PROBABILITIES OF DESIGNED LOCATIONS OF CEREMONIAL FOCI: the Chaco meridian, Temple IV at Tikal, and a large-scale sacred Adena river landscape

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Abstract

Considering that prehistoric cultures may have had the socio-religious need and technical ability to create accurate geometric patterns across a large landscape, limited ethnographic and archaeologic evidence are reviewed. Simple but accurate land surveying is discussed. Since any set of existing sites at larger scales coincidentally creates accurate three-point alignments and right-angles, the critical research problem attempts to distinguish designed from random geometry. Unpublished patterns involving great kivas in Chaco Canyon and Temple IV at Tikal are tested for probabilities of design. The more expansive third test considers the location of 26 prominent Adena mounds in relation to 32 river confluence points and 4 highest mountains in a geographic area some 900 x 1,200 km, just slightly larger than a Chacoan world. In 14 test boxes modeling the locations of the 26 mounds, 1000 sets of random points replace equal numbers in each box. Each set is searched for numbers of three-point alignments and ninety-degree angles at or under 0.10º accuracy. Chaco and Tikal tests show a strong likelihood of design at these sites; in the Adena, data indicates a high probability that *some number* of existing patterns were intentionally surveyed.

Introduction to a new kind of research

Is the consideration of formalized large-scale landscape patterns in fact anthropology, or just amateurish speculation from making lines in Google Earth? The present work evolves from structuralism evident in ritual space, mostly at architectural scales, described by social anthropologists particularly in the 1960's and 70's. Despite being a licensed architect and a social anthropologist (M.A.), however, the author was undisciplined in the formalities of ritual space. Then, Roy Rappaport suggested Hopi ceremonialism as the semester paper in his seminar on ritual at Michigan. The dissertation topic in the doctoral program in architecture there (Rappaport on the committee) had already been focused on the wealth of vernacular farm architecture in Norway; structuralist background for this work, however, was essential.

The Hopi paper (eventually Doxtater 1978) was written only a few years after one of the most unique accounts of a ritually used natural landscape described by a Pueblo Indian himself, Alfonso Ortiz (1969). As a social anthropologist, Ortiz's goal was not primarily to elucidate an ethnography of larger ritual space—three tiers of sacred sites radiating out from San Juan Pueblo to four of the highest most visible peaks—but to counter Levi-Strauss's argument about the invisible, structuralist, triadic element hidden in primitive dualism. While Ortiz described clearly experienced dualistic ritual practices in physical topography, he is largely mute on how these "systems" evolved, relying more on parallels with Tewa origin myth.

Ortiz's diagram of the geometrically formal cross structure on the landscape, about 70 km across, is however, misleading. The possibility that surveying techniques might have cardinally positioned the twelve natural features is not mentioned. When one maps the four opposed mountains on the periphery, they are neither accurately cardinal nor do they intersect close to the San Juan pueblo at the center. My Hopi paper as well never considered large-scale surveying. Actual fieldwork in this very sensitive cultural landscape was impossible, and mapping was not yet digitally facilitated. More recently, Snead & Preucel (1999) and Fowles (2009) find evidence of similar symbolically structured Pueblo landscape concepts, but again cannot map the extent of actual practice, or any comprehensive location of features.

Shortly after taking a design position at the University of Arizona, the author received a National Endowment for the Arts grant to study the "origins of Anasazi (Ancestral Pueblo) design". This study, mostly an introduction to archaeology through the SW literature, led to initial ideas of large-scale cosmos explored in Doxtater 1991. More ethnographically, Witherspoon & Peterson (1995) illustrate graphically formal cosmological patterns in Navajo design expressed in small scale ritual settings and artifacts, e.g. the Hogan and sand paintings; they rely less on cosmology in Navajo myth than actual spatial patterns in ritual settings and artifacts. Kelly & Francis (2005) briefly discuss Navajo linguistic concepts that differentiate two kinds of "paths" in the landscape, one that follows topography, and the other that is strait as an arrow's trajectory, connecting in their example the confluence of the two Colorado rivers in the Grand Canyon sacred to the Hopi (Eiseman 1959) to a mountain or mountains some distance east. If Kelly & Francis had been interested in possibilities of indigenous land surveying, they might have discovered that perhaps the only accurate totally coincidental three-point alignment in the Pueblo/Navajo world runs from the Grand Canyon *sipapu* confluence point east to Chicoma and Truchas peaks – the two "cardinal" east-west mountains of Ortiz's Tewa structure.

The scale of the author's dissertation work on Medieval Norway (1981) was not the larger landscape of mountain valley or fjord, but the structured ritual layouts of principal dwelling interiors and positioning of buildings at the farm core. The power of these rich traditional settings clearly flowed from concepts of "*axis mundi*" (most recently Doxtater 2019a) expressed both horizontally and vertically. This cosmology is well documented in the "*stue*" or open room dwelling with sacred fire and smoke opening at the center—where the spirit passed vertically at death. Ultimately more important ritually, this building axis was horizontally and symbolically subordinate to a natural landscape element located on the periphery of farm buildings or "*tun*". At the ritually "central" old Norse day of the week, Thursday (Thor), the farmer dutifully gave ale to the farm spirit in the sacred tree mound to the north of the *tun*; or after dressing the newly deceased in the *stue*, the straw and body trimmings would be carried in procession out to the *tun* tree and burned. Probable evidence of prehistoric ritual at larger scales lies in the folk wedding party journeying by boat to "church" as most sacred natural focus of the fjord community (even when no clergy was present during the Black Death). Burning an *axis mundi* cross at a communal landscape site at Summer Solstice replicates this subordination of individual farms at this largest calendrical and spatial scale.

Again, dissertation work did not consider any surveyed relationship between the location of farms and the church or summer solstice site. Yet, in measuring the orientations of 12th century *stues* still standing on their original foundation, one found a pattern of orientation offset from cardinal east. More recent archaeological work finds not dissimilar "systematic" orientation patterning among prehistoric graves in Scandinavia. Lindström (1997, 2005) disputes archaeoastronical ideas that attempt to link an individual's grave orientation to local sun rise or set positions on the immediate horizon. The implication here suggests large scale ritual landscapes with more regional orientation patterns, perhaps originating from important ritual places or surveyed "frames". In Scandinavia with its wealth of recorded Saga cosmology, Bradley asks whether archaeologists can discover enough evidence to reveal prehistoric, possibly landscape based religion (2006).

A remnant valley or fjord formalized scale of space in more recent historical Norway may have caused the change in orientation of the *stue* in the 17th and 18th centuries (Doxtater

1990). At this late time a cognitive spatial "sense" may still have associated the orientation of the freestanding church in the landscape to symbolic orientations of farm dwellings. The now Lutheran church finally expresses its cosmological meanings, i.e. East as sacred Christian opposition to human mortality in the West, and Male (cooperation) to the South opposed to Female (competition) to the North. By reorienting new *stues* 90 degrees in this period, the quadrant symbolic meanings in dwelling finally become "homologized" with those in the church. The most powerful spirit location rotates from North to East.

About 1860 – 1900 in the New World, immigrant Norwegian cemeteries in Minnesota were positioned in what for a time may have been a commensurate new cultural landscape; this included related socio-symbolic orientations of churches (Doxtater 2019b, Doxtater 2020a,). As poetically illustrated by Willa Cather in *My Antonia*, when these early cemeteries were consecrated, prior to building the church, the prairie was still wild, with no cultural expression of the newly surveyed grid, save for the nearly invisible corner stakes in the high grasses. Particularly meaningful were the central meridian lines of the six by six square mile townships, which often positioned multiple Lutheran cemeteries whose related social histories could be read as well by their church orientations. Often, churches on an axis would be of nominally distinct Lutheran synods, though only a few miles from one another. The grid expression that connected a larger Norwegian community as the only cultural landscape expression of scale for thirty to forty years—in one case a matrix some 60 by 80 miles-- possibly served to socially integrate the experience of varying synods. This work revisits ideas that explored the distinction between "discursive" and "non-discursive" expression, i.e. between symbolic media and ritual practice (Doxtater 1984). In Minnesota, Christian discourse contrasts with "non-discursive" landscape.

Returning to indigenous landscapes in the New World, Gossen's work on the Mayan Chamula frequently links ethnographically documented spatial cosmologies and Mesoamerican archaeology. He graphically illustrated how symbolism and ritual structure of Chamula churches and dwellings serve as homologues of a formal large-scale concept of space, whose power flows from the rising sun (1972). The meaning of the large-scale frame seems to have been derived from myth, not unlike in Ortiz's Tewa. Gossen maps no separate but analogic structure in the greater natural landscape. The general absence of astronomical elements in Ortiz's frame, however, suggests the possibility of greater influence of actual practice in the landscape as a possible initiator of large-scale cosmic structure. Mesoamerican archaeology has perhaps been more taken with the importance of myth and astronomy, despite a multitude of ethnographic examples of how Mayans, for example, still use many natural features ritually (see especially Wilson 1995, Stanzione 2003, Toohey 2013, and Carlsen 2009). Schele & Freidel's (1990) volume on "the untold story of the Maya" fuse mythic elements primarily from the *Popol Vuh* with the movement of the Milky Way axis. At sites like Copán and Tikal, architectural sculptures provide good evidence of these connections. The location of Mesoamerican sites in the larger landscape is seldom questioned as to whether they formally integrate into cosmological schemes, despite a likely technical ability to survey.

In Schele & Freidel's case this is somewhat surprising, given their collegiality with the well-regarded ethnographer Johannes Wilbert. His 1993 account of the Warao on the river deltas of Venezuela is one of the very few documented layouts--by some sort of land survey—of an accurate large scale cardinally oriented cosmos on their landscape. While shamanistic ritual at the center pole of their communal round house involved many symbolic artifacts, myth and observations of the sun's entry to openings at the roof's peak, the layout of the architecture models the formalized larger landscape. Shaman power in these rituals was accessed by traveling out to real quadrant landscape points of the cosmic frame, over two hundred kilometers in scale. Wilbert could not practically map the entire use of this landscape by diverse Warao groups and therefore does not describe social organization at this scale. Yet he did document the principal locations of power on the frame periphery and their geometric accuracy.

One final example of possible formalized landscape structure are the locations of principal religious foci, *aka* "palaces" on Minoan Crete. Again, one finds an interplay between myth, archaeoastronomy, and landscape. As a student in architecture, we read Vincent Scully, perhaps the best-known architectural historian at the time. His "*Earth, the Temple, and the Gods: Greek Sacred Architecture*" (1962) was well regarded in our landscape-oriented school in Seattle, welcomed as evidence of how the power of the landscape can integrate with architecture. He did not speak of cosmological framing, *per se*, just alignments between architectural axes and "horned" mountains in the immediate viewshed. When publishing work on site location in Crete, some included in Scully's book, (Doxtater 2009), the *Landscape Journal* editor specifically asked for a greater critique of his assertions. Archaeologists it turned out, had dismissed most of his coincidences between the axis of building alignment to horned mountain with the feast date of the temple's god.

On Crete, for example, rather than Knossos orienting to the visible peak sanctuary site of Juktas (a full 5° off with no associated Minoan god), the axis runs accurately to the center mountain of an island scale cosmic structure (some 260 km in length) which cannot be seen from Knossos. The frame includes the two highest spatially opposed mountains and their associated caves; it integrates the major site locations and makes understandable the orientations of their architectural axes. Significantly, no myth or astronomical components are necessary to the frame's geometry, though oriented architectural features that time ritual are only logical. In this work, the concept of "intension" / "extension" is introduced. *Extension* occurs when a building is located anywhere in a natural feature viewshed and then some architectural aperture or axis is oriented or extended to the feature—giving the impression of "integration" with nature. *Intension* is when a building or site location is determined by a line or lines *intended* from two or more wholly natural features, whether the azimuth of two mountain peaks or that of an astronomical rise/set at a unique horizon marker—more subordination to than integration with nature. *Intension* is not constrained to viewshed scale, given possibilities of surveying geometries across the larger landscape, including prolonged astronomical observation.

Possible techniques of large-scale prehistoric land surveying

Consider the geometric relationship between Pueblo Alto and Tsin Kletsin, though a short, visible 3.7 km between north and south rims of Chaco Canyon. The north walls of the two buildings are identically oriented east-west (my measurements of 0.85° and 0.83° from true), and their two west walls very precisely align north-south across the canyon (from Pueblo Alto, Tsin Kletsin's azimuth is 180.094°). This relationship has been so implicitly accepted as designed, including assumptions of some accuracy, that no published work precisely describes these patterns or how they were technically accomplished. From the completed north great house, surveyors needed to establish a true south azimuth, and then project it to a participating crew on the south rim. Did the existing wall provide a good enough cardinally accurate sight line, or was some instrument required?

Possible larger scale Ancestral Pueblo surveying, while more labor intensive, likely also had important religious meaning. Regarding great house construction in the period of peak Canyon activity, Wills (2000), describes the probable ritually conceived activities of building, and particularly of hauling the many roof timbers needed from distant mountains. Overall, multiple collective groups participated at different times in these tasks. The symbolism of bringing an artifact from a distant sacred mountain (the timbers), itself a kind of pilgrimage to the center, fits well with a religious function of a formalized large-scale ritual landscape on the plateau, Doxtater (2002, 2003, 2020b). Certainly, the most extensive discussion not only of surveying, but at very large scales is Lekson's Chapter Four (1999) in his "Chaco Meridian" book. He speaks of technical issues and accuracies, citing work of archaeoastronomers associated with the National Oceanographic & Atmospheric Administration (NOAA). They discuss a probable prehistoric ability to prolong lines very accurately down to less than two arc minutes of error (0.033°).

Ethnographic descriptions of possibly surveyed alignments in traditional cultures exist but provide no mapping analysis. At the visible range of about 10 km, Stanzione (2003: 240-244) and Carlsen (2009) document ritual pathways and solar symbolism around the town of Santiago Atitlan on the east shore of the lake below the Tolimán twin peaks and Atitlán volcano on the east and San Pedro volcano to the west. The early church in the town was built over a Mayan temple. Carlsen (personal communication) says it is approximately aligned with San Pedro's peak and the mid-saddle point between the Tolimán twins. Mapping, however, reveals a very precise alignment: it hits the church structure, an average deviation of 0.073º. This precision, he continues, despite the half a millennium overlay of Catholic belief and practice, is today still recognized in a "symbolic line that runs down the middle of the floor in the church" and that "a hole in front of the churches' altar is thought to be the very center of the world".

People today still ritually climb the 1,600 meters from Santiago Atitlán to volcano tops and doing so to originally position a ceremonial site below would have been part and parcel to their religion. With a survey party at the Tolimán center point observing fire or mirror signals on the opposite volcano top, San Pedro, as well as below at lake side, they needed to site vertically down from the San Pedro signal, communicating with the crew below when their position aligned. The vertical angle from the Tolimán center to the area below is about 15°. Modern surveyors would simply set their plumbed transit, sight to the opposite peak and then rotate the scope 15° down to the location below. This can easily be done as well with two tall tripods, each with a plumb bob. In this example, despite the ethnographic emphasis on ritually integrated astronomical observation of the sun, the azimuth of about 242° looking east from San Pedro to the Tolimán point appears *not* to be astronomically aligned. It orients almost 28° south of cardinal east, while the maximum sun rise angle at this latitude is about 23°.

In the Old World, Romans were about twice this accurate in their alignment of twelve watch towers spaced over 80 km in Germany (Söderman 1989). Interestingly, such precise alignment wouldn't have served any logical function. Again, the technology is quite simple, e.g. the "instrument" used by the Romans might have been threesomes of "range poles" (Gallo 2004:14) aligned across the landscape. In "prolonging" a line, one of the (exterior) poles is moved to an aligned next position and so on. The accuracy of this method depends on the diameter of the poles and their distance apart. Given poles of 0.10 m in diameter, an accuracy of visual acuity or 0.017° can be achieved when the poles are spaced about 300 m.

While prolonging points can rely upon sighting along instruments such as range poles, aligning an interim point between two visible end points some distance apart can also be accurately accomplished using only the unaided eye and basic back sighting techniques. This can be easily demonstrated in the field using the mentioned two tripods (about ten feet tall) each with a plumb line. To align an interim point to a line between two distant points at much longer distances than at Atitlán the vertical cord of the first tripod is aligned with one of the peaks. The second tripod cord is then aligned to these two points. Under normal sighting conditions, one can clearly see a plumb line cord about 2mm thick from about 6.75 meters (the cord width equals 0.017º at this distance). Next, the "backsight" or reverse alignment is checked. By such a process of trial and error, eventually each peak can be aligned with the two tripod lines without having to move one of the tripods. The tripods are then on or very close to the line between the two mountain peaks. Under decent conditions it is possible to align a midpoint between two peaks 100 kilometers apart to within about 15 meters. Atmospheric refraction and other sighting impairments, and the slight movement of plumb lines by wind can of course influence accuracy.

