant relief, like the Ozarks, least-cost distances are more important than straight-line distances, as they more accurately reflect the distances people travel over the landscape.

Patrick Livingood (2012) used least-cost analysis to convert straight-line distance to cost distance to examine political hierarchy in Mississippian mound sites in Southern Appalachia. Livingood's (2012) study site contained networks of mound sites of varying size—likely reflecting political power—and calculated cost distance based on environmental features, travel time, and travel effort. He found that travel time between centers served as a good proxy for community integration. He found mounds from within the same polity are located less than 26 km (16.16 miles), or 5.6 hours on foot away from each other, factoring in the landscape (elevation changes). Political administrative mound centers or political capitals were located further apart, about 33 km (20.51 miles) or 7.5 hours apart from each other (Livingood 2012). Most of this travel was on foot, rather than by canoe along water routes, as canoe travel was a minor form of transportation in the Southern Appalachians.

Livingood (2012) presented a compelling argument using these spatial data that community or polity boundaries could be delineated by considering factors such as travel time and distance between centers. This study was based on the basic assumption that in non-state or emergent complex societies, communities are best defined by those who you interact with regularly. Furthermore, buffer zones between polities or interacting sites supported the argument that spatial clustering of sites (sites located within 5.6 hours of travel time of each other) formed discreet communities.

As discussed above, the three mound centers in Northwest Arkansas do not form a clear size hierarchy, and it appears that no mound center rose to prominence if size and number of mounds is the defining factor. If the three mound sites in Northwest Arkansas function independently, it is expected that the mound centers were located far enough from each other to suggest they were integrated dispersed and independent communities. Clustering of bluff shelters around mound centers, if apparent, would suggest that each center has a “catchment” or an area where residents responsible for the construction or use of the mound center periodically used bluff shelters. This research seeks to understand how intensively each catchment around the mound centers was used, if there are differences between mound center catchment areas, and if those differences can be quantified using a least-cost analysis.

Chapter 2. Geospatial Methods

Bluff shelters that produced shell-tempered pottery (those shelters with Mississippian components) were plotted in a GIS using location data drawn from the Arkansas Archeological Survey's (ARAS) Automated Management of Site Location Data in Arkansas (AMASDA) database. Sites located near the Collins, Goforth-Saindon, and Huntsville mound sites were examined. Through ESRI's ArcGIS Pro, Euclidean, or straight-line distance, was used to create buffers with approximately 24-kilometer (15-mile) radii around each of the mound sites before least-cost analysis was implemented to identify the most efficient routes people might have used to traverse the landscape between each bluff shelter to each mound site. For the rest of this paper, I will refer to these as buffers or catchments as having 15-mile radii. I estimated this distance being around the maximum distance a human could travel in a landscape with significant relief within a day. Because path distances generated from least-cost methods would be greater from each bluff shelter to their associated mound site than straight-line distances, these 15-mile buffers reasonably represent the maximum extent of bluff shelters within a day's travel of a mound site. The 15-mile buffer was chosen to narrow the universe and facilitate comparisons between each mound catchment area. I will discuss bluff shelter locations (or lack thereof) in Chapter 3.

Least Cost Analysis Workflow

For the least-cost analysis, four cost surfaces were created, considering environmental factors such as slope and water routes: the first considered only slope; the second considered slope, but used bodies of water as barriers; the third factored in slope as well as all water routes, intermittent and perennial; and the fourth looked at slope and perennial water sources only.

Data for the study area, mound sites, bluff shelters, slope, and water sources was acquired from multiple sources, including AMASDA and United States Geologic Survey (USGS) data download service. As mentioned above, the northing and easting values in the Universal Transverse Mercator North American Datum 1983 (UTM NAD83) projected coordinate system for the three mound sites and all bluff shelters with evidence of occupation from the Mississippian period—primarily the presence of shell-tempered pottery—within Benton, Carroll, Washington, Madison, and Newton County, were sourced from the AMASDA database. A total of 83 of these bluff shelters are recorded that have Mississippi period components and this research assumes these bluff shelters reflect occupations contemporary with the mound center construction and periodic use as ceremonial centers.

The boundaries of the study area were created using the outer boundary of the shapefiles of the five previously mentioned counties, sourced from the Arkansas GIS Office (Figure 2). A 10-meter resolution digital elevation model (DEM) was provided courtesy of Dr. Jessica Kowalski for its use in creating a slope raster. This DEM was generated from publicly available airborne LiDAR point clouds, generally with a point density of 2-4 per meter. Shapefiles of water resources were created using the water area, waterbody, and flowline datasets from hydrologic unites 1101, 1107, and 1111 in the National Hydrography Dataset Plus (NHD Plus) database (U.S. Geological Survey 2018a; U.S. Geological Survey 2018b; U.S. Geological Survey 2018c).

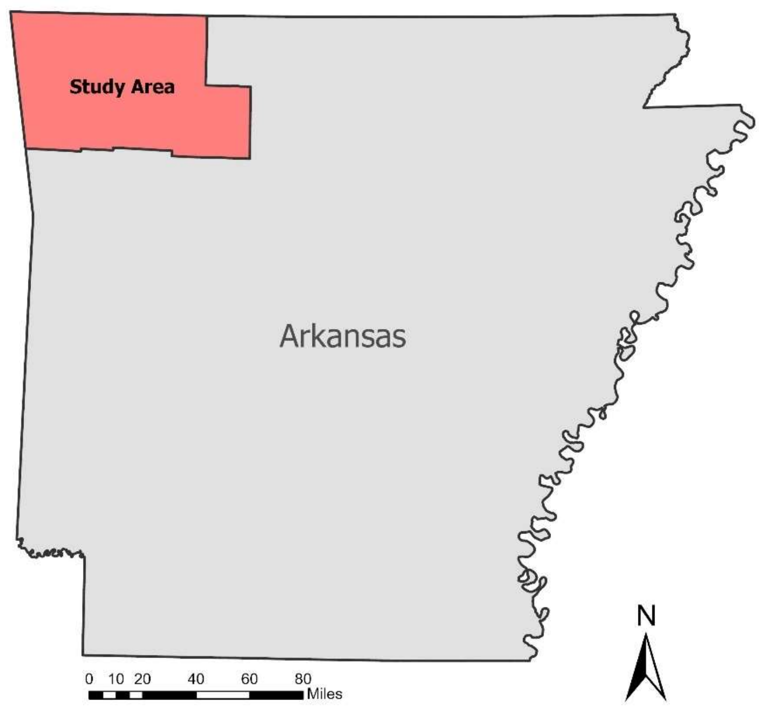

Figure 2. Study area within Arkansas.

Again, to compare mound catchment areas, 15-mile buffers were created around each mound site in ArcGIS Pro. The bluff shelters within each resulting circle were selected for the least-cost analysis. The first cost surface was created using slope as the critical input, approximating the terrain that people may have traversed from each of the selected bluff shelters to their respective mound sites.

A slope raster was generated using ArcGIS Pro's Slope function from its Spatial Analyst toolbox using the 10-meter DEM. The resulting raster was clipped to the boundaries of the study area using the Clip Raster function. The Slope function produced arbitrary classes, so the resulting raster was then reclassified to represent different degrees of difficulty it would take to traverse cells in each slope range. Table 1 shows the new values of the reclassified slope raster. Higher degrees of slope represent steeper terrain and were therefore assigned higher values of energy expenditure.

Table 1. Slope degrees and reclassified values.