Laying out an even longer line between end points not visible from any single interim point is more labor intensive, but still could have relied only upon tripod pairs. In this case the process could have involved an iterative straightening of multiple three-point segments back and forth sequentially across the full length of the line until a requisite alignment is achieved. To initiate the process, approximate interim points could have been set up on ridges or high points along the full length of the line. It must be possible to view the two adjacent points from each point of the total line (see simulation in appendix to Doxtater 2020b). Lewis (2001:223) provides a related diagram and further explanation.

Although archaeologists speak of signal fires by Puebloan Ancestors at larger scales, the published record is limited (Lange 2001). He has experimented with signal fire communication between "tactical" pueblo sites at distances up to eight miles and briefly discusses possibilities at larger distances. Others discuss signal fires, but at shorter intervals, e.g. Hayes and Windes 1975; Windes et al. 2000. Swanson (2003) maps aligned signal fire locations on Cerro Moctezuma, a few kilometers in length. He quotes Ellis (1991:60-62) as having ethnographically determined that the maximum daytime visibility of a fire is around 70 km. The maximum viewing distance at night or at sunrise/sunset, however, may be farther. In Agamemnon, Aeschylus describes signal fires between Athos and Macistus, 177 kilometers apart. One of the best examples in modern times is documented naked eye observations of the sun's reflection off of Sputnik, the size of a beach ball, orbiting at 250 km above earth close to its perigee (Hyde Memorial Observatory:www.cloudynights.com).

DISTINGUISHING DESIGN FROM RANDOM GEOMETRY

To date the author has spent over 20k to develop tools to both accurately describe great circle geometric relationships (primarily alignments, right angles, and cardinals) and test found geometric patterns against random sets of equal numbers of sites in equivalent geographical areas (see Doxtater 2007). Present calculations are based on ellipsoid geometry of the earth and NOAA's interactive applications ("Direct and Inverse Solutions of Geodesics on the Ellipsoid with Application of Nested Equations" from the April 1975 issue of "Survey Review" http://www.ngs.noaa.gov/PUBS_LIB/inverse.pdf.). Despite older, simple computer examples of how random points create geometric patterns, (Papadopoulos 2001, O'Carroll 1979), and limited archaeological discourse on prehistoric land surveying (Williamson & Bellamy 1983), the presently most critical and interesting issue is how to distinguish designed from random patterns. While the author has published several exploratory examples of simple "probability testing" (Doxtater 2003, 2007, 2009) this technique remains to be critiqued in archaeological discourse. Toward this end, considered here are two unpublished examples, one related to Chaco, and the other to Mesoamerica, before focusing on a more extensive test of larger, prominent Adena mounds. The two first examples map elements of some larger ritual cosmology in the landscape and are not immediately associated with myth or astronomy.

Testing the Mount Wilson meridian

The following exercise is one of six included in a volume on “Chaco’s place” in a formalized large-scale landscape (Doxtater 2020b). The first and largest scale test in this volume studies the spatial distribution of 21 unique natural features and 61 great kiva sites from Basketmaker III to PIII periods, figure 1.

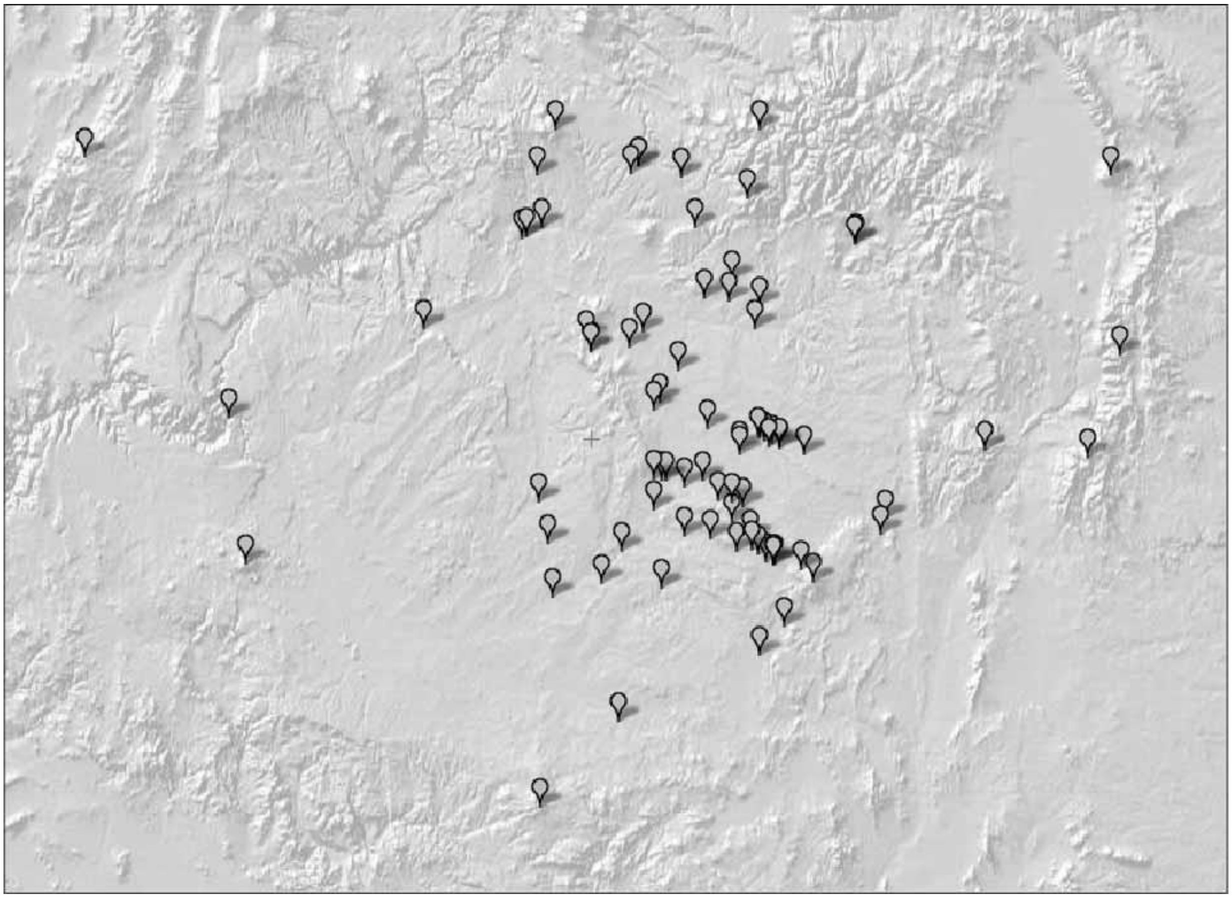

Figure 1. Location of 61 Basketmaker III – Pueblo III great kiva sites plus 21 most significant natural features on the Southern Colorado Plateau (Cerro Moctezuma is off map to the south)

Found among existing patterns are sites aligned with a long meridian, itself associated at a right angle to an east-west cardinal line. The “Chaco” meridian in question is not Lekson’s (1999), in that his does not link to great mountains or other natural features. His idea is a somewhat shorter line that varies about 2° “extended” from Chaco north to Aztec, and south to Paquimé. The line tested here runs much more accurately from Mount Wilson in the north to Cerro Moctezuma in the south (just west of Paquimé); this is an “*intension*” line that may have positioned one of the two first great kivas in the canyon. Diagramed in figure 2, it includes seven points, three natural and four sites built with great kivas. The likely spiritual power of Mount Wilson, the highest mountain in the Chaco world, might well have been amplified by its coincidental location precisely east of Abajo Peak, a possible north point of a ritually understood parallel meridian, and observation point for an equinox rise over Mount Wilson; this 90° relationship is included in the test. The two natural feature ends of the meridian are coincidentally aligned with one of the latest volcanic eruptions, McCarty's Flow. Built sites on the meridian include the center point of the huge Aztec layout, one of the two earliest great kivas (Basketmaker III) in the canyon, 29SJ423, its related later great house at Peñasco Blanco, and the "outlier" great kiva at Andrews to the south. Within an accuracy 0.075° (the median of the Chapter 2 exercise in the Chaco volume) the following individual patterns occur:

3-pt alignments (5)

Andrews – 29SJ423 – Mount Wilson (0.008°)
Peñasco Blanco – Aztec – Mount Wilson (0.020°)
Andrews – 29SJ423 – Aztec (0.053°)
Andrews – Aztec – Mount Wilson (0.054°)

[Peñasco Blanco – McCarty's Flow – Cerro Moctezuma]

2-pt cardinal relationships (10)

29SJ423 – McCarty's Flow (0.010°)
Mount Abajo – Mount Wilson (0.011° west – east)
Peñasco Blanco – Andrews (0.047°)
Aztec – McCarty's Flow (0.068°)

[Cerro Moctezuma – Mount Wilson]
[Cerro Moctezuma – McCarty's Flow]
[Cerro Moctezuma – Aztec]
[Cerro Moctezuma – 29SJ423]
[Cerro Moctezuma – Peñasco Blanco]
[Cerro Moctezuma – Andrews]

Prominent in this list are cardinal relationships created by Cerro Moctezuma. Mathematically this occurs simply because of this point's great distance south from the other points. The greater distance between points, relative to a precise north-south meridian, the smaller the angle of deviation. The location of Cerro Moctezuma as a somewhat latter-day extension of Chacoan layout is discussed in Chapter 8 of the Chaco volume. The inclusion of Cerro Moctezuma, however, in probability tests seems unwarranted, even though the alignment relationships to the meridian are very precise.

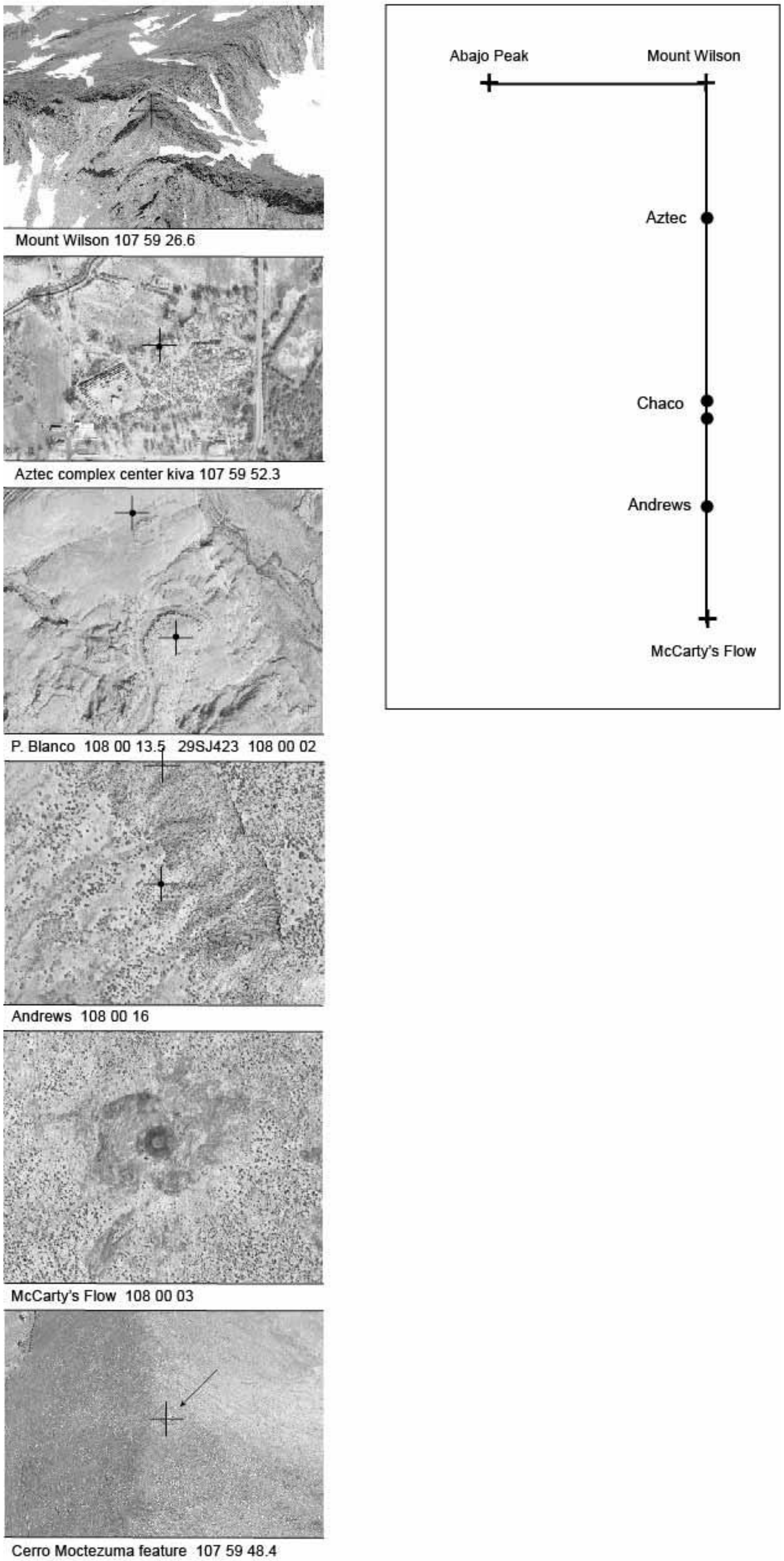

Figure 2. Location of four Chacoan sites in cardinal context with three prominent natural features (test w/o Cerro Moctezuma).

Presently, one considers four 3-pt. alignments and four 2-pt. cardinals which seem to connect three natural and four great kiva sites. To compare this existing "compound" with random phenomena, test areas shown in figure 3 are created, placing numbers of random point equal to the existing in each. The compound model from the existing 81 sites is the search string: A+A(2)+A(2)+A(3)+C(2)+C(1)+C(2)+C(1), where "A" is a three point alignment, and "C" is a cardinal relationship between two points (either north-south or east-west). "A+A(2)" asks for an overlap of two three point alignments with two points in common, and so on. The 21 natural features are held constant while large numbers of random sets are generated. The two test boxes

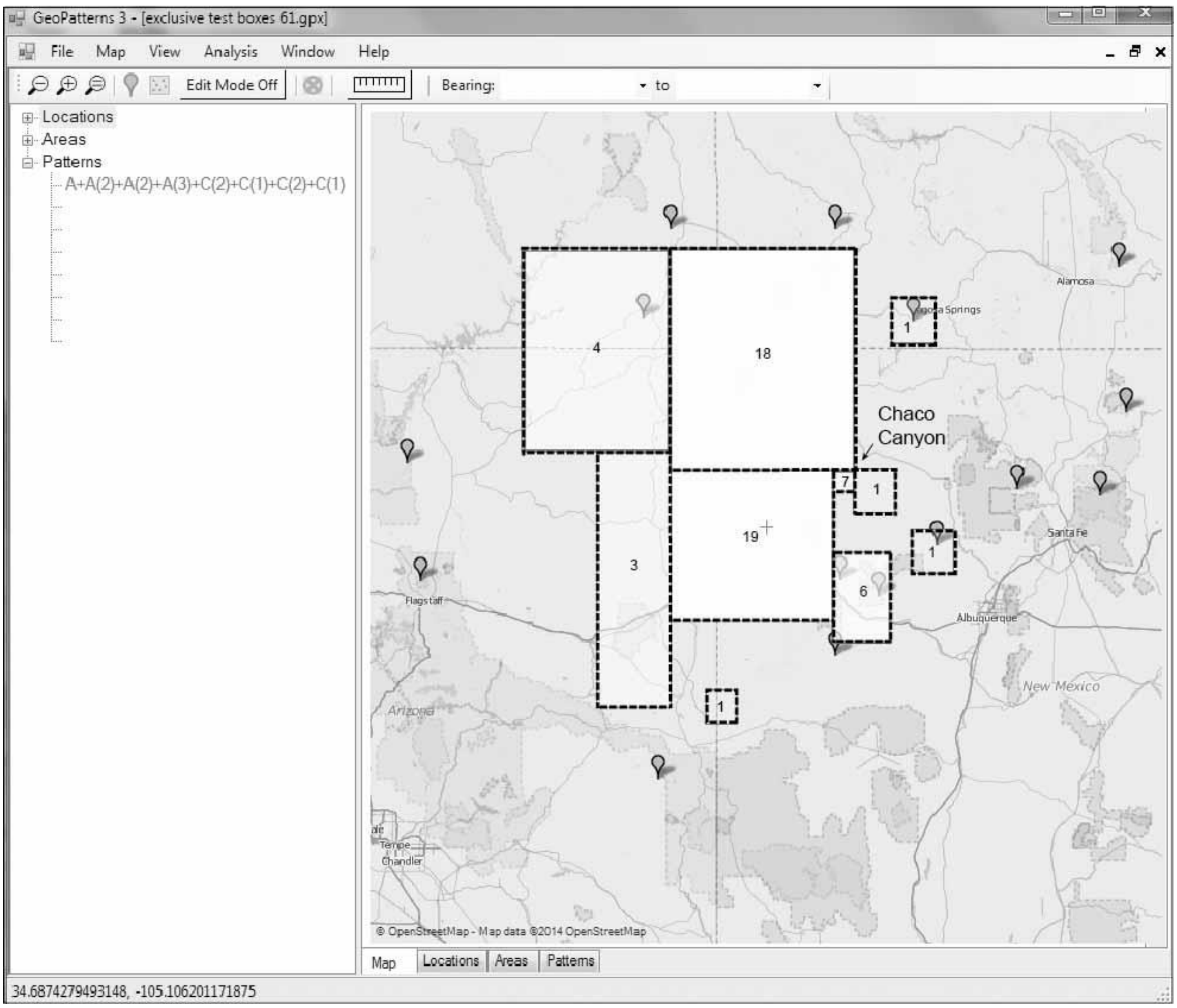

Figure 3. Test areas for Mount Wilson meridian (multiple alignments and cardinal relationships); numbers indicate existing great kiva sites and random points located in each set of the analysis.

on the meridian just north and south of Chaco Canyon contain 18 and 6 great kiva sites, which together with Chaco's 7 add up to 31 random points, or about half of the plateau total. In 5,000 sets of 61 random points distributed in the nine boxes, the compound pattern at 0.055° (alignments) and 0.070° (cardinals) occurs twice in sets #409 and #1,615.

The probability of four great kiva sites (one included as the Aztec center) participating accurately in this compound pattern is about 0.0004 (1 in 2,500). Curiously, constraining seven random points within Chaco Canyon only produces one pair of aligned sites (to match the existing 29SJ423 and Peñasco Blanco) in set #409, while set #1,615 has only one random point in the canyon. The location of 29SJ423 is key to the idea that, along with its partner Shabik'eschee, they founded Chaco in Basketmaker III as the large-scale ritual focus on the *axis mundi* from Mount Wilson.

With the exception perhaps of Andrews, the other three great kiva sites on the vertical are not just any ordinary 3 of 61. Ideally, future pattern tests should weigh a ranking of sites according to ceremonial or organizational importance. 29SJ423, for example, is the most northerly (intuitively most sacred) of the two early great kiva sites in Chaco Canyon (the line to the second runs directly through the plaza space in front of the "Rock that Speaks" eventually flanked by Pueblo Bonito and Chetro Ketl). Later, the ultimately most northern great kiva in the canyon is built as part of the Peñasco Blanco great house. Finally, at the build-out climax of Chacoan influence, the center point of the formally laid out multi great house complex of Aztec—emulating Chaco itself-- is located precisely on the line from the Peñasco Blanco great kiva to Mount Wilson.

Tikal as center of three-point alignments

The second example of probability testing uses the locations of 50 "earlier" Mayan sites together with 6 prominent natural features as described in the map of figure 4 (one of several tests in a recent report on Mesoamerican work (Doxtater 2020c). This test evaluates Middle Pre-Classic E-Group site relationships identified by James Doyle (2012). An E-Group is a recognizable triadic group of features with a spread of possible astronomically aligned elements to the east; they occur widely in Mayan sites from Pre-Classic through Classic periods. Without attempting to engage Doyal's cited Mayan literature on the subject, one can consider spatial issues *per se*. His ideas stem mostly from GIS methodology, more so than archaeological theory of

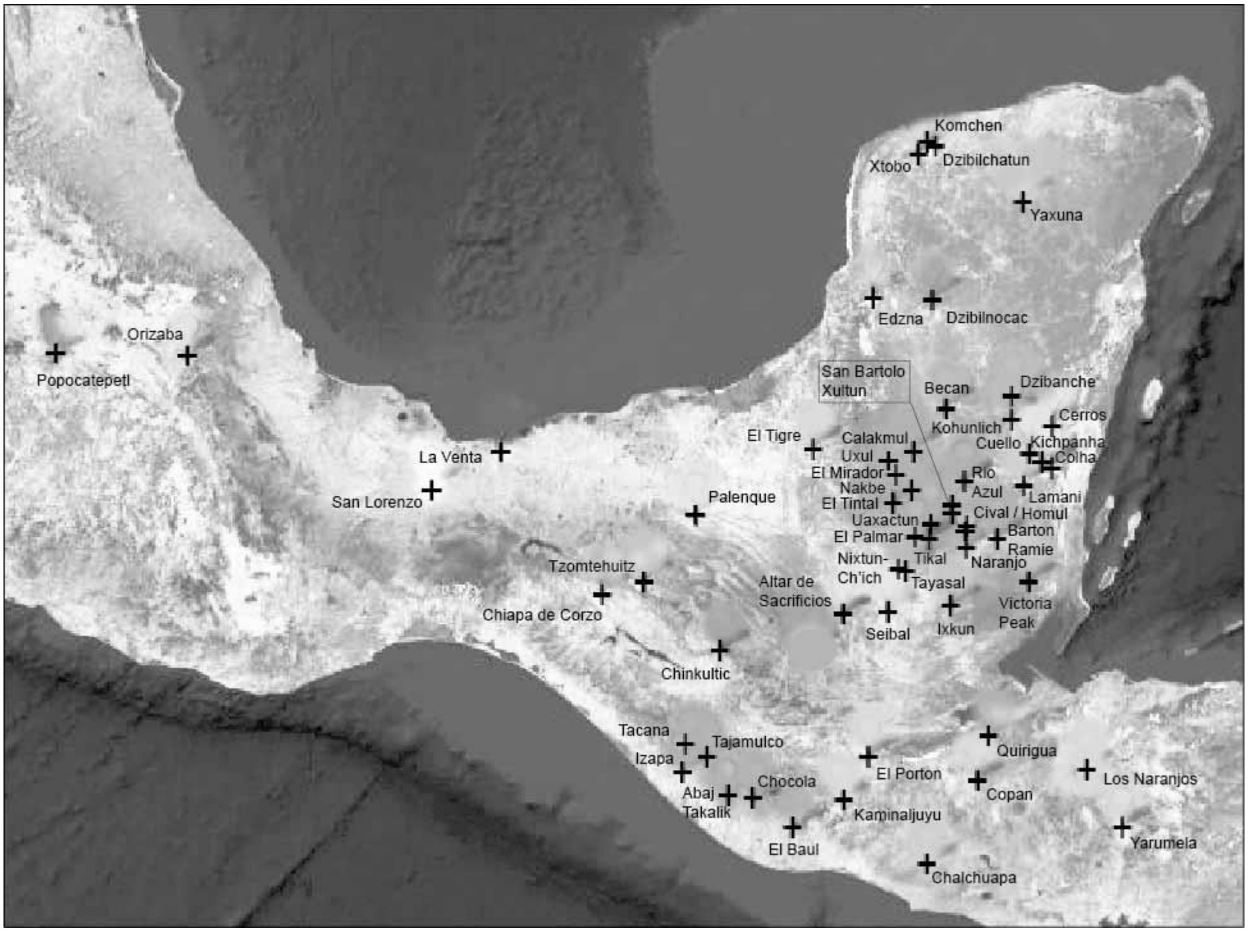

Figure 4. Locations of 50 “earlier” Mayan (2 Olmec) sites together with 6 prominent volcano peaks.

landscape cosmology. He uses GIS tools to map viewsheds between 22 Middle Preclassic sites with an E-group. Ultimately, Doyle’s landscape map reproduced in figure 5 (2012:367) focuses on seven Middle Preclassic E-group sites where GIS analysis most clearly illustrates his argument.

Here is a group of sites selected by a mainstream Mayan archaeologist which are argued *to have been intentionally located in part by defined social relationships between them*. Setting aside his conclusions about largely undefined social practices possibly associated with viewsheds between “E-Group” sites, what happens if one tests Doyle’s seven sites against random alignment phenomena involving a much larger non-viewshed scale? Most importantly, someone other than the present author chose these sites as being interesting social space.

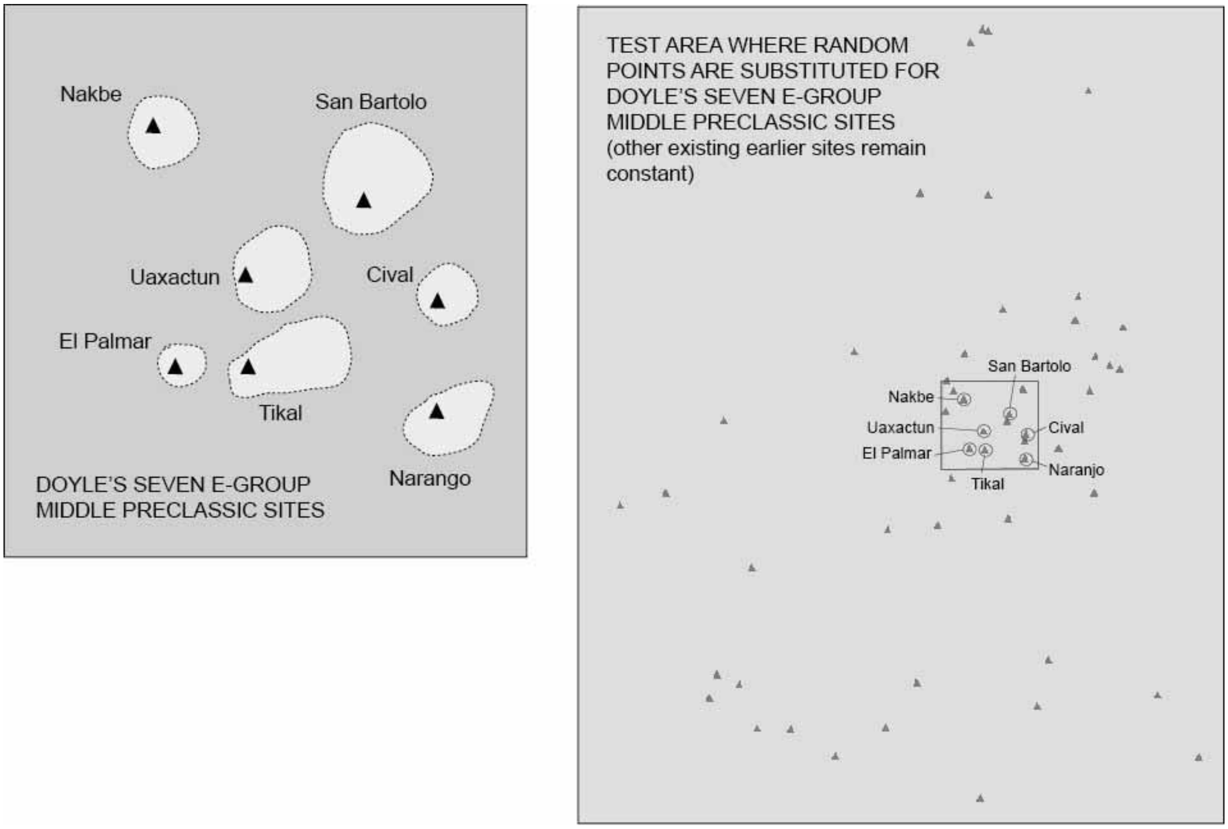

Figure 5. Viewshed territories of seven early sites reproduced from Doyle 2012 (left); test area where random points are substituted in 100 sets of seven each while 43 (plus 6 volcanos) are held constant (right).

The latitude/longitude points within all sites of the present study are positioned in a central point of the site (see examples in figure 8); the exception is the huge site of Tikal, where its largest pyramid Temple IV is selected. Figure 5 illustrates the test area drawn around Doyal's seven sites of Nakbe, El Palmar, Tikal, Uaxactun, San Bartolo, Cival, and Naranjo. In each of 100 sets, 7 random points are substituted for the existing in the test area, while the rest of the existing sites, now 43 in number, together with the 6 natural features are held constant. In each of the 100 sets the number of three-point alignments involved with each of the seven random points is recorded; this includes alignments with both the 43+6 constants, and with other random points of the seven. The total number of alignments for each random set is also recorded. One additional measure tracks how the number of alignments per site (existing and random) varies with the size of the site. All 50 existing sites have been scaled together as evident in figure 8. As a subgroup Doyle's seven existing sites rank: 1) Tikal, 2) Nakbe, 3) Narango, 4) Uaxactun, 5) San Bartolo, 6) Cival, 7) El Palmar. For each random set, the numbers one through seven