Slope (Degrees)	Reclassified Value
0-5	1
5-10	2
10-20	3
20-30	4
30-50	5
50-90	6

ArcGIS Pro's Distance Accumulation tool from the Spatial Analyst toolbox was then used to generate a distance accumulation and backlink raster for each of the three mound sites with the reclassified slope raster input as a cost surface. Each distance accumulation raster represents the accumulative distance to a mound site within the study area while each backlink raster indicates the direction of travel from each cell needed to return to the mound site. These two rasters were then used as inputs in ArcGIS Pro's Optimal Path as Line tool from its Spatial Analyst toolbox to generate least-cost paths from each bluff shelter in the three mound groups to their respective mound centers across the first cost surface. As mentioned above, these paths are created by forcing polylines through adjacent pixels of cells with the least cost; here being the values assigned to the lowest slope degrees—essentially flat land.

A second cost surface was created using the reclassified slope raster with large bodies of water input as barriers. Using the waterbody and water area shapefiles from the NHD Plus dataset, bodies of water smaller than 0.1 square kilometers were selected and deleted from the data layers. Again, using the Distance Accumulation tool, a distance accumulation and backlink raster were generated for each of the three mound sites, however, the selected water body and water area geometries were input under the barrier option of this tool. The Optimal Path as Line tool created least-cost paths across the second cost surface for each of the three mound groups, this time forcing paths to circumnavigate larger bodies of water.

The third cost surface created represented travel over a variety of water routes. This model considered water to be more efficient (rather than barriers) and may reflect canoe travel. Travel over water was common among southeastern Native Americans (Livingood 2012). Instead of solely using the reclassified slope raster as a cost surface, waterbodies, water areas, and flowlines were rasterized and included in the model. Similar to the specification for the water resources that were treated as barriers in the previously constructed cost surface, only waterbodies and water areas larger than 0.1 square kilometers were kept, but those smaller than the threshold that intersected flowline features, ensuring they were continuous and uninterrupted, were kept as well. The flowline features and remaining waterbody and water areas were rasterized individually and merged using ArcGIS Pro's Mosaic to New Raster function. This raster was then clipped to the study area and using the Raster Calculator function, converted to a 1-bit raster showing only where water was present and no additional attributes. The new water raster was reclassified using the Reclassify function so cells with no water present would represent higher energy expenditure, while cells with water present represented lower energy expenditure. The Raster Calculator function was used again to add both the reclassified slope raster and the reclassified water raster together to produce a final cost surface. Inputting this cost surface into the Distance Accumulation tool produced distance accumulation and backlink rasters for each mound center upon which paths could be generated using the Optimal Path as Line tool.

Table 2. Reclassified slope and water values for the third and fourth cost surfaces.

Layer	Weighting	Value	Reclassified Value
Slope	35%	0-5%	1
		5-10%	2
		10-20%	3
		20-30%	4
		30-50%	5
		50-90%	6
Water	65%	Water Present	1
		No Water Present	6

Unlike the previous cost surface, which included both intermittent and perennial flowline data, the fourth and last cost surface only factored in perennial flowline data, representing travel over larger, more well-established waterways. The process of creating paths across this cost raster is identical to the process of creating the previous paths; however, when selecting the flowline data to rasterize before using the Mosaic to New Raster function, only flowline features that were perennial were rasterized. In the fourth model, larger bodies of water were considered to be more efficient means of travel, and cells overlapping water features would be assigned low costs.

For each of the four cost surfaces, the Optimal Line as Path tool was used twice, one centered on the Collins mounds, and one centered on the Goforth-Saindon mounds. Using the tool twice created paths between Goforth-Saindon and Huntsville, Collins and Huntsville, and Goforth-Saindon and Collins twice across each cost surface, allowing for the hypothetical travel distances along each path between mound sites to be identified.

Chapter 3. Results of Least-Cost Analysis

Looking at the results of the paths plotted between mound sites, distances varied over the use of each of the cost surfaces. For the first (slope only) and second cost surfaces (water as barriers), the distances from the Goforth-Saindon site to the Collins site is around 51 kilometers, approximately 32 miles, and to the Huntsville site is around 78 to 79 kilometers, approximately 48 to 49 miles. Between the Collins mound center and Huntsville mounds, the distance is approximately 31 kilometers or 19 miles. Over the third cost surface, considering water to be a more efficient means of travel, the Goforth-Saindon site to the Collins site is around 73 kilometers or 45 miles, and to Huntsville, it is around 100 kilometers or 62 miles. Between the Collins and Huntsville sites, it is around 41 kilometers or 25 miles. Over the fourth cost surface, the distance from the Goforth-Saindon site to the Collins site is around 81 kilometers, approximately 50 miles, and to Huntsville, it is around 114 kilometers or 71 miles. Between the Collins mound center and Huntsville mounds, the distance is approximately 38 kilometers, which is around 24 miles.

Using the paths generated on all four cost surfaces, travel between mound centers was unlikely to be completed within a day, and when water routes were considered to be a more efficient means of travel, distances between mound sites increased greatly. Water bodies, while acting as barriers, do not drastically alter travel distances compared to when slope was used alone. The second model actually decreases the distances between mound sites, revealing paths that avoid large bodies of water to be slightly more efficient. Contrastingly, when considering perennial and intermittent water sources (cost surface 3) as efficient, distances between mounds on average increased 33.7% from the path distances produced using the first cost surface and considering only perennial water sources (cost surface 4) as efficient increased the distance between mound sites 41.2% on average (Table 3). If water routes were used to travel between mound sites, the increased distance of the paths when considering both intermittent and perennial water resources as efficient to only perennial water sources emphasize the role of water availability. Although the paths that include intermittent water resources between mound centers are shorter, perennial water routes were more likely to be utilized, as they are generally present year-round and likely to be more navigable. Travelers might have utilized intermittent water routes when available to shorten their travel distance to perennial streams and rivers.

Table 3. Distances between mound sites and the percentage of change between each of the cost surfaces from Cost Surface 1. All distances in kilometers.

Mound Sites	Cost Surface 1 Distance (slope only)	Cost Surface 2 Distance (water as barrier)	Cost Surface 3 Distance (water as efficient)	Cost Surface 4 Distance (large bodies of water as efficient)
Goforth-Saindon and Huntsville	78.582	78.442	99.868	114.338
	Percent change:	-0.2%	+27.1%	+45.5%
Goforth-Saindon and Collins	51.362	50.878	73.104	80.551
	Percent change:	-0.1%	+42.3%	+56.8%
Collins and Huntsville	31.452	31.401	41.408	38.166
	Percent change:	-0.2%	+31.7%	+21.3%

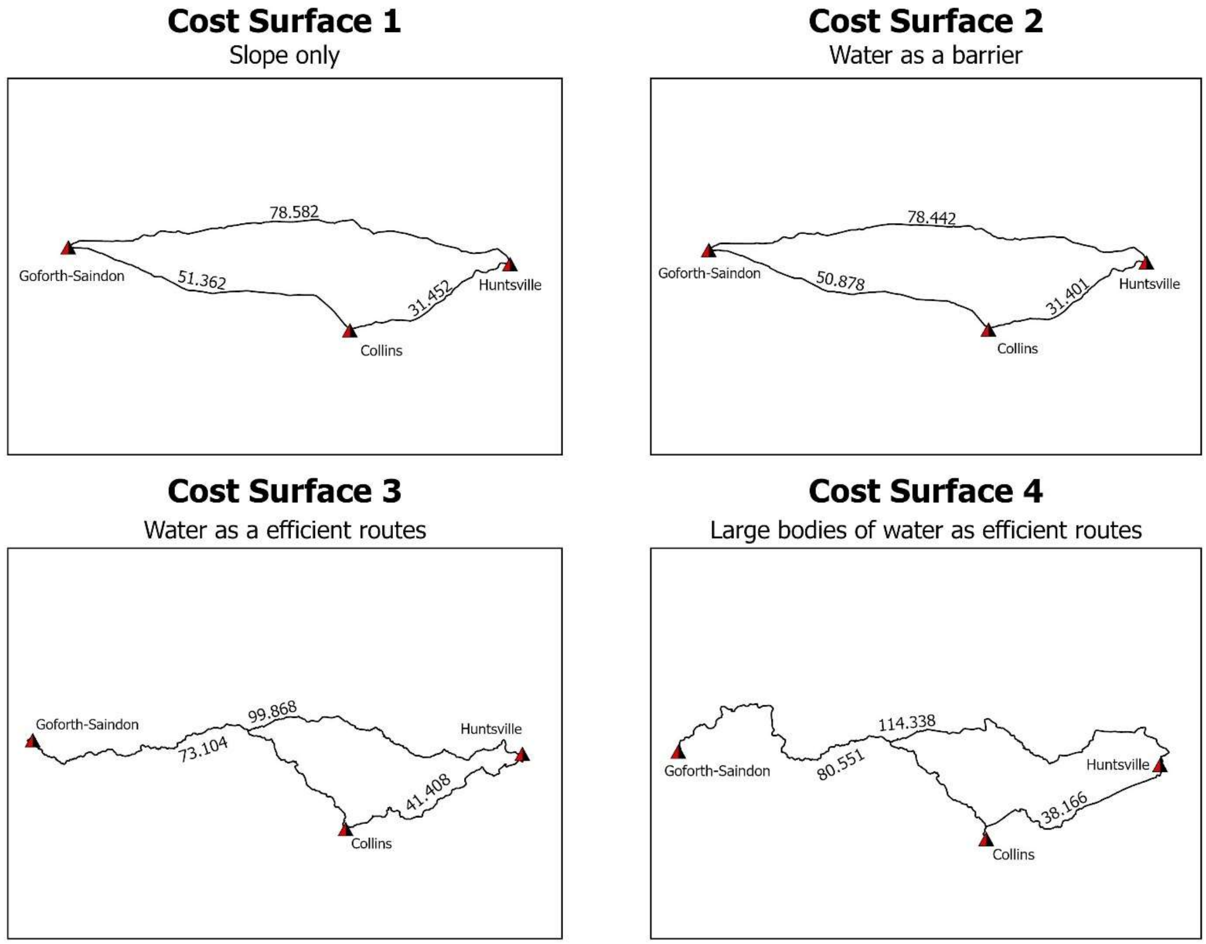

Figure 3. Cost distances between mound centers across the four cost surfaces. All distances in kilometers.

After plotting the mound sites and Mississippian bluff shelters within 15 miles of each center, differences in the number of bluff shelters located in that buffer and the distances between bluff shelters and their respective mound center were recorded (Table 4). The Goforth-Saindon and Huntsville mound sites both have 18 known bluff shelters within a 15-mile Euclidean distance buffer or catchment, while the Collins mound is associated with 13 shelters. It is important to note that due to the datasets available for this research, bluff shelters within the 15-mile radius of the Goforth-Saindon site located outside the Arkansas border in Oklahoma were not able to be included in the study. This may result in an underrepresentation of bluff shelters associated with the site—

which is intriguing because with half of the catchment removed the site was associated with just as high number of shelters as the Huntsville mounds. The community surrounding the Goforth-Saindon mounds may have been intensively utilizing bluff shelters in a way not apparent for Huntsville and Collins. Goforth-Saindon's location and underlying geology may be the reason why. While Huntsville and Collins are situated in the Boston Mountains, Goforth-Saindon is located on the Springfield plateau, a region within the Ozark Mountains attributed with lower topographic relief and rolling hills (Figure 4).

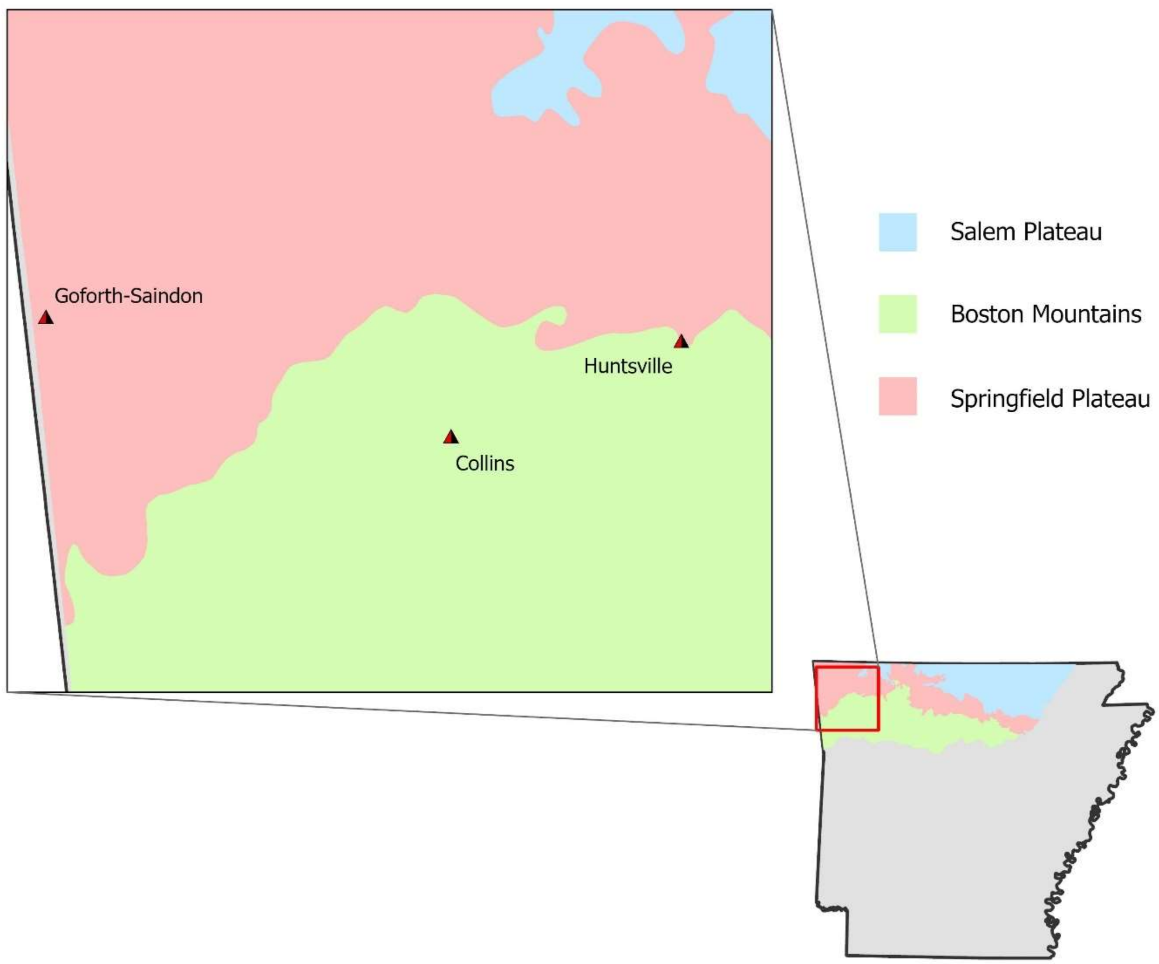

Figure 4. Mound site locations within the Ozark Mountain subregions.

Table 4. Distance between bluff shelters and mound centers according to four different cost surface models. All distance in kilometers.