EXISTING SITE SET @ 0.10
alignments per Doyle's seven sites

25 (49): 1-9, 2-0, 3-0, 4-4, 5-5, 6-3, 7-4

100 SETS - 7 RANDOM PTS. EACH
alignments per each random point

26 (50): 1-2, 2-2, 3-6, 4-5, 5-3, 6-6, 7-2 [97]
25 (50): 1-6, 2-3, 3-4, 4-2, 5-4, 6-4, 7-2 [20]
24 (47): 1-2, 2-1, 3-2, 4-1, 5-3, 6-5, 7-10 [31]
24 (50): 1-6, 2-3, 3-3, 4-2, 5-5, 6-2, 7-3 [73]
24 (47): 1-1, 2-1, 3-5, 4-6, 5-6, 6-3, 7-2 [75]
23 (49): 1-5, 2-4, 3-3, 4-5, 5-2, 6-4, 7-0 [24]
23 (45): 1-7, 2-1, 3-3, 4-3, 5-4, 6-2, 7-3 [61]
23 (49): 1-4, 2-2, 3-4, 4-3, 5-3, 6-5, 7-2 [91]
22 (46): 1-2, 2-3, 3-5, 4-2, 5-3, 6-2, 7-5 [65]
22 (46): 1-2, 2-1, 3-3, 4-5, 5-2, 6-4, 7-5 [95]
21 (46): 1-4, 2-0, 3-4, 4-3, 5-5, 6-2, 7-3 [40]
21 (44): 1-3, 2-2, 3-3, 4-2, 5-7, 6-3, 7-1 [43]
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21 (46): 1-2, 2-0, 3-1, 4-6, 5-6, 6-4, 7-2 [96]
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20 (45): 1-4, 2-3, 3-2, 4-2, 5-3, 6-5, 7-1 [29]
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20 (43): 1-3, 2-2, 3-1, 4-3, 5-2, 6-6, 7-3 [66]
20 (45): 1-2, 2-5, 3-1, 4-7, 5-1, 6-1, 7-3 [78]
20 (44): 1-2, 2-0, 3-6, 4-2, 5-0, 6-4, 7-6 [79]
20 (47): 1-2, 2-2, 3-7, 4-3, 5-1, 6-2, 7-3 [82]
19 (46): 1-4, 2-0, 3-2, 4-3, 5-5, 6-2, 7-3 [19]
19 (42): 1-3, 2-2, 3-5, 4-2, 5-2, 6-2, 7-3 [30]
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19 (44): 1-3, 2-4, 3-2, 4-3, 5-1, 6-4, 7-2 [50]
19 (46): 1-1, 2-1, 3-2, 4-4, 5-5, 6-2, 7-4 [83]
19 (43): 1-4, 2-2, 3-3, 4-0, 5-5, 6-3, 7-2 [49]
18 (44): 1-2, 2-4, 3-2, 4-3, 5-1, 6-4, 7-2 [16]
18 (45): 1-1, 2-3, 3-4, 4-2, 5-3, 6-1, 7-4 [13]
18 (44): 1-3, 2-2, 3-3, 4-2, 5-6, 6-1, 7-1 [22]
18 (44): 1-4, 2-1, 3-5, 4-2, 5-0, 6-4, 7-2 [27]
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17 (44): 1-2, 2-2, 3-4, 4-1, 5-3, 6-1, 7-4 [3]
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17 (42): 1-2, 2-1, 3-2, 4-5, 5-2, 6-2, 7-3 [100]
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16 (43): 1-4, 2-2, 3-2, 4-4, 5-4, 6-0, 7-0 [12]
16 (43): 1-3, 2-3, 3-1, 4-2, 5-2, 6-2, 7-3 [15]
16 (41): 1-0, 2-5, 3-1, 4-3, 5-1, 6-4, 7-2 [25]
16 (43): 1-3, 2-2, 3-2, 4-4, 5-4, 6-0, 7-1 [33]
16 (44): 1-4, 2-4, 3-3, 4-1, 5-1, 6-2, 7-1 [42]
16 (44): 1-4, 2-2, 3-2, 4-1, 5-3, 6-2, 7-2 [45]
16 (45): 1-1, 2-3, 3-4, 4-2, 5-3, 6-1, 7-2 [47]
16 (43): 1-2, 2-2, 3-4, 4-3, 5-2, 6-1, 7-2 [54]
16 (42): 1-3, 2-4, 3-1, 4-4, 5-0, 6-3, 7-1 [71]
16 (45): 1-3, 2-1, 3-0, 4-2, 5-4, 6-2, 7-4 [74]
16 (43): 1-3, 2-0, 3-4, 4-1, 5-1, 6-4, 7-3 [81]
16 (41): 1-3, 2-2, 3-3, 4-2, 5-5, 6-0, 7-1 [99]
16 (39): 1-4, 2-2, 3-2, 4-2, 5-2, 6-2, 7-2 [51]
16 (42): 1-3, 2-3, 3-2, 4-0, 5-1, 6-4, 7-3 [52]
15 (44): 1-3, 2-4, 3-2, 4-3, 5-1, 6-1, 7-1 [5]
15 (43): 1-1, 2-2, 3-3, 4-4, 5-5, 6-2, 7-2 [6]
15 (44): 1-5, 2-3, 3-3, 4-0, 5-1, 6-2, 7-1 [10]
15 (40): 1-2, 2-2, 3-3, 4-4, 5-0, 6-3, 7-1 [63]
15 (42): 1-5, 2-2, 3-2, 4-3, 5-1, 6-1, 7-1 [64]
15 (42): 1-1, 2-2, 3-3, 4-2, 5-2, 6-3, 7-2 [72]
15 (42): 1-3, 2-0, 3-1, 4-2, 5-4, 6-2, 7-3 [76]
15 (42): 1-1, 2-3, 3-5, 4-1, 5-2, 6-3, 7-0 [87]
15 (40): 1-0, 2-1, 3-2, 4-2, 5-2, 6-3, 7-5 [90]
14 (43): 1-2, 2-2, 3-2, 4-4, 5-4, 6-0, 7-0 [1]
14 (45): 1-1, 2-3, 3-3, 4-2, 5-2, 6-1, 7-2 [2]
14 (40): 1-2, 2-2, 3-2, 4-0, 5-4, 6-4, 7-0 [26]
14 (42): 1-2, 2-2, 3-2, 4-1, 5-1, 6-4, 7-2 [44]
14 (39): 1-4, 2-2, 3-0, 4-2, 5-0, 6-1, 7-5 [53]
14 (40): 1-1, 2-1, 3-4, 4-3, 5-1, 6-1, 7-3 [59]
14 (39): 1-1, 2-1, 3-2, 4-5, 5-1, 6-2, 7-2 [69]
14 (39): 1-3, 2-2, 3-2, 4-2, 5-1, 6-1, 7-3 [77]
14 (41): 1-3, 2-1, 3-3, 4-0, 5-2, 6-1, 7-4 [80]
14 (40): 1-3, 2-0, 3-2, 4-2, 5-2, 6-2, 7-3 [86]
14 (40): 1-3, 2-3, 3-0, 4-1, 5-0, 6-3, 7-4 [89]
14 (41): 1-2, 2-2, 3-1, 4-3, 5-1, 6-2, 7-3 [93]
14 (41): 1-2, 2-3, 3-3, 4-1, 5-1, 6-2, 7-2 [34]
14 (39): 1-3, 2-3, 3-3, 4-2, 5-0, 6-0, 7-3 [38]
14 (39): 1-2, 2-2, 3-1, 4-2, 5-4, 6-0, 7-3 [23]
13 (38): 1-2, 2-0, 3-1, 4-4, 5-2, 6-1, 6-3 [58]
13 (38): 1-1, 2-1, 3-2, 4-3, 5-1, 6-2, 7-3 [62]
13 (40): 1-2, 2-2, 3-2, 4-2, 5-2, 6-1, 7-2 [75]
11 (37): 1-0, 2-2, 3-0, 4-1, 5-4, 6-2, 6-2 [28]
11 (39): 1-2, 2-1, 3-2, 4-1, 5-1, 6-2, 7-2 [39]
11 (39): 1-0, 2-0, 3-4, 4-2, 5-2, 6-1, 7-2 [67]
10 (39): 1-2, 2-0, 3-2, 4-1, 5-1, 6-2, 7-2 [7]
9 (39): 1-1, 2-1, 3-2, 4-0, 5-1, 6-2, 7-2 [18]
9 (36): 1-2, 2-1, 3-0, 4-1, 5-1, 6-3, 7-1 [94]

Figure 6. Total of alignments in each of 100 sets of seven random points each @ 0.10º; breakdown of each set as to numbers of alignments associated with each of the seven, ranked from 1-7 to indicate largest to smallest site.

imitate a site size ranking; “1” is the largest, “7” the smallest.

Doyle’s seven existing Middle Pre-Classic sites create 25 total three-point alignments, just over half of the 49 total number of alignments for all existing sites (50 built+6 natural). Results of running the test at 0.10° accuracy are listed in Figure 6. In terms of the seven, only one random set of 100 is higher than the existing, 26 vs. 25 alignments. For all 56 existing sites and their 49 alignments, three random sets of the 100 have 50 alignments, and two match the existing 49.

The way the number of alignments associated with each site works with the scale of the seven sites is also interesting. In the existing, Tikal (Temple IV) has a highest of 9 alignments associated with this largest site. The highest number of alignments associated with any random point of the 700 is 10, linked to the 7th largest (smallest) site of set number 31; set 57 has 8 alignments associated with the second largest random site. The best largest scale random site has 7 (set number 61). This site scale relationship with alignments, however, does not hold for the rest of the existing sites. Neither Nakbe nor Naranjo have any alignments at 0.10°, and the second highest number after Tikal occurs at San Bartolo with 5. Uaxactun and El Palmar both have 4, and Cival 3.

To more fully test a range of accuracy, the high range in the Chaco work, 0.15° was used to generate a second comparative exercise of 100 sets, again focusing only on Doyle’s seven sites. Listed in figure 7 are the highest 21 of the 100 sets of 7 random points each. In this case both the total involvement of the seven, and the total overall numbers of alignments becomes more positive for the random. The existing seven at 0.15° themselves create 38 alignments, while six of the random sets exceed this number, with a high outlier of 49. Looking at total involvement of all 56 existing locations, the comparison narrows a bit. The existing has 72, exceeded by only two of the random, with the high outlier clocking in at 78.

Temple IV, the selected Tikal point, performs even better at 0.15°. It not only outdistances the highest random number for any of the 700 random points, 15 vs. 11 (site 6, set 81), but associates with the largest site area of the existing seven. The highest random point involvement with alignments of the 700, associating with a number1 site, is 8 (sets 71 and 65). Curiously, the second most involved site of the seven in the 0.10° test, San Bartolo, keeps pace with Tikal at

EXISTING SITE SET @ 0.15
alignments per Doyle's seven sites

38 (72): 1-15, 2-0, 3-2, 4-4, 5-9, 6-3, 7-5

HIGHEST 21 OF 100 SETS 7 PTS. EA.
alignments per each random point

49 (78):1-6, 2-7, 3-9, 4-5, 5-7, 6-10, 7-5 [53]
39 (73): 1-4, 2-6, 3-6, 4-9, 5-4, 6-8, 7-2 [25]
35 (71): 1-5, 2-1, 3-12, 4-6, 5-5, 6-3, 7-3 [34]
39 (71): 1-5, 2-7, 3-8, 4-6, 5-6, 6-5, 7-2 [45]
35 (70): 1-8, 2-4, 3-2, 4-4, 5-5, 6-5, 7-7 [71]
39 (70): 1-6, 2-7, 3-3, 4-5, 5-3, 6-11, 7-4 [81]
38 (69): 1-5, 2-4, 3-5, 4-4, 5-8, 6-7, 7-5 [70]
34 (69): 1-2, 2-5, 3-6, 4-5, 5-7, 6-6, 7-3 [90]
38 (68): 1-4, 2-3, 3-6, 4-6, 5-5, 6-8, 7-6 [50]
33 (68): 1-3, 2-3, 3-6, 4-4, 5-8, 6-7, 7-4 [58]
31 (68): 1-6, 2-4, 3-5, 4-3, 5-5, 6-3, 7-6 [64]
34 (68): 1-4, 2-4, 3-8, 4-5, 5-5, 6-4, 7-4 [74]
32 (67): 1-7, 2-3, 3-4, 4-3, 5-5, 6-4, 7-6 [9]
33 (67): 1-5, 2-6, 3-5, 4-3, 5-2, 6-4, 7-8 [10]
33 (67): 1-2, 2-6, 3-4, 4-4, 5-7, 6-3, 7-7 [41]
31 (67): 1-8, 2-3, 3-2, 4-3, 5-7, 6-1, 7-7 [65]
30 (66): 1-5, 2-4, 3-3, 4-7, 5-4, 6-6, 7-1 [14]
32 (66): 1-5, 2-5, 3-5, 4-5, 5-3, 6-7, 7-2 [19]
28 (66): 1-5, 2-3, 3-2, 4-3, 5-3, 6-7, 7-5 [28]
32 (66): 1-6, 2-8, 3-6, 4-3, 5-1, 6-2, 7-6 [62]
29 (66): 1-3, 2-5, 3-1, 4-3, 5-7, 6-5, 7-5 [95]

Figure 7. Highest 22 alignment totals of 100 sets with 7 random points each @ 0.15º; numbers of alignments associated with each point in a set with 1-7 indicating the ranking of site size.

0.15°, almost doubling its number of alignments from 5 to 9. Only 3 of the random 700 involve more alignments than San Bartolo, with two additional others having 9. Nakbe still has no alignments, while Naranjo picks up 2. Uaxactun stays the same, and El Palmar gains 1.

Does using Temple IV prejudice this comparison? In one sense its use does not vary from choosing a central point of smaller sites. While this work hasn't tested a variety of locations in different sized Mayan sites, it is quite likely that a change in the location of a single point *anywhere* within a site will only minimally change the number of large scale three – point alignments that connect. This because of the large distances involved, i.e. the scale relationship between line accuracy and site size. It is true, however, that at Tikal at least, this isn't so. Temple IV works best. But this may not make any difference, if one assumes that because of the smaller scale of most other sites, the point chosen is also the best point.

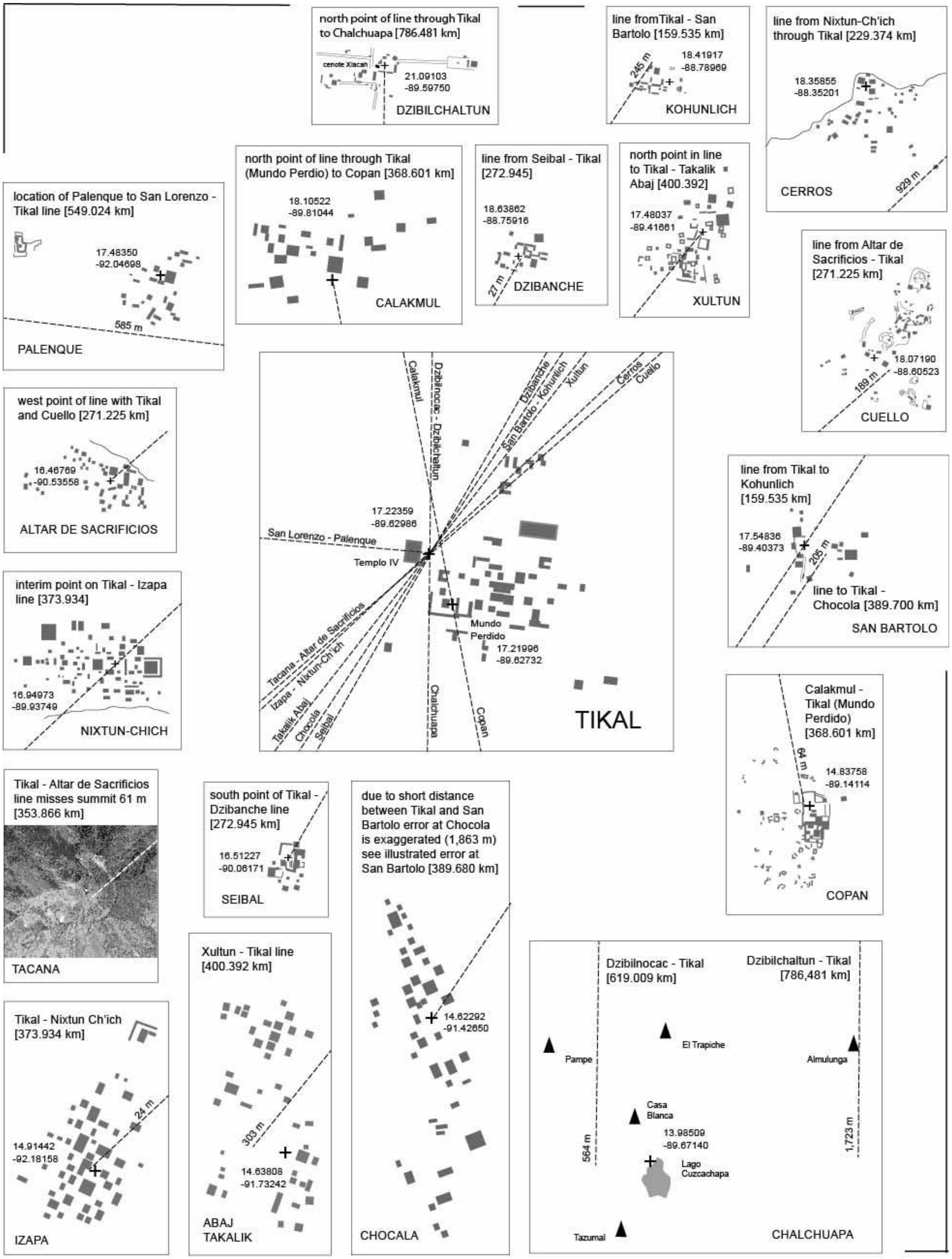


Figure 8. Fifteen sites aligned with Tikal's Temple IV at or under 0.15º

Finally, the scaled sites involved in the 15 three-point alignments of Temple IV, are illustrated in figure 8. At least *some* design, and prehistoric surveying, appears to be behind *some* of these geometric relationships, a much more structuralist, symbolic and possibly ritual set of meanings far different than more territorial GIS viewsheds. The author's Mesoamerican work maps the original positioning and layout of Tikal as integrated into a Mesoamerican frame possibly initiated by the Olmec. Not unlike Chaco, Temple IV's location at Tikal is an *axis mundi* meridian expression as well, precisely located cardinally north of the volcano Santa Ana on the south coast.

PROBABILITY OF DESIGN IN THE LARGE-SCALE ADENA LANDSCAPE

Having searched for large-scale patterns among comparably sized largest mounds in Scandinavia (50 – 77m diameter) without clear results in probability testing, the author had avoided research in the Adena-Hopewell sphere. Also, one considered the lack of powerful mountain peaks to anchor an "*intension*" frame, as in the Southwest, Mesoamerica, and Scandinavia. Yet in these three, water features can figure prominently as powerful ritual thresholds, e.g. the "*sipapu*" or confluence of the two Colorado rivers in the Grand Canyon, or possibly sacred waterfalls like *El Chiflón* in Chiapas positioned coincidentally on major frame axes, or a huge conical island called *Gudfjelløya* "god-mountain-island) north of Trondheim fjord as a terminus for large-scale ritual axis beginning with the great mounds at Bertnem on the fjord river and passing very accurately through the sentinel peak of Heimdalshaugen (Norse "frame god" who overlooks the world). When stopping by Cahokia traveling cross country, however, a tantalizing clue associates the location of the prehistoric city close to the confluence of three major rivers, and its meridian position coincidentally cardinally north of the Mississippi delta at New Orleans. Cahokia, of course, is more a Chaco period phenomenon than the almost millennia earlier Adena.