Mound Site	Bluff Shelter	Cost Surface 1 Distances	Cost Surface 2 Distances	Cost Surface 3 Distances	Cost Surface 4 Distances
Goforth-Saindon	3BE0052	11.663	11.618	16.590	16.609
	3BE00243	3.182	3.178	3.842	3.446
	3BE0275	10.776	10.777	15.453	15.465
	3BE0651	12.602	12.604	17.544	17.552
	3BE0879	24.496	24.489	32.326	32.265
	3BE0962	21.871	21.854	28.332	30.424
	3WA0005	17.285	17.233	26.245	29.305
	3WA0016	13.470	13.482	19.668	18.576
	3WA0020	15.831	—	22.368	21.132
	3WA0062	18.520	18.465	29.885	30.148
	3WA0065	16.089	16.167	22.560	20.898
	3WA0067	15.738	—	22.676	20.804
	3WA0074	15.758	15.725	22.606	20.861
	3WA0075	15.783	15.736	22.544	20.922
	3WA0252	11.002	10.980	17.044	17.034
	3WA0335	23.235	23.218	34.083	35.251
	3WA0888	16.390	16.394	22.900	21.567
	3WA1334	23.484	23.472	32.997	32.086
Huntsville	3MA0002	13.153	13.241	16.042	15.633
	3MA0007	14.870	14.960	23.201	19.307
	3MA0020	11.467	11.416	17.048	16.737
	3MA0032	16.412	16.489	26.267	20.752
	3MA0034	16.809	16.802	20.134	20.896
	3MA0036	18.911	18.759	25.015	20.796
	3MA0109	22.656	23.145	28.655	39.866
	3MA0114	1.283	1.276	1.663	1.646
	3MA0120	0.424	0.420	0.509	0.493
	3MA0128	5.843	5.827	9.339	9.880
	3MA0132	4.455	4.460	7.937	8.063
	3MA0133	7.319	7.314	11.955	11.534
	3MA0138	9.948	9.773	15.005	13.178
	3MA0139	5.148	5.128	8.089	8.073
	3MA0166	19.784	19.784	25.287	29.455
	3MA0298	13.534	13.617	16.310	16.855
	3MA0335	28.555	28.572	40.270	39.753
	3MA0448	22.480	22.468	31.344	34.830
Collins	3MA0003	12.308	12.295	15.610	15.599
	3MA0020	26.177	26.016	31.755	29.526
	3MA0042	9.622	9.618	12.375	12.417
	3MA0043	9.484	9.474	12.340	12.387
	3MA0489	18.305	18.313	23.106	23.859
	3WA0004	25.869	38.094	35.458	47.893
	3WA0010	25.841	25.812	33.199	48.020
	3WA0197	20.643	20.965	29.010	40.660
	3WA0258	3.003	3.017	4.704	3.121
	3WA0319	16.507	16.220	23.381	31.287
	3WA0871	8.826	8.847	13.066	19.166
	3WA0876	18.249	18.260	23.505	27.809
	3WA01278	18.508	18.545	24.278	31.488

Table 5. Average and range values for the cost distances of bluff shelters to mound sites. All distances in kilometers.

Mound Site		Cost Surface 1 Distances	Cost Surface 2 Distances	Cost Surface 3 Distances	Cost Surface 4 Distances
Goforth-Saindon	Average	15.954	15.962	22.759	22.464
	Range	21.314	21.311	30.241	31.805
Huntsville	Average	12.947	12.970	18.004	18.208
	Range	28.131	28.152	39.761	39.372
Collins	Average	10.197	10.777	13.469	16.406
	Range	23.173	35.077	30.754	44.899

The average length and range of distances for each set of paths generated for the four cost surfaces are shown in Table 5. As observed when comparing cost distance between mound sites, there is an insignificant difference between the average distances using the first and second cost surfaces. The same can be said for range values, with one exception: the Collins mound site and its associated bluff shelters. The range value for path distances when large bodies of water are considered barriers (the second cost surface) is over one and a half times that of when only slope was considered in the cost surface. This is due to a bluff shelter within Collins' 15-mile buffer, catalogued 3WA0004, that was forced to generate a path around a section of War Eagle Creek that acted as a barrier, increasing its length by 12.225 km or 7.596 miles. This suggests that only the largest bodies of water between a bluff shelter and mound site may have inhibited travel.

It is important to note that two of the bluff shelters within the Goforth-Saindon buffer zone, 3WA0020 and 3WA0067, could not have paths plotted from them, as the coordinates provided for each from the AMASDA database place them within bodies of water large enough to be considered barriers, thus, the GIS considered travel from these bluff shelters impossible. This may have skewed the resulting average distance for bluff shelters associated with the Goforth-Saindon site; however, the effects of the skewing are likely miniscule.

The average and range values for path lengths on cost surfaces that considered water travel as efficient increased significantly in comparison to those on the first cost surface, factoring in slope only. The meandering nature of these water routes lengthens them, increasing the averages, and affecting the range even more. Bluff shelters such as 3MA0120, located practically next to the Huntsville mound site that do not require the use of water travel to reach it, are affected relatively little, if at all, by the meandering courses of water routes compared to those further away, creating high variability in the length of paths and subsequently, higher range values. Lower range values, meaning lower variability in distance between mound centers and their associated bluff shelters, may imply higher degrees of integration, where populations have more uniform access to resources and social networks. This likely makes the first two cost surfaces, in which water is not considered an efficient means of travel, a more accurate representation of travel between mounds and bluff shelters.

Even though paths are longer and have higher variability when water travel is considered efficient, canoe travel can at times be more efficient than traveling on foot, even at these distances. Ozark waterways are rain fed however, and as stated before, likely not navigable year-round. Water was probably not used as a major means of travel most of the year.

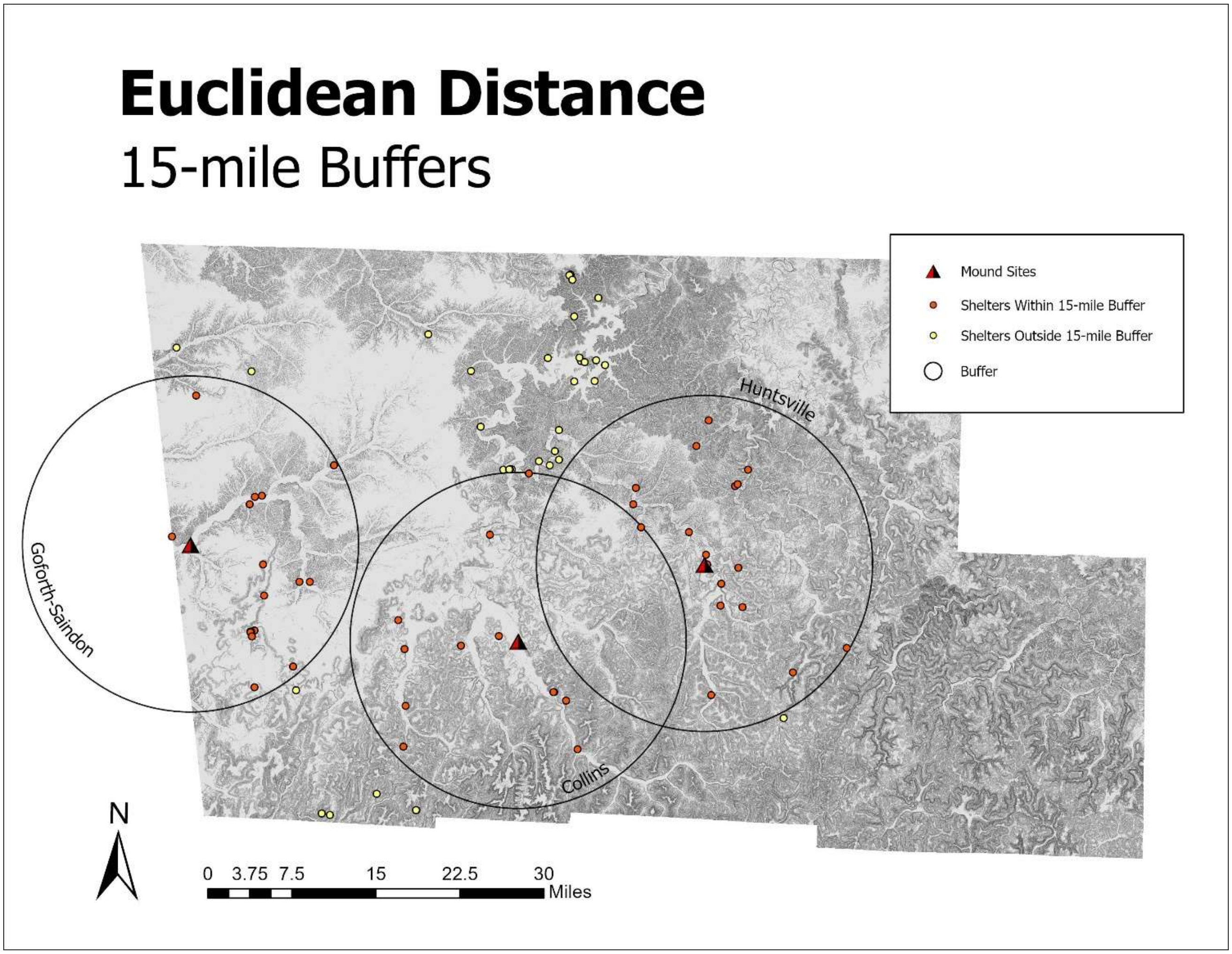

Figure 5. Buffers of 15 miles surrounding mound sites.

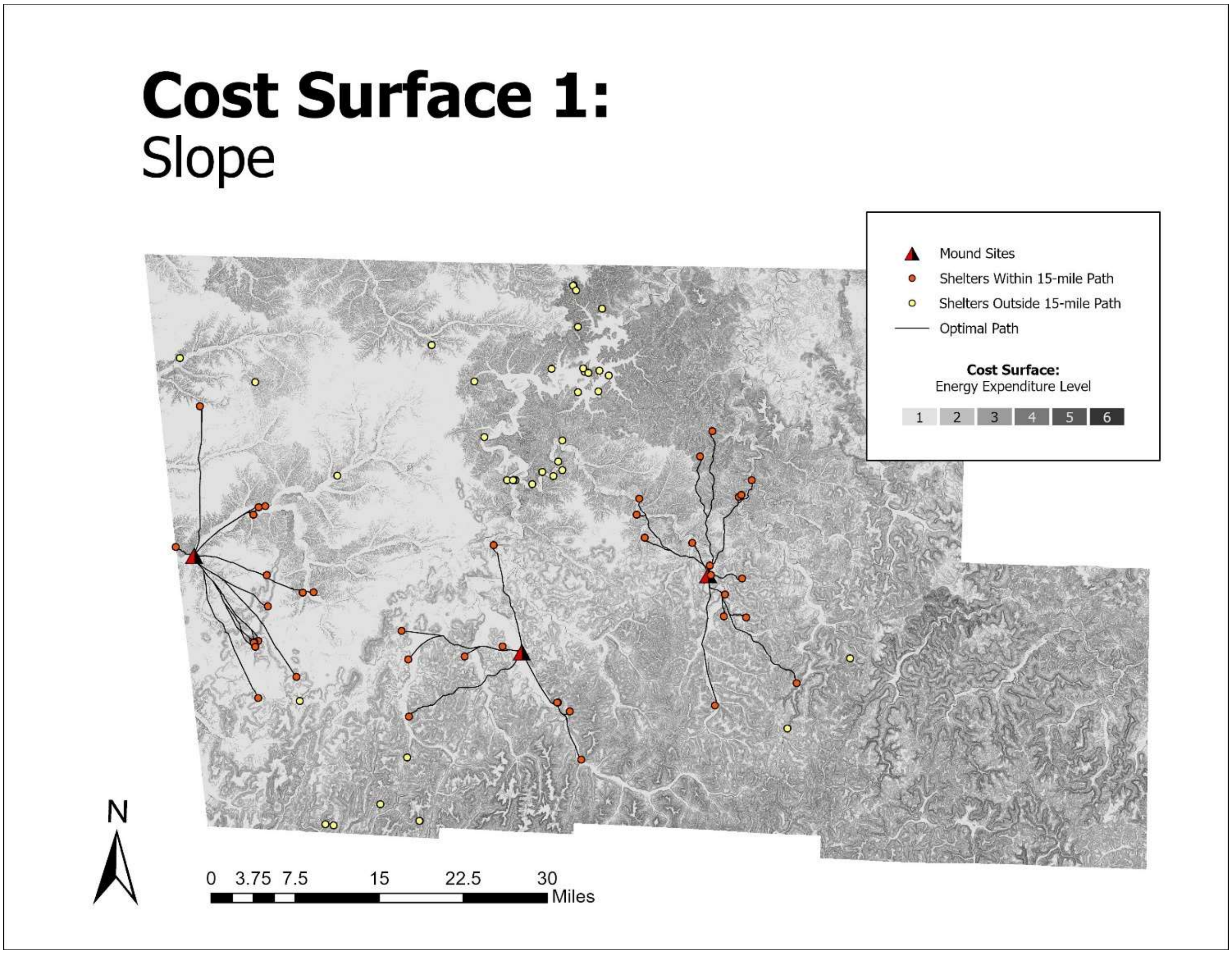

Figure 6. Cost distance model 1.

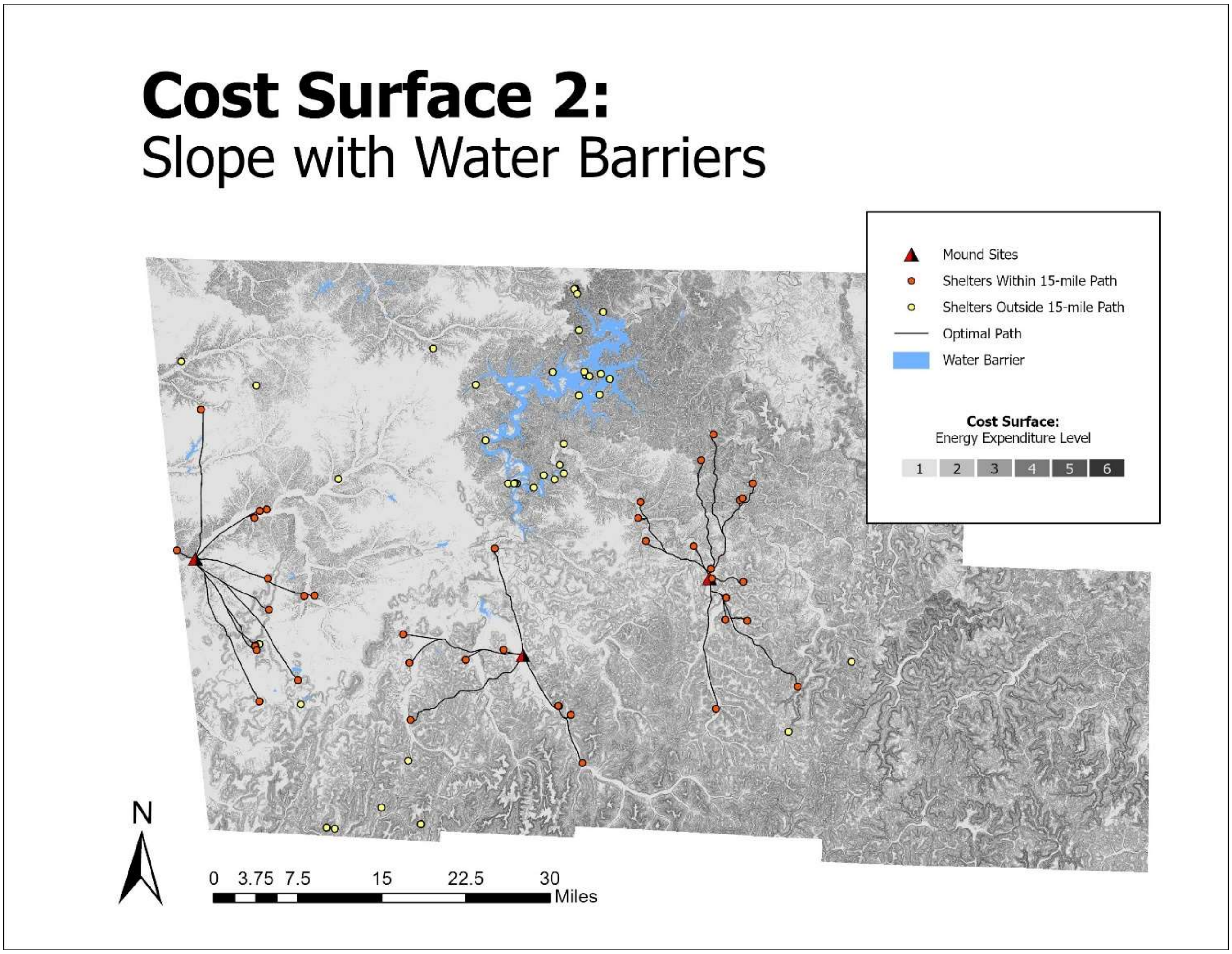

Figure 7. Cost distance model 2.