Although most Adena-Hopewell sites are on rivers, and many sites were scenically striking, the primary cultural images here are not the "non-discursive" mounds or forts, but the remarkably large circular, square, elliptical or octagonal Hopewell religious earthworks—not to exclude some very geometrically aesthetic personal artifacts. Having cited Wesley Bernardini for his knowledge of Historic Pueblo ethnography regarding large scale Chacoan ritual, his 2003 piece comparing in part Hopewell and Chacoan ceremonial architecture provides evidence of scale similarity:

> "(Hopewell) earthwork construction was not 'experienced' by participants as the convergence of a local community. Instead earthwork construction was the product of labor pooled at a regional level, and thus was experienced as a much larger social phenomenon than previously recognized" (313).

Did this larger scale pattern also relate to the Adena mounds? When people gathered to build the largest mounds, was this regional experience itself (not unlike hauling logs to Chaco) a significant religious effect? Or do Adena mound monuments primarily communicate a more local territoriality of big men or chiefs? What does research on Scandinavian mounds tell us? Yes, important people are buried in these largest built forms, but they also serve larger more collective purposes of ritual gathering, and perhaps larger scale social integration (Oestigaard & Goldhahn 2006). Aside from this potential comparative discourse, no ritually or symbolically motivated research, new or old worlds, seeks to discover why and how "great" mounds were positioned in the larger landscape. Even if these Adena locations were used ceremonially, their location is likely assumed to be primarily ecologically driven by river use, and perhaps related political control by more hierarchical entities.

Prominent in any initial look at Adena-Hopewell sites in the landscape is the impressive mapping of Hopewell enclosures by archaeoastronomers. Again, at a certain scale of organization, a ritually practiced shamanistic landscape appears to give way to cosmological beliefs structured by the geometries of sun, moon and stars—though here without any recorded contemporary mythology. The present exercise began by collecting site positions of Hopewell earthworks, hilltop enclosures, and prominent Adena mounds. Initially, two aspects of the Hopewell structures were particularly interesting. Beyond their astronomical meanings, particularly well-illustrated in Romain's extensive lidar mapping (2015), the first apparent reality is a considerable technical experience in laying out geometry at a large architectural scale.

Hively and Horn (1982) describe a possible method for mathematically laying out the Newark Octagon, primarily how dimensions of squares and circles relate, yet do not discuss possible construction tools. One can find no published discourse about surveying techniques among the Hopewell save for the civil engineer Marshall's piece which again focuses primarily on mathematics: " earthworks were constructed using a standard unit of measure; plans were made to scale before construction; and knowledge of geometry entailed at least the use of right triangles with precise geometric proportions" (1980:8). He suggests that a circle could have been accurately laid out by a group of individuals holding hands in a chain and rotating around a center point. Laying out much more complex geometry at the Newark Octagon for example, about 450 meters across, seems improbable with this circle method.

In Hively & Horn's newer work for Newark (2013), the question quickly arises as to how the Hopewell oriented large enclosures, and perhaps also positioned them in the landscape, *without* using tripod-based surveying. Their hypothesis holds that the primary places to observe astronomical rises and sets were not from within the ceremonial structures themselves but from higher hill tops up to five miles away. This contrasts significantly from ritual experiences, such at Stonehenge, where participants gathered on its intimately scaled axis observing the summer solstice rise aligned with the heel stone. At Newark, Hively & Horn describe what may be the best comparable experience in the Wright Square as participants could track the moon extremes as alignments between the square's vertices and diagonals and a pair of closer hill points on the northern horizon.

How does the largest feature at Newark, the common axis of the Observatory Circle and the Octagon ritually associate with to the north maximum moon rise to the northeast? Hively & Horn point out the inaccuracy between the azimuth of the monumental site axis itself and the azimuth to the rise point on the horizon. The site axis is mathematically closer to the calculated rise axis between equal elevation high points on hills surrounding the valley. Unlike the singular Wright Square, no marked rise point on the northeast horizon can be seen from the monumental axis. Instead, did participants parade to the "backsight" hilltop point, where they could "see the moon rise over the Observatory Circle – Octagon axis" (2013: 97)? Figure 9 maps the inaccuracies of hill top observations in relation to the earthwork architecture in the valley. The north maximum moon rise observation azimuth (dotted line), clearly doesn't align accurately to the Observatory Circle – Octagon axis, in spite of being able to generally associate it from the hill top to the west with the moon rise at the opposite unmarked distant horizon.

Why didn't these Adena successors use tripods to accurately align the most formal artifact in the Newark complex with an observation azimuth? Even if the view to the rise position was obscured from the site, tripod pairs could have been set up on the southwest hill observation point, accurately aligned with the best rise point on the opposite horizon. Then, sighting down the leading tripod to a pair of aligned tripods set up in the prospective site area, a

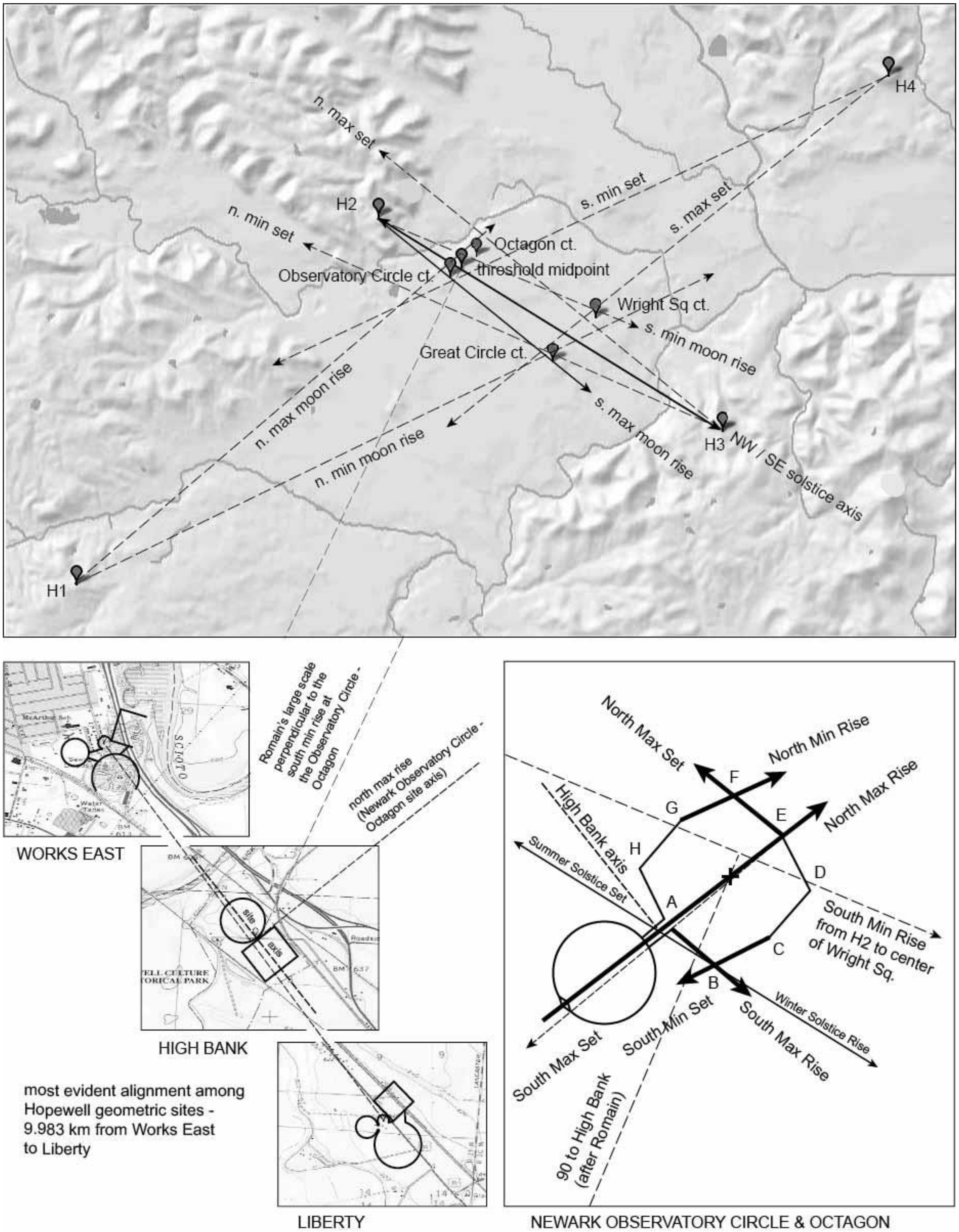


Figure 9. Comparison of alignment accuracies from astronomical observation with those possible by prehistoric land surveying: Newark structure after Horn & Hively 2013 (above), derived from their determinations of alignments from the Octagon (below right); often assumed alignment of three earthworks in Scioto valley (below left).

line quite identical to the astronomical observation could have been laid out as the Observation Circle – Octagon axis. Perhaps the north maximum moon rise wasn't used to *position* the site, only to orient the axis. The author (2020c) currently explores the possibility that Mesoamericans had the ability to record azimuths, often created from prominent natural features with coincidental geometry. They could then transfer a relatively accurate azimuth (more in the astronomically oriented range described by Hively & Horn) to lay out a symbolic feature of a ceremonial site.

The observation hilltops surrounding the Newark complex are obviously not in a class with Chacoan or Mesoamerican most significant natural coincidences used ritually for framing space and time. At the Observatory Circle – Octagon axis, shifting the climatic ritual effect to the modest observation hill seems unlikely. If, however, one could find a large-scale north maximum moon rise azimuth associated coincidentally with natural features at this general latitude, then it, when transferred to Newark would command more powerful *regional* ritual effect.

The most accurate astronomical alignment in figure 9, however, does involve the great axis. The most interesting of the two solid lines of the illustration, accurate in terms of possible prehistoric surveying, is the shorter transverse axis between hill tops that mark the solstice azimuth between opposite winter rise and summer set. This ritually observable axis runs accurately through the midpoint of the "bridge" between Observatory Circle and Octagon. The power of ritual lies in the liminal function of threshold separation between symbolic domains, whatever the opposition of circle and octagon meant. This axis might be the only surveyed line at Newark originally positioning the great axis. When mapping the larger scale as follows in this paper, one can find two accurate large-scale lines, understood perhaps by the Adena, that may have worked with the solstice axis to fix the Circle – Octagon threshold. The moon orientation of the axis could have been a "transfer" from a larger landscape.

While the 2013 work of Hively & Horn raises more questions than answers, no news to these innovative authors, their ideas potentially invite new discourse about symbolic landscape "frames" that can both position and orient site architecture. Implicit at Newark is the theoretical distinction between spiritual power from the periphery, "*intention*", and that flowing outward as "*extension*". The scale of the hill top observation points is still phenomenologically small, however, but could expand with the acceptance of prehistoric surveying. Despite no discourse of such in the Adena-Hopewell, certain alignments at modest landscape scales are mentioned where some sort of technique would have been necessary. Accuracies, however, are less than prehistoric possibilities.

Returning to figure 9, Hively and Horn (2013) and various others, describe the apparent non-astronomical alignment between three tripartite earthworks sites along the Scioto river: Works East, High Bank, and Liberty. It is held that the Circle – Square axis of the middle site, High Bank, aligned with the center points of the other two sites. Yet a prehistorically surveyed line between the two end site center points would pass inaccurately about 0.48º (though within typical astronomical related tolerances) or about 47 meters from the High Bank center point.

Romain observes that the perpendicular to the axis of High Bank itself is identical to the azimuth of the major Observatory Circle – Octagon axis at Newark, and when extended a long distance northeast will hit this feature. He offers no calculation of any land surveyed precision here. As accurate and comprehensive as is Romain's lidar based mapping, one cannot conclude that most sites were positioned by astronomical alignments. The larger scale perpendicular from High Bank to Newark may not have been an observed line as such, but a geometric transfer of some recorded observation azimuth elsewhere, perhaps not dissimilar to the layout of many of his 25 or more mapped earthworks. Some number of these investigated sites of course are only faint traces in the topography, seriously compounding the difficulties of determining whether astronomical alignments were observed in enclosure features themselves, whether points on the natural horizon were involved, or whether azimuths were taken from some more regional mathematical record of symbolically important orientations.

Other intimations of designed longer lines exist in De Boar's (2010) idea that the orientations of earthworks were not to astronomical rises, but to specific allied others in the Scioto – Paint Creek valleys. Though not discussed, this too would have required some sort of surveying techniques to align across obscuring landscape features. Most clearly an artifact, the Hopewell built a fifty-mile road from Newark down to the Chillicothe area. As context, Lepper (2010) provides an anthropological overview of ritually used roads in the New World. Knapp's web site (1998) perhaps best tracks the Hopewell road, beginning at the great axis at Newark and ending just east of Sugarloaf hill near Chillicothe. Neither speak of survey techniques nor alignment accuracies. From the author's mapping of Chacoan roads, however, (see section on the great north road, Chapter 8, 2020b), segments can be perceptually straight, but will vary considerably over longer roughly aligned distances. So too with Mayan *sacbes* laid out to be somewhat linear, but they too are not precise (see rare comments by archaeologists on Mayan surveying in David Stuart's blog 2009)

Testing probabilities of designed patterns among largest scale prominent natural features and conical Adena mounds

Beginning with a list of 104 accurately located sites that included natural features, Hopewell earthworks, Adena mounds and hilltop enclosures--at possible prehistoric surveying accuracies--a very large number of three-point alignments and right-angles (between three points) exist in a larger Adena-Hopewell landscape. Reviewing these mapped patterns, the two "largest" conical mounds, Grave Creek and Miamisburg align with a good topographic point that visually unifies the confluence of the Mississippi, Missouri, and Illinois Rivers; the line is 831.857 km in length. Recalling the relation of the later Cahokia great plaza and city to this confluence, though less accurately a few miles downstream, one's attention considered some possible Adena predecessor. Furthermore, in analyzes in the SW, the locations of earlier great kivas showed greater probability of intentional alignments to prominent natural features and each other. For these reasons and the need to reduce the huge number of existing patterns, Hopewell and hilltop enclosure sites were dropped from the test, instead focusing only on the patterns that Adena mounds make with river confluences and highest mountains.

The location of 26 mostly Adena mounds in relation to smaller scale river confluence points used in the study is shown in figure 10. Four included archaeological points are not large conical mounds, the north and south features at Fort Ancient hill with their sense of formal ritual dualism, the large linear Mound 25 and its unusually large surrounding site at the Hopewell Mound Group, and the Serpent Mound (a point at its midsection) not only because of its Adena dating but its recognition as one of the most important "mound" features in the region. The Rouge mound on the Detroit river is not shown on this smaller scaled map of figure 10. Though not well documented because of its destruction in historic Detroit, it could have been one of very largest mounds, in the range of 400 x 800 ft. (Detroit Urbanism blog, 12/21/2015).

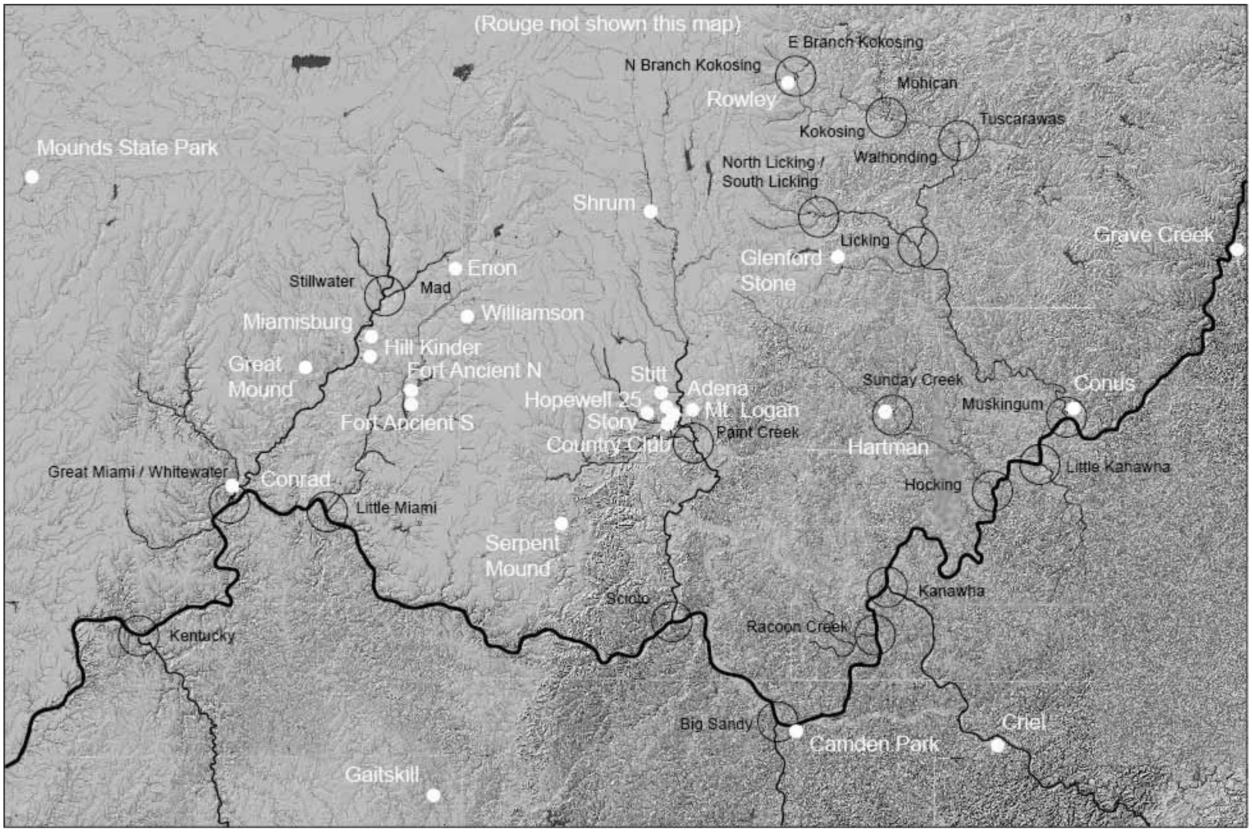


Figure 10. Location of 26 Adena mounds (plus Fort Ancient N. & S., Mound 25, and the Serpent Mound) and smaller scale river confluence points used in the study (circled).

Most mounds are located near rivers, and several reside at or near important confluences, figure 11. These latitude/longitude points will have geologically migrated over two thousand years, though alternative locations for the large number of sites are beyond the scope of the present exercise (Niagara Falls is the exception here). Such differences, however, might only be significant in smaller scale patterns. Additionally, archaeologists may question the sole criterion of “Adena” mound size in the selection of sites, apart from the four exceptions. Certainly, it would be helpful if, like the Tikal test, a mainstream archaeologist had systematically studied sites relating to some larger landscape. Such a list with mound size as a criterion does not apparently exist. When studying mound locations of the largest in Scandinavia (unpublished work) the author crossed the Øresund to Copenhagen to bribe a young IT whiz at their national historical archives to provide a list of the largest conical mounds over 50 meters diameter in Denmark (absent in the literature). His price was four bottles of Chardonnay. It matters not, however, if the present list is incomplete or chosen from too few criteria. The pattern search will

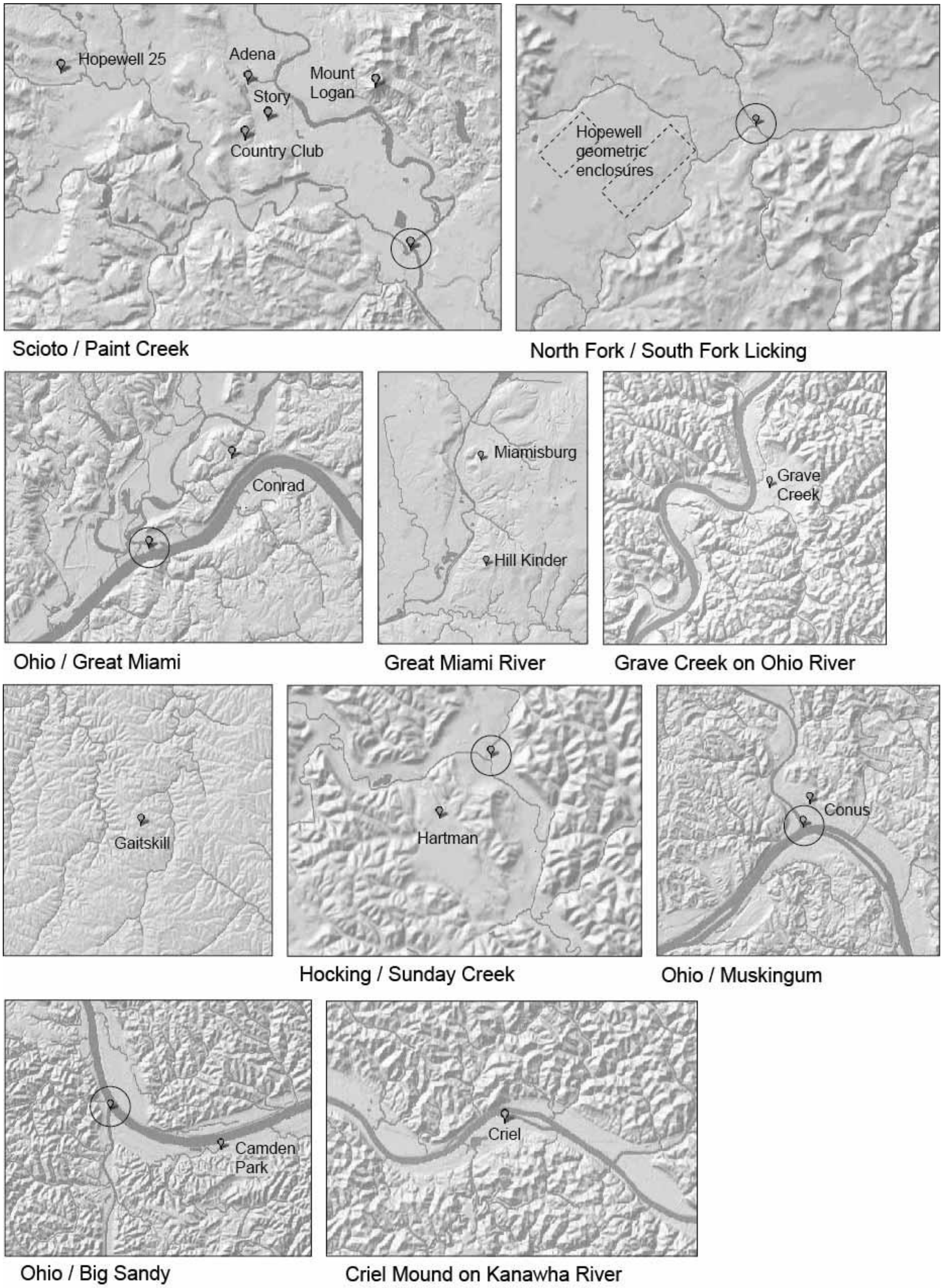


Figure 11. Locations of most prominent mounds in relation to rivers and confluences (circled if used in study).

still be valid because using these kinds of numbers for tests precludes influencing results by cherry picking the inclusion or exclusion of a couple of sites.

The one site intentionally included for its role in an alignment is the mentioned "Pelican Island" in St. Louis, mapped in figure 12. Through trial and error, it is precisely aligned with Grave Creek and Miamisburg. One will see how the Pelican Island point works with *all* the other points of the test which were not chosen for their participation in any pattern.

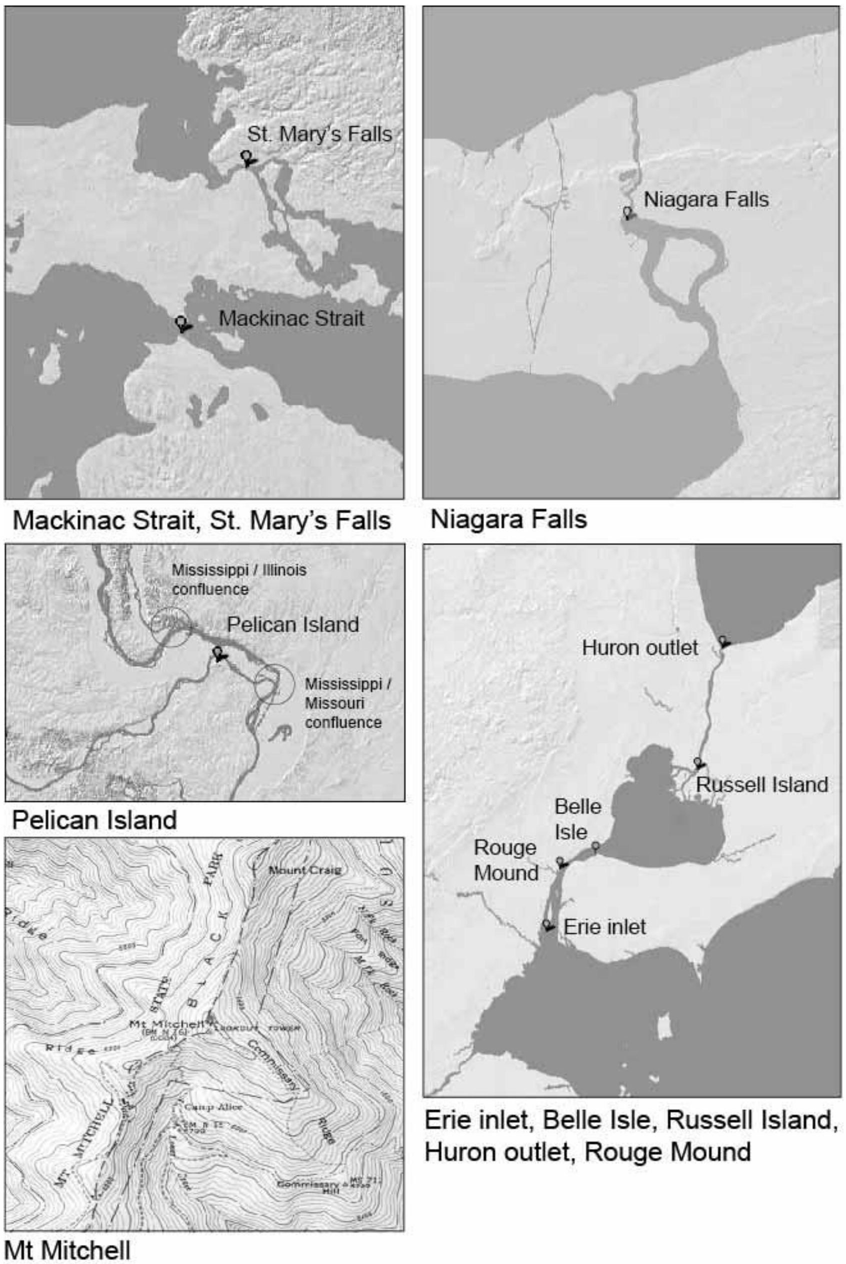


Figure 12. Major large-scale natural features used in the study.

The size of the present paper and limitations of the author's background in this area does not allow for any decent anthropological inclusion of literature on sacred, religious meanings of water in this cultural landscape, e.g. Lankford 1987. Nevertheless, one can assume that the Adena cognitively knew of the locations of most significant, probably symbolic, large scale sites, shown in figure 12. Though not as phenomenologically powerful, there exist possible spiritual high points in the Appalachians. Besides Mt. Mitchell in figure 12, included are Clingman's Dome, often competing with Mt. Mitchell as the highest point west of the Mississippi, and the somewhat lower Cheat Mountain (midpoint of the ridge) and Spruce Knob.

When considering the scale of figure 13, the reader should understand the dotted line circles showing the size of the possible formalized frame in the Ancestral Pueblo world. Just as these Chacoans hauled their timbers from higher regions a hundred kilometers or more, surveying lines at larger distances too would have required considerable work from diverse regional crews. The tripod techniques are the same at longer distances, though these lines, because of the many iterations of straightening will end up being slightly curved because of the great circle that they describe. Considerations of resources expended in surveying at this scale might have been part and parcel to the work and symbolic meaning involved in building large mounds.

Figure 14 lists the latitude/longitude points used in the test: 37 natural and 26 built. One can set the "tolerance" or accuracy at a reasonable number considering work in the SW and Mesoamerica, in this case 0.10º. Again, naked eye visual acuity is about 0.017º, a logical lower limit, and the number at Tikal that worked best in comparison with random phenomena, was 0.15º. These survey related numbers are considerably more accurate than tolerances in archaeastronomy, generally as high a full 2 degrees, though Romain's careful work stays closer to 1 degree on average. The width of the sun and moon is about 0.50°.

Software quickly records existing three-point alignments (figure 14) and ninety-degree angles among the 63 sites (15a, and 15b). Accuracy of a three-point alignment is represented by a single number, the average of the two deviations of interim point from each end of the line (unless the interim point is precisely equidistant). The number for accuracy of ninety-degree angles is the angular spread between azimuths taken from the vertex.

When existing site points within the dotted squares of figure 13 are replaced with equal numbers of randomly located ones, the null hypothesis says that the numbers of patterns of the existing should be well within the range of the random. Ten tests are run for each of the two patterns, each test with 100 sets of different random points in the test squares.

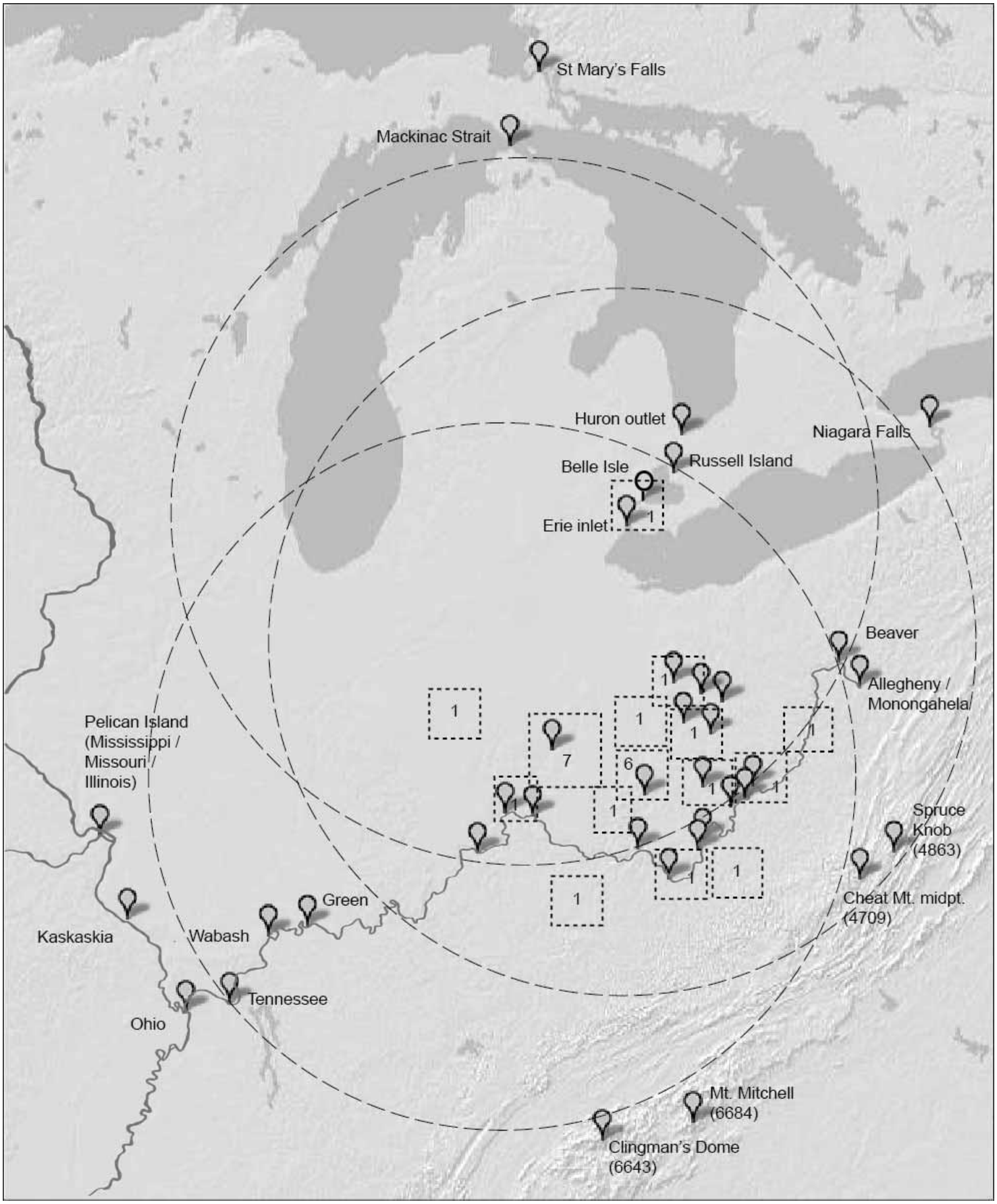


Figure 13. Location of 36 natural feature points used in the study; large dotted circles indicate the scale of possible large-scale surveying among the Ancestral Pueblo (Chaco); dotted squares are