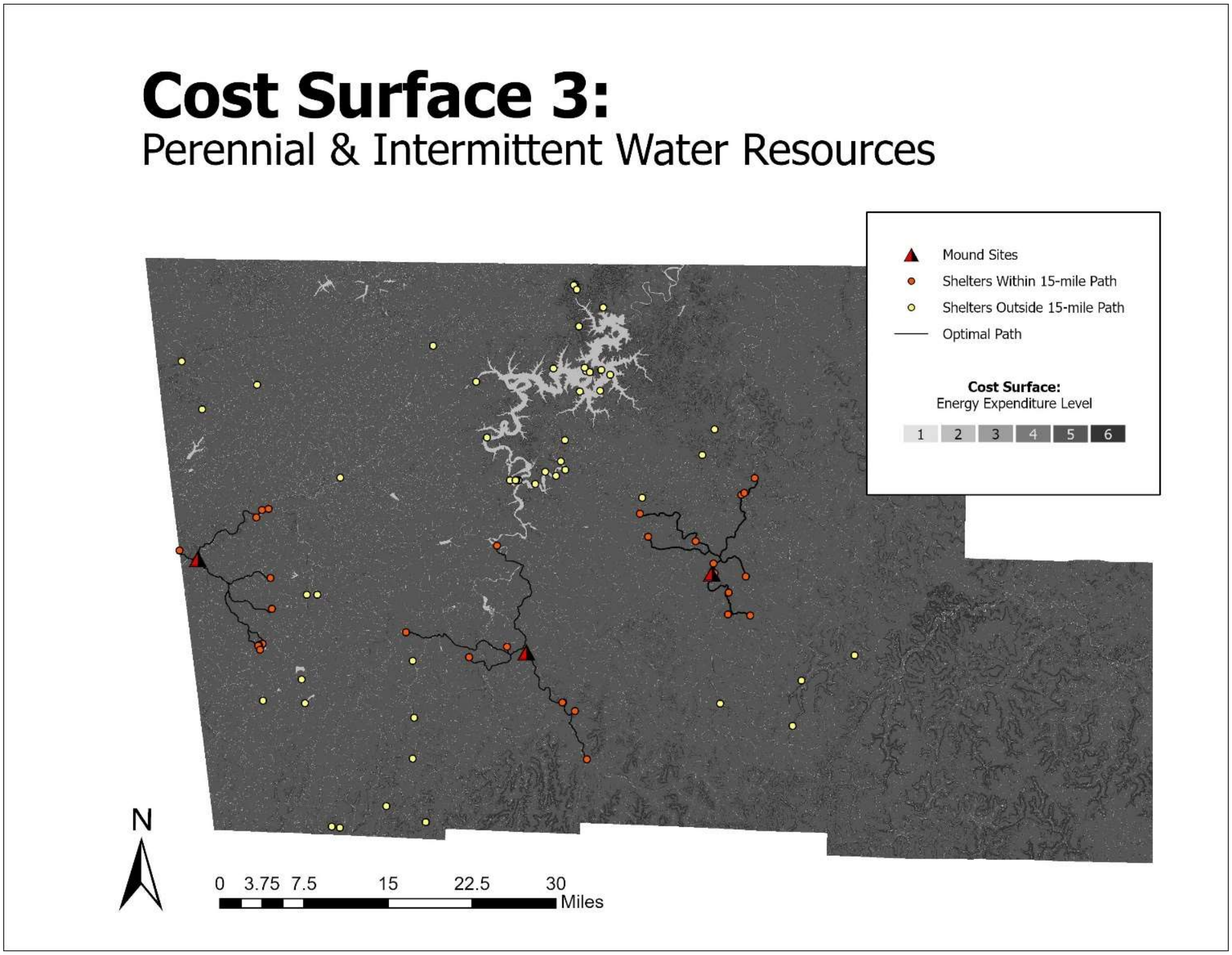

Figure 8. Cost distance model 3.

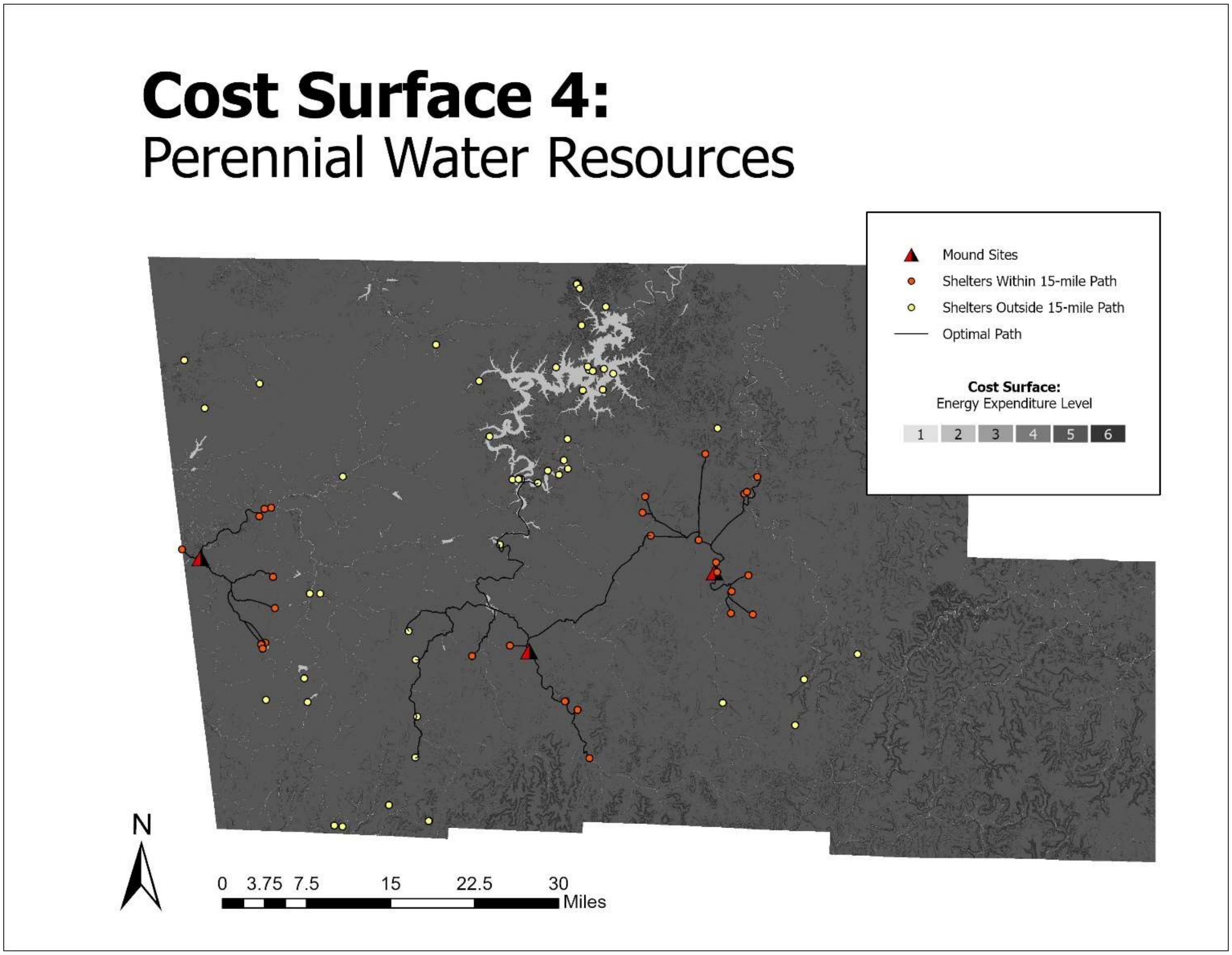

Figure 9. Cost distance model 4.

Figures 6-9 show the differences between the spatial structures of each community when analyzing them using Euclidean distance versus cost distance. It can be observed that when least-cost paths across all four cost surfaces are calculated, the numbers of bluff shelters within a day's travel significantly decreases. Examining the cost paths according to slope (cost distance model 1), Goforth-Saindon and Huntsville mound center incorporate communities of 17 bluff shelters, both communities losing 1 bluff shelter from the original count, and the Collins mounds incorporates a community of 10 bluff shelters, a loss of 3 bluff shelters. Bodies of water being treated as barriers (cost distance model 2) only affects Goforth-Saindon, which loses an additional 2 associated bluff shelters due to their coordinates placing them within bodies of water, rendering them impossible to access. When intermittent and perennial water routes are considered as efficient (cost distance model 3), the number of bluff shelters within a day's travel of the Goforth-Saindon community reduces to 10, 8 less than the Euclidean distance count, the Collins community reduces to 8, 5 less, and the Huntsville community reduces to 12, which is 6 less than the Euclidean distance count. Finally, when only perennial water routes were considered as efficient (cost distance model 4), the number of bluff shelters within 15 travel miles from the Goforth-Saindon count reduces to 11, the Collins site the count reduces to 6, and the Huntsville count increases to 14—7, 7, and 4 less than the Euclidean distance count, respectively.

Table 6. Number of bluff shelters within 15 miles cost distance.

Mound Site	Cost surface 1	Cost surface 2	Cost surface 3	Cost surface 4
Goforth-Saindon	17	15	12	11
Huntsville	17	17	12	14
Collins	10	10	8	6

Chapter 4. Mississippian Community Structure in the Ozarks

The results of this GIS model support the idea that these mound centers functioned independently from each other, or at least served separate communities because they are distant or more than a days' travel. In an emergent complex society, face-to-face interaction is critical to community organization. More than a day's travel, as explored by Livingood (2012) delineates communities well in the Mississippian world. Resulting differences in the number of bluff shelters within a day's travel of each mound site, the average distance and range of distances between bluff shelters and their associated mound sites also highlight the idea of independently functioning mounds.

More critically, these data reflect differences between each of the three mound centers and surrounding communities of bluff shelters. For example, the number of bluff shelters in the vicinity of each mound center and the average travel distance from bluff shelters to their respective mound centers, might be indicative of meaningful inter-community differences. Although with the data available it is unsure how many bluff shelters are located across the Oklahoma state line from Goforth-Saindon—I estimate multiple to be present. If so, this attributes Goforth-Saindon as the mound center with the most bluff shelters within its 15-mile catchment and probably within 15 miles cost distance, implying that bluff shelters were most likely used more intensively around this mound site compared to the other two. Reasons for one mound integrating more bluff shelters than another are not entirely known, but could include local population differences, environmental factors, vicinity to larger cultural or political centers, or a combination of those. The differences in the average distance bluff shelters are from their associated mound center is relatively small, at least across the first two cost surfaces. Closer bluff shelters on average might be indicative of higher degrees of cultural activity and shared practices around a mound site. Although the reasoning behind these differences is not certain and not exactly quantifiable, they do nonetheless imply that these communities of bluff shelters and mound centers have differences to be further examined.

The distances between the mound centers are the most important in establishing these groups as separate communities. With 15 miles being an estimate for the distance a person could reasonably travel in a day in the Ozarks on foot, all three mound sites are more than a day's travel from each other. In this period or history, it would have been difficult to draw labor for the construction of each mound from or exert influence any further than a day's journey. Additionally, Patrick Livingood (2012) found that mounds in the same polity were generally less than 26 kilometers from each other, and competing administrative centers were generally more than 33 kilometers apart via least-cost path distance. The rugged physical landscape of the Southern Appalachians and low use of water travel is comparable to the Northwest Arkansas Ozarks, allowing one to assume that these distances between mound centers would be relatively similar. With the closest mound site to Goforth-Saindon within the study area being the Collins mounds approximately 30 to 50 miles, around 48 to 80 kilometers, away depending on which cost surface one used, it is highly likely that Goforth-Saindon was independently functioning and integrating a separate community of bluff shelters from the other two mound sites. The distance between the Collins and Huntsville sites, however, was approximately 19 to 20 miles, approximately 31 to 32 kilometers, across the first two cost surfaces which also suggests that these mound centers may have been more independent, but it is possible residents frequenting these centers may have occasion to interact in the wider Ozark Mississippian community.

If one were to only use the cost surfaces in which water travel was not considered, the distance between the Collins and Huntsville mound sites are only slightly above the distance Livingood (2012) identified for mounds within the same polity. Without additional archaeological evidence, one might suggest these mounds and their communities could be part of the same polity; However, I do not believe so and certainly neither mound site exhibits characteristics that make it seem supreme. Recall that none of these mound centers are larger than the other, suggesting there is no centralized capital.

Evidence to support this claim lies in the location and cost distances associated with bluff shelter catalogued as 3MA0020. When looking at the bluff shelters within 15 Euclidean miles of each mound center, 3MA0020 (Figure 10) stands out as the only bluff shelter overlapping two catchments—the buffer zones around the Collins and Huntsville sites—suggesting there are no buffer zones and that the mound centers and associated bluff shelters may have been integrated into one polity. After examining least-cost paths across all four cost surfaces, one can observe that 3MA0020 is solely associated with the Huntsville mound community. In other words, there are no bluff shelters recorded that fall within the catchment of two or more of these mound centers. Although more work needs to be done, these communities do appear to be separate, or at least bluff shelter utilization and mound center use may have been associated with three individual communities in the Ozarks.