Allegheny / Monongahela 40.44159, -80.01205
Belle Isle 42.34371, -82.96703
Cheat Mt. midpt. 38.41713, -79.99729
Clingman's Dome 35.56292, -83.49860
Erie inlet 42.08854, -83.16444
Hocking / Sunday Creek 39.39217, -82.12345
Huron outlet 43.00465, -82.41394
Kokosing / Mohican 40.36025, -82.16125
Mackinac Strait 45.80918, -84.75266
Mississippi / Kaskaskia 37.97768, -89.94507
Mississippi / Ohio 36.98473, -89.14410
Mt. Mitchell 35.76518, -82.26494
Muskingum / Licking 39.94105, -82.01526
N / E Branches Kokosing 40.48814, -82.53964
NF / SF Licking 40.05336, -82.39171
Niagara Falls 43.08615, -79.06809
Ohio / Beaver 40.69834, -80.28963
Ohio / Big Sandy 38.41541, -82.59504
Ohio / Great Miami 39.10944, -84.81694
Ohio / Green river 37.90249, -87.49786
Ohio / Hocking 39.18489, -81.75442
Ohio / Kanawha 38.83684, -82.13688
Ohio / Kentucky 38.68183, -85.18799
Ohio / Little Kanawha 39.26823, -81.56919
Ohio / Little Miami 39.07700, -84.43259
Ohio / Muskingum 39.40967, -81.45590
Ohio / Racoon Creek 38.72269, -82.19662
Ohio / Scioto 38.73101, -83.01141
Ohio / Tennessee 37.06478, -88.55633
Ohio / Wabash 37.80110, -88.01971
Pelican Island 38.87341, -90.31208
Russell Island 42.61425, -82.52209
Scioto / Paint Creek 39.29518, -82.93356
Spruce Knob 38.69986, -79.53260
St Mary's Falls 46.51474, -84.35577
Stillwater / Mad 39.76913, -84.18566
Walhonding / Tuscarawas 40.27416, -81.87338

Adena Mound 39.35565, -83.00858
Camden Park Mound 38.39777, -82.53101
Conrad Mound 39.14692, -84.77241
Conus Mound 39.41999, -81.45196
Country Club mound 39.33535, -83.00982
Criel Mound 38.36887, -81.69674
Enon Mound 39.87960, -83.93170
Fort Ancient N 39.40701, -84.08974
Fort Ancient S. 39.39950, -84.09463
Gaitskill Mound 38.07254, -83.95080
Glenford Stone Mound 39.87394, -82.31796
Grave Creek Mound 39.91724, -80.74458
Great Mound 39.51563, -84.47628
Hartman Mound 39.37938, -82.13748
Hill Kinder Mound 39.57486, -84.27767
Hopewell Mound 25 39.35959, -83.09518
Miamisburg Mound 39.62761, -84.28091
Mounds St Park 40.09435, -85.62272
Mount Logan Mound 39.35414, -82.94952
Rouge Mound 42.29169, -83.10693
Rowley Mound 40.47333, -82.54213
Serpent Mound midpt. 39.02591, -83.43037
Shrum Mound 39.99001, -83.08054
Stitt Mound 39.44942, -83.03780
Story Mound 39.34226, -82.99926
Willamson Mound 39.74390, -83.82817

Figure 14. Latitudes and longitudes of points used in the study.

<0.02

Ohio/Wabash - Ohio/Little Miami - Allegheny/Monogahela
Serpent Mound midpt. - NF/SF Licking - Niagara Falls
Mackinac Strait - Erie inlet - N/E Branches Kokosing
Ohio/Great Miami - Scioto/Paint Creek - Conus Mound
Ohio/Great Miami - Serpent Mound midpt. - Spruce Knob
Mounds St. Pk. - Miamisburg Mound - Ohio/Kanawha
Pelican Island - Miamisburg Mound - Grave Creek Mound
Clingman's Dome - Story Mound – Russell Island
Erie inlet - Rowley Mound - Hartman Mound
Mounds St. Pk. - Ohio/Great Miami - Mt. Mitchell
Pelican Island - Conrad Mound - Ohio/Hocking
Ohio/Wabash - Shrum Mound - Kokosing/Mohican
Hopewell 25 - Hocking/Sunday Creek - Ohio/Muskingum
Ohio/Scioto - Hocking/Sunday Creek - Ohio/Beaver
Belle Isle - Camden Park Mound - Mt. Mitchell

0.02 – 0.04

Hopewell Mound 25 - NF/SF Licking - Niagara Falls
Mounds St. Pk. - Hill Kinder Mound - Ohio/Racoon Creek
Ohio/Green - Great Mound - Rowley Mound
Country Club Mound - Hartman Mound - Ohio/Muskingum
Erie inlet - Rowley Mound - Glenford Stone Mound
Mackinac Strait - Rowley Mound - Glenford Stone Mound
Mounds St. Pk. - Rowley Mound - Ohio/Beaver
Erie inlet - Glenford Stone Mound - Hartman Mound
Fort Ancient S. - Glenford Stone - Allegheny/Monogahela
Ohio/Wabash - Mounds St. Pk. - Rouge Mound
Fort Ancient N. - Enon Mound - Erie inlet
Fort Ancient S. - Hopewell Mound 25 - Adena Mound
Great Mound - Walhonding/Tuscarawas - Ohio/Beaver
Hill Kinder Mound - Walhonding/Tuscarawas - Ohio/Beaver

0.04 – 0.06

Pelican Island - Mt. Logan Mound - Hartman Mound
Mackinac Strait - Erie inlet - Hocking/Sunday Creek
Mackinac Strait - Stitt Mound - Country Club Mound
Ohio/Kentucky - Stitt Mound - Allegheny/Monogahela
Ohio/Great Miami - Fort Ancient S. - NF/SF Licking
Mississippi/Kaskaskia - Miamisburg - Williamson Mound
Ohio/Green - Miamisburg Mound - N/E Branches Kokosing
Mackinac Strait - Rowley Mound - Hartman Mound
Mt. Mitchell - Criel Mound - Ohio/Muskingum
Pelican Island - Hocking/Sunday Creek - Ohio/Muskingum
Mississippi/Kaskaskia - Enon Mound - Kokosing/Mohican
Fort Ancient N. - Hopewell Mound 25 - Ohio/Little Kanawha
Pelican Island - Hopewell Mound 25 - Ohio/Muskingum
Great Mound - Fort Ancient N. - Ohio/Kanawha
Ohio/Great Miami - Fort Ancient N. - Walhonding/Tuscarawas
Ohio/Big Sandy - Ohio/Kanawha - Ohio/Hocking
Mississippi/Ohio - Ohio/Green - Hill Kinder Mound
Kokosing/Mohican - Muskingum/Licking - Ohio/Hocking
Rowley Mound - Kokosing/Mohican - Walhonding/Tuscarawas

0.06 – 0.08

Mackinac Strait - Erie inlet - Glenford Stone Mound
Mounds St. Pk. - Adena Mound - Cheat Mt. midpt.
Miamisburg Mound - Serpent Mound midpt. - Ohio/Big Sandy
Ohio/Kentucky - Williamson Mound - Niagara Falls
NF/SF Licking - Glenford Stone - Hocking/Sunday Creek
Huron outlet - Grave Creek Mound - Cheat Mt. midpt.
Mt. Mitchell - Criel Mound - Conus Mound
Mt. Logan Mound - Hocking/Sunday Creek - Conus Mound
Miamisburg Mound - Enon Mound - Niagara Falls
Pelican Island - Hopewell Mound 25 - Hocking/Sunday Creek
Pelican Island - Ohio/Kanawha - Spruce Knob
Ohio/Green - Ohio/Kentucky - Adena Mound
Ohio/Kentucky - Ohio/Racoon Creek - Spruce Knob
Mt. Mitchell - Ohio/Racoon Creek - Kokosing/Mohican

0.08 – 0.10

Shrum Mound - Mt. Logan Mound - Mt. Mitchell
Hill Kinder Mound - Mt. Logan Mound - Spruce Knob
Mackinac Strait - Erie inlet - Rowley Mound
Mackinac Strait - Erie inlet - Hartman Mound
Fort Ancient N. - Adena Mound - Ohio/Little Kanawha
Ohio/Tennessee - Serpent Mound midpt. - Grave Creek
Mississippi/Ohio - Miamisburg Mound - Rowley Mound
Ohio/Scioto - Hartman Mound - Ohio/Beaver
Mackinac Strait – Belle Isle – Ohio/Little Kanawha
Mackinac Strait - Glenford Stone Mound - Hartman Mound
Shrum Mound - Conus Mound - Spruce Knob
Ohio/Wabash - Conrad Mound - NF/SF Licking
Conrad Mound - Gaitskill mound - Mt. Mitchell
Rouge Mound - Ohio/Big Sandy - Mt. Mitchell

Figure 15. Accuracies of 76 existing three-point alignments at or below 0.10º among the study points.

N (102)

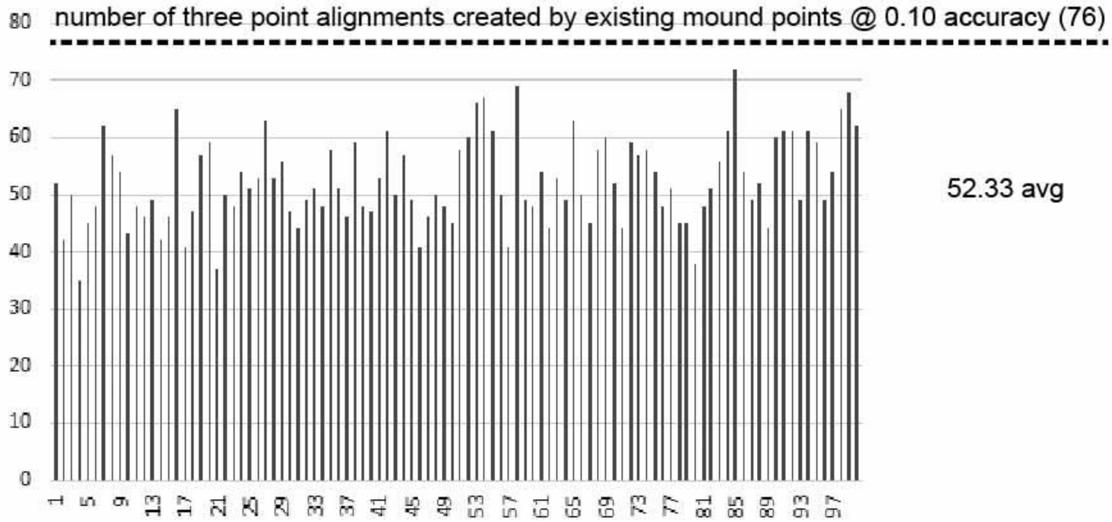
89.998258 **Ohio/Muskingum** - Shrum Mound - Niagara Falls
89.997986 **Rowley Mound** - Kokosing/Mohican - Hopewell Mound 25
89.996083 **Mt. Logan Mound** - Scioto/Paint Creek - Mississippi/Kaskaskia
89.990836 **Criel Mound** - Hill Kinder Mound - Allegheny/Monogahela
89.989532 **Ohio/Hocking** - Gaitskill mound - Glenford Stone Mound
89.984100 **Clingman's Dome** - Ohio/Little Miami - Mt. Mitchell
89.979339 **Williamson Mound** - Shrum Mound - Serpent Mound midpt.
89.979227 **Country Club Mound** - Mt. Logan Mound - Camden Park Mound
89.976720 **Muskingum/Licking** - Adena Mound - Rowley Mound
89.976356 **NF/SF Licking** - Grave Creek Mound - Ohio/Big Sandy
89.976211 **Great Mound** - Huron outlet - Ohio/Racoon Creek
89.973053 **Walhonding/Tuscarawas** - Great Mound - Mackinac Strait
89.970587 **Williamson Mound** – Russell Island - Ohio/Hocking
89.970266 **Ohio/Hocking** - Ohio/Wabash - St Mary's Falls
89.969885 **Ohio/Scioto** - Belle Isle - Ohio/Racoon Creek
89.969054 **NF/SF Licking** - Glenford Stone Mound - Hill Kinder Mound
89.967440 **Mt. Logan Mound** - Ohio/Great Miami - Shrum Mound
89.963079 **Mt. Logan Mound** - Grave Creek Mound - Camden Park Mound
89.960343 **Muskingum/Licking** - Ohio/Hocking - Mississippi/Kaskaskia
89.959954 **Ohio/Little Kanawha** - Mt. Mitchell - Hill Kinder Mound
89.959953 **Ohio/Kanawha** - Ohio/Kentucky - Huron outlet
89.956312 **Conus Mound** - Mt. Mitchell - Stillwater/Mad
89.952918 **Belle Isle** - Spruce Knob - Mississippi/Kaskaskia
89.952685 **NF/SF Licking** - Ohio/Racoon Creek - Shrum Mound
89.952240 **Ohio/Big Sandy** - Serpent Mound midpt. - Grave Creek Mound
89.951956 **Criel Mound** - Ohio/Green - Walhonding/Tuscarawas
89.944448 **Ohio/Racoon Creek** - Ohio/Scioto - Kokosing/Mohican
89.943182 **Muskingum/Licking** - Fort Ancient S. - Mackinac Strait
89.943024 **Niagara Falls** - Ohio/Scioto - Mackinac Strait
89.940978 **N/E Branches Kokosing** - Muskingum/Licking - Williamson Mound
89.933800 **Country Club Mound** - Pelican Island - Erie inlet
89.931430 **Ohio/Scioto** – Belle Isle – Ohio/Racoon Creek
89.927633 **Grave Creek Mound** - Hocking/Sunday Creek - Grosse Ile
89.925605 **Stitt Mound** - Stillwater/Mad - N/E Branches Kokosing
89.923361 **Ohio/Racoon Creek** - Mt. Mitchell - Ohio/Scioto
89.922422 **Hocking/Sunday Creek** - Miamisburg Mound - Muskingum/Licking
89.921558 **Fort Ancient S.** - Belle Isle - Cheat Mt. midpt.
89.920368 **Story Mound** - Glenford Stone Mound - Ohio/Racoon Creek
89.919115 **Ohio/Little Kanawha** - Mississippi/Ohio - Belle Isle
89.917159 **Stitt Mound** - Grave Creek Mound - Story Mound
89.913588 **Camden Park Mound** - Serpent Mound midpt. - Grave Creek Mound
89.912469 **Miamisburg Mound** - Erie inlet - Cheat Mt. midpt.
89.911888 **Scioto/Paint Creek** - Clingman's Dome - Fort Ancient S.
89.911563 **Ohio/Scioto** - Mt. Mitchell - Ohio/Wabash
89.910685 **NF/SF Licking** - Miamisburg Mound - Erie inlet
89.910089 **Muskingum/Licking** - Ohio/Muskingum - Serpent Mound midpt.
89.908731 **Fort Ancient S.** - Ohio/Tennessee - Miamisburg Mound
89.903051 **Hartman Mound** - Ohio/Kentucky - N/E Branches Kokosing
89.902017 **Ohio/Beaver** - Scioto/Paint Creek - Huron outlet
89.901979 **Hartman Mound** - Ohio/Big Sandy - Enon Mound
89.901397 **Serpent Mound midpt.** - Ohio/Tennessee - Enon Mound
89.901044 **Ohio/Racoon Creek** - Mississippi/Kaskaskia - Glenford Stone Mound

Figure 16a. Accuracies of 102 existing ninety-degree patterns at or below 0.10º among the points of the study (less than 90º).