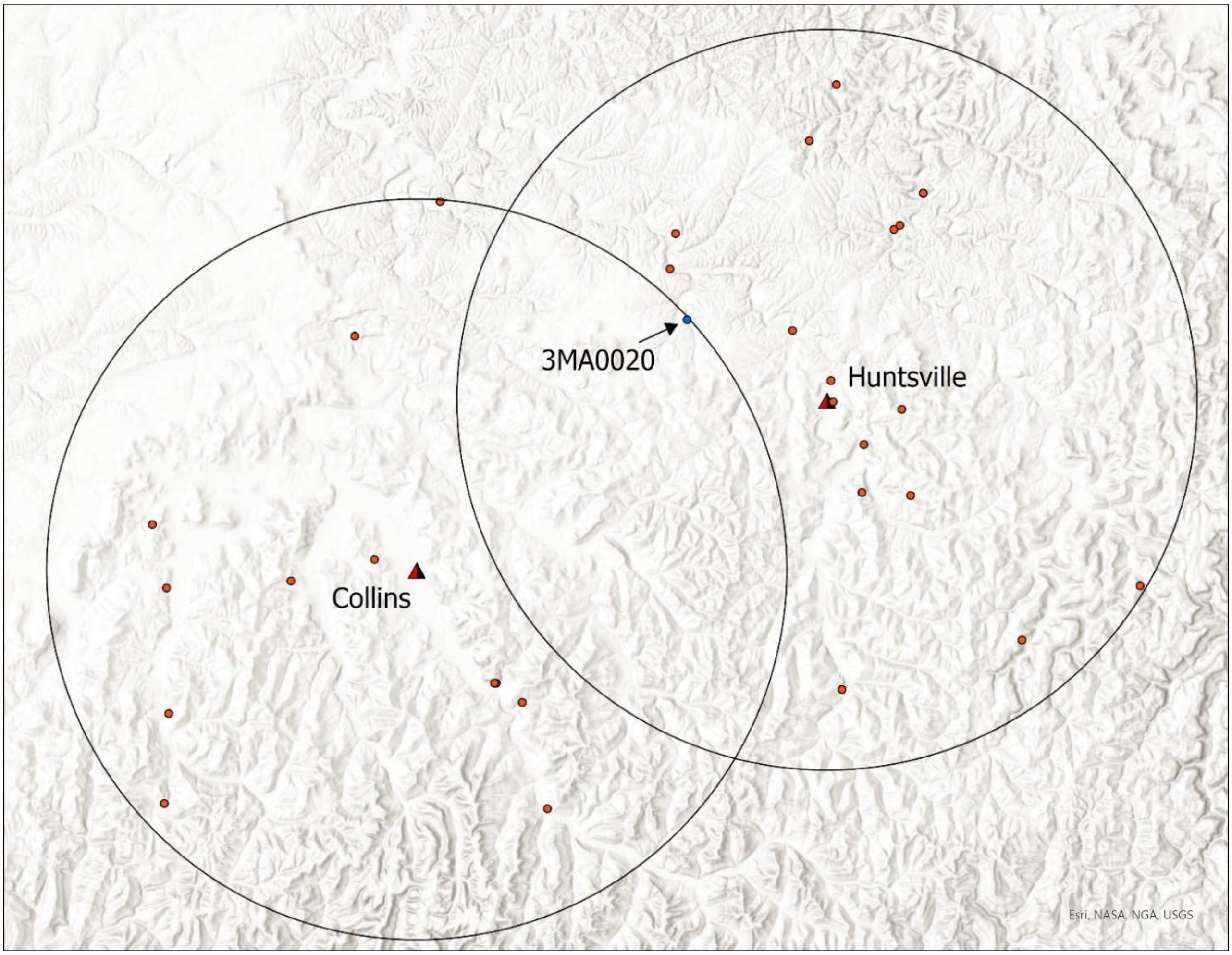

Figure 10. Location of bluff shelter 3MA0020 within the 15-mile buffers of Huntsville and Collins.

Comparing the plotted bluff shelters associated with each mound based on Euclidean distance, or within a 15-mile buffer or catchment area, and those within 15 miles cost distance, buffer zones became apparent. Looking at bluff shelters within a 15-mile travel across the first two cost surfaces, there are no Mississippian-era bluff shelters unincorporated within a mound community between two adjacent mound sites. Unseen in maps created for this study, there are bluff shelters that have evidence of earlier occupation throughout these observed buffer zones, but they likely were not utilized to the extent, if at all, during the Mississippi period. This, coupled with the evidence that all mounds are more than a day's travel between each other, continues to show that these mound centers likely integrated and served separate communities.

Thrice now, has the phrase 'across the first two cost surfaces' been used in this section. This is because the first cost surface, that only factors slope, and the second cost surface, that factors slope but uses larger polygons from the NHD Plus waterbody and water area datasets as barriers, appear similar to each other and more accurate than the two cost surfaces that account for the utilization of water ways in travel. Livingood (2012), who performed a study of polities in Southern Appalachia—a comparable mountainous terrain and karst landscape—claims water travel accounted for an estimated 1.8-2% of paths he generated. Many of the water routes in this area of the Ozarks are not navigable year-round, as mentioned above (Kowalski 2023). Additionally, we cannot be certain as to the nature of waterways and bodies of water during the period in which this research is focused, as the NHD Plus data used reflect recent or current water resources, many of which, over time, have been modified by humans for their use or altered naturally.

With that being said, numerous Mississippian-era bluff shelters populating Beaver lakes and its shores potentially could have had access to these mound sites—particularly the Collins mound center—via larger water routes such as the White River and War Eagle Creek; However, it would be difficult to confirm with the data available in this research. One might think with the heavy concentration and clustering of bluff shelters in the area, there would be a mound site in the locality, but no such site has been located. It is possible that they may be associated with another mound site to the north, but I believe it is more likely they were associated with one that might have been present at one time, now levelled for development or agriculture, submerged when the White River was dammed, forming Beaver Lake, or both. If no mound were present within a day's journey of these clustered bluff shelters around Beaver Lake in the past, it would raise different questions.

Were bluff shelters in this area integrated, whether with each other or through another mound center? Was water utilized more as a means of travel, allowing inhabitants to reach more distant mound sites? How are bluff shelters further from mound sites utilized compared to those that are closer? Ultimately, how were the residents of these bluff shelters culturally, socially, and politically related to other populations in the Ozarks? These are intriguing questions but would require further archaeological research to answer.

Chapter 5. Conclusion

Community organization among Mississippian communities in the Ozarks remains a research question for the region. Although further investigation into the spatial relationships between mound centers and bluff shelters may be needed to further archaeologists' understanding of their use and development by Native American populations in the Ozarks, we can assume that these mound sites were religious and ceremonial centers of different, largely mobile communities. The rugged landscape and lack of year-round navigable water routes make traversing the terrain in Northwest Arkansas a difficult feat. The three major mound sites in the region are too far apart to travel from one to either of the other two in a day; even two days would likely be an arduous journey suggesting that no single mound center was the center of a complex chiefly polity exerting political power over other mound centers. The mound sites probably drew labor for their constructions and populations for ceremonial purposes from their immediate hinterlands, which consisted of somewhat mobile groups utilizing bluff shelters.

This study observed buffer zones between the groups of mound centers and their associated bluff shelters, especially when walking over sloped terrain was considered without the use of water routes. When strictly looking at the length of least-cost paths that could be walked in a day, no bluff shelters were in the range of more than one mound center. Additionally, the lack of bluff shelters between any two mound-bluff shelter groups creates clear buffers.

Fieldwork may be required to provide information reflecting the degree of accuracy of these conclusions. In this research, I made the assumption based on available data that all bluff shelters with evidence of Mississippian occupation and usage were contemporary. With this era spanning nearly five centuries, it would be difficult to identify which bluff shelters were truly contemporary without obtaining radiocarbon dates from each one. I also discuss the possibilities of a fourth mound center potentially submerged in Beaver Lake or destroyed. Locating this site would likely be an extensive project, requiring excavations, the use remote sensing equipment such as ground-penetrating radar and electromagnetic surveys, and bathymetric studies of Beaver Lake.

Without extensive fieldwork, this study of the spatial landscape of the Mississippian Ozarks using GIS and least-cost analysis can still be greatly enhanced with additional research and data. Repeating similar steps used here with a higher focus on energy expenditure or travel time and walking speed, implementing Tobler's hiking function, may increase the accuracy of the results. Additional hydrographical studies including identifying watershed boundaries as a method of delineating communities, and obtaining more detailed water resource data, for example flow rate or historic water resources, to examine travel along larger water routes would also be beneficial in studying the potential for integrated mound sites.

Further examination of the spatial patterning of sites within the Ozarks can deepen archaeologists' understanding of the development of the region. Are locations of such sites a product of cultural similarities and exchange or geographical situations? How does human-environment interaction affect cultural landscape and exchange in the region? How does the spatial distribution of sites reflect the acceptance or rejection of contemporary advancements? Ultimately, interdisciplinary research embracing new archaeological methods and technology can aid in answering these questions and unraveling the complexities of Mississippian-era societies and development.

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