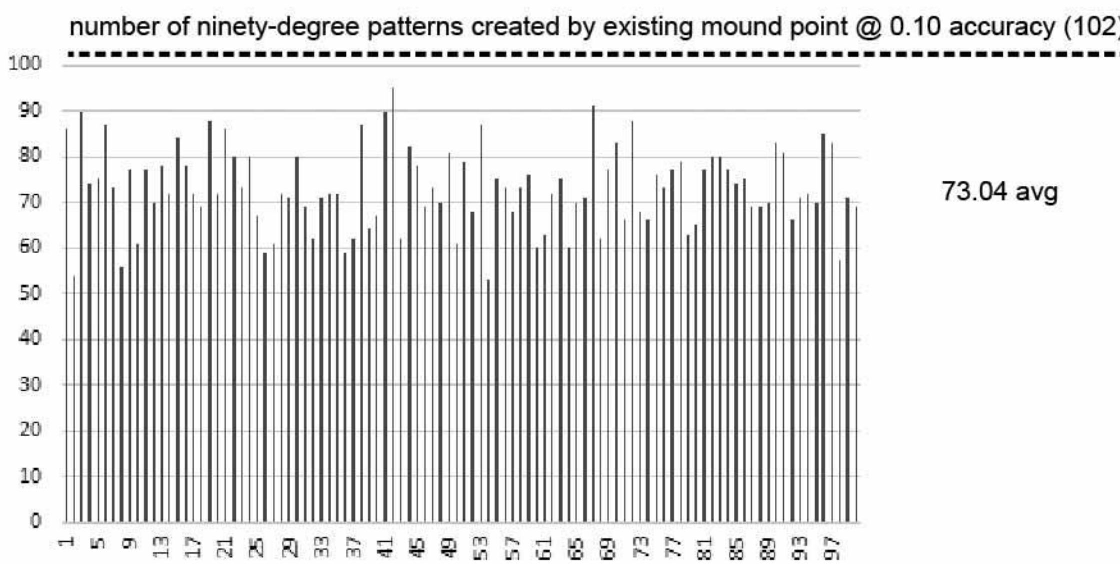
90.003777 **Mt. Logan Mound** - Conrad Mound - St Mary's Falls
90.004739 **Shrum Mound** - Mt. Mitchell - Pelican Island
90.007533 **Ohio/Great Miami** - Gaitskill mound - Ohio/Tennessee
90.007807 **Allegheny/Monogahela** - Scioto/Paint Creek - St Mary's Falls
90.008655 **Walhonding/Tuscarawas** - Hill Kinder Mound - Mackinac Strait
90.010372 **Belle Isle** - Allegheny/Monogahela - Ohio/Green
90.011508 **Walhonding/Tuscarawas** - Spruce Knob - Scioto/Paint Creek
90.011723 **Hocking/Sunday Creek** - Ohio/Racoon Creek - Stitt Mound
90.014196 **Hartman Mound** - Criel Mound - Serpent Mound midpt.
90.015637 **Ohio/Big Sandy** - Mississippi/Ohio - Shrum Mound
90.016690 **Stillwater/Mad** - Kokosing/Mohican - Mt. Mitchell
90.016843 **Ohio/Kanawha** - Camden Park Mound - Hopewell Mound 25
90.017649 **Story Mound** - Grave Creek Mound - Ohio/Big Sandy
90.017680 **Hartman Mound** - Mt. Mitchell - Fort Ancient N.
90.018763 **Ohio/Little Miami** - Ohio/Beaver - Mt. Mitchell
90.021341 **Stitt Mound** - Pelican Island - Shrum Mound
90.023664 **Allegheny/Monogahela** - Spruce Knob - Williamson Mound
90.028400 **Ohio/Big Sandy** - Miamisburg Mound - Grave Creek Mound
90.033894 **Ohio/Muskingum** - Ohio/Green - St Mary's Falls
90.034272 **Shrum Mound** - Ohio/Kanawha - Ohio/Great Miami
90.035291 **Ohio/Little Miami** - Erie inlet - Criel Mound
90.037420 **NF/SF Licking** - Ohio/Hocking - Ohio/Tennessee
90.043192 **Shrum Mound** - Scioto/Paint Creek - Enon Mound
90.043653 **Rowley Mound** - Walhonding/Tuscarawas - Hopewell Mound 25
90.044739 **Fort Ancient S.** - St Mary's Falls - Conus Mound
90.044816 **Hill Kinder Mound** - Rouge Mound - Cheat Mt. midpt.
90.044853 **Williamson Mound** - N/E Branches Kokosing - Camden Park Mound
90.046473 **Ohio/Beaver** - Ohio/Little Miami - St Mary's Falls
90.047230 **Story Mound** - Conrad Mound - St Mary's Falls
90.050171 **Rowley Mound** - Ohio/Little Kanawha - Great Mound
90.051159 **Story Mound** - Walhonding/Tuscarawas - Scioto/Paint Creek
90.054301 **Ohio/Kanawha** - Ohio/Wabash - Rowley Mound
90.055023 **Glenford Stone Mound** - Ohio/Little Kanawha - Adena Mound
90.065637 **Huron outlet** - Niagara Falls - Ohio/Kanawha
90.066815 **Ohio/Big Sandy** - Ohio/Kentucky - Glenford Stone Mound
90.069028 **Walhonding/Tuscarawas** - Mackinac Strait - Ohio/Beaver
90.071223 **Shrum Mound** - N/E Branches Kokosing - Hartman Mound
90.071686 **Ohio/Little Kanawha** - Ohio/Beaver - Cheat Mt. midpt.
90.084902 **Adena Mound** - Ohio/Little Miami - Stitt Mound
90.085940 **Cheat Mt. midpt.** - Mt. Mitchell - Ohio/Little Kanawha
90.088051 **Mississippi/Kaskaskia** - Pelican Island - Conrad Mound
90.092761 **Fort Ancient N.** - Belle Isle - Cheat Mt. midpt.
90.094188 **Mounds St. Pk.** - Camden Park Mound - Ohio/Green
90.094288 **Conus Mound** - Ohio/Green - St Mary's Falls
90.095713 **Ohio/Racoon Creek** - Pelican Island - Hartman Mound
90.096041 **Rowley Mound** - Ohio/Little Kanawha - Ohio/Green
90.096200 **Stitt Mound** - Hartman Mound - Clingman's Dome
90.097894 **Hocking/Sunday Creek** - Ohio/Kanawha - Fort Ancient N.
90.098353 **Adena Mound** - Pelican Island - Erie inlet

Figure 16b. Accuracies of 102 existing ninety-degree patterns at or below 0.10º among the points of the study (greater than 90º).

Numbers of existing three-point alignments (76) and ninety-degree angles (102) are compared with numbers created by randomly located points at or under 0.10º, figure 17. *For alignments, in 1,000 sets the high random number matched the existing once, and never exceeded it.* The first chart of figure 16 shows the alignments of the set among ten which had a high of 72 (the average of the ten ranging from 65 to the one-in-a-thousand 76).



NUMBER COMPARISON OF THREE POINT ALIGNMENTS UNDER 0.10 DEGREES ACCURACY WHEN REPLACING 26 EXISTING MOUND POINTS WITH RANDOM ONES: set of 100 tests where existing mound locations create 76 alignments (ten sets of 100 each were run with random highs ranging from 65 to 76, set illustrated is the average of the ten, 72; thus the number of alignments created by the existing mound distribution, 76, occurred randomly once in 1,000 tests and was not exceeded).



NUMBER COMPARISON OF NINETY-DEGREE PATTERNS AMONG THREE POINTS UNDER 0.10 DEGREES ACCURACY WHEN REPLACING 26 EXISTING MOUND POINTS WITH RANDOM ONES: set of 100 tests where existing mound locations create 102 ninety-degree patterns (ten sets of 100 each were run with random highs ranging from 91 to 102, set illustrated is the average of the ten, 95; thus the number of ninety-degree patterns created by the existing mound distribution, 102, was matched once but not exceeded in 1,000 tests).

Figure 17. Test results comparing numbers of existing geometric patterns with numbers generated by substituted random points.

For right-angles, one notes a significantly greater number of ninety-degree angles (102) at or under 0.10º, than three-point alignments (76). In other work, numbers of ninety-degree angles tend to be much closer to numbers of three-point alignments; both are geometric relationships between three points. Here the random highs in the ten runs ranged from 91 to 102. *The existing number of 102 was matched once and not exceeded in 1,000 sets.* The graph for ninety-degree patterns shown in figure 17 shows the average high set of the ten, 95.

These kinds of probability tests are obviously not sophisticated statistical analyses working from some limited number of examples to predict outcomes. In the present case, there are no example limits, since one can easily run millions of random pattern sets in the same context. This isn't necessary to clearly see that something quite unusual is happening. One logically concludes that among the total list of existing patterns, *some unknown number were likely designed*, thereby deflating the null hypothesis.

Most interesting patterns

For the present, the archaeologist should consider the following maps simply as factual site data, both at smaller and larger landscape scales, rather than any documentation of discursively recognized artifacts. These patterns, if in the record, might someday contribute to a fuller archaeological investigation of cultural landscape.

<u>1. Serpent Mound – Seip – Hopewell – Newark – Niagara Falls</u>

The long line between two of the most symbolically powerful ritual points, Niagara Falls and the Serpent Mound is spatially associated with three culturally important interim sites: the confluence of the North Fork / South Fork Licking River (Newark), the Hopewell enclosure and Mound 25, and the triatic Seip earthworks, figure 18. Note that the point used for Niagara Falls is the approximate location two thousand years ago.

While this paper attempts very little close analysis of particular patterns, one can briefly consider how this line relates to earlier discussion of Newark monuments. The map of this area shown in figure 18, shows the precise prolonged meridian down from the Huron outlet point used in the exercise. Did the Adena also revere meridians involving prominent natural features, not unlike the Ancestral Puebloans and Mesoamericans? If true, the solstice related threshold of the monumental Observatory Circle – Octagon axis may have been positioned on an

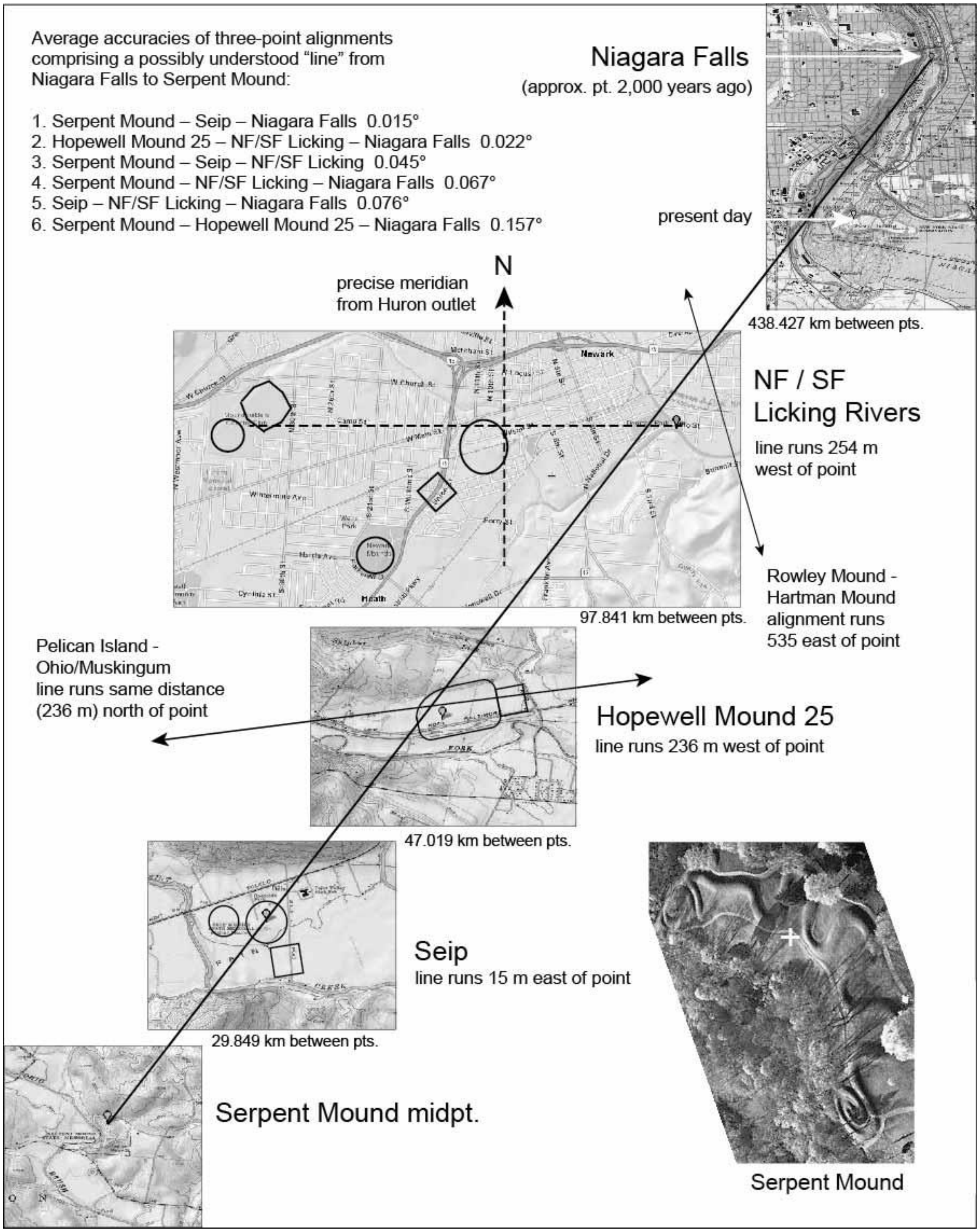


Figure 18. Accuracy of existing line between the Serpent Mound midpoint and Niagara Falls with major interim sites.

east-west line from the confluence point. The intersection of this line with the Huron outlet meridian creates a possible Hopewell "benchmark", relating both to the Huron outlet axis and to the alignment axis of the Ellipse, Wright Square, and Great Circle. At the Hopewell Mound Group, the Niagara/Serpent Mound line isn't as accurate (0.157) to Mound 25 but does run through the western side of the enclosure. And at Seip, the line is extremely accurate with respect to the center of the formal triadic layout.

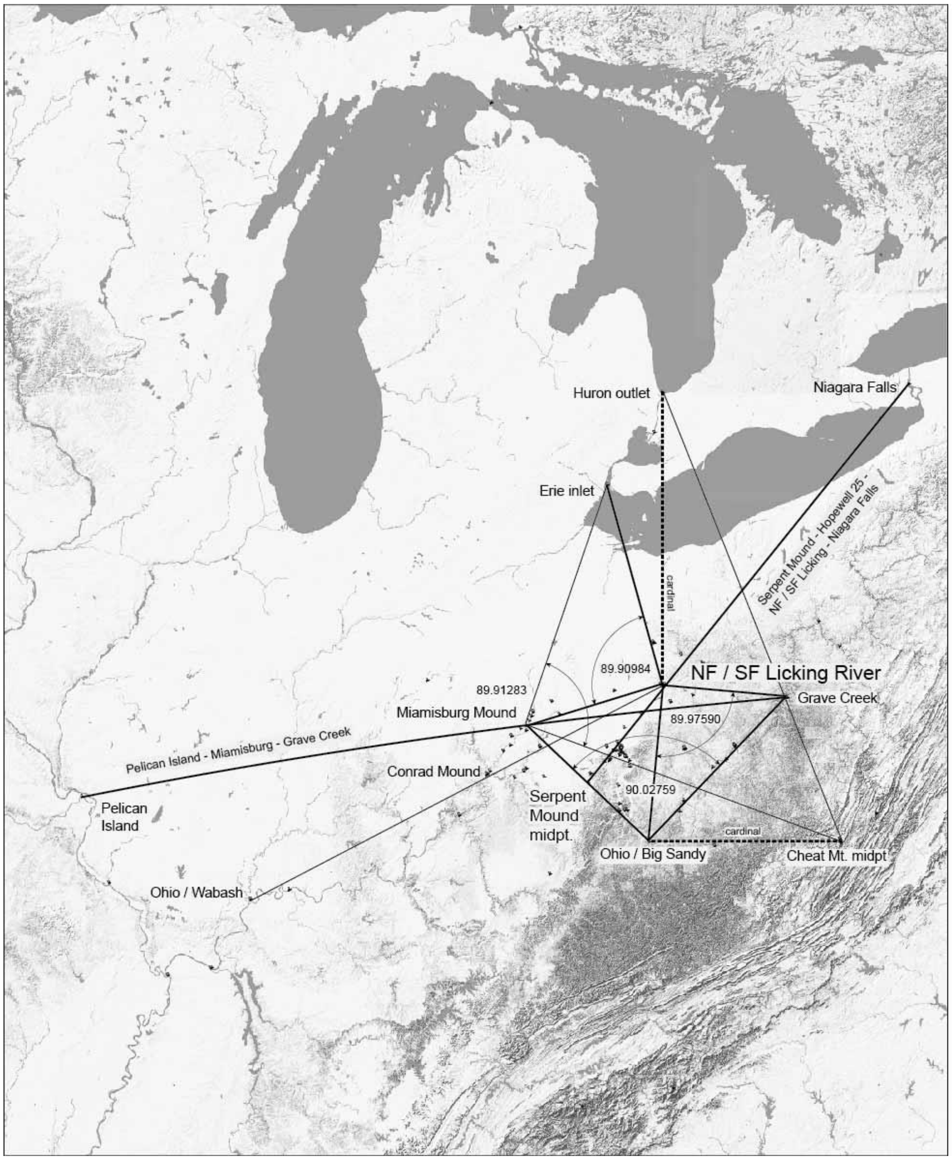


Figure 19. Selected existing patterns associated with the NF / SF Licking River point (Newark)

Given this additional Newark site data for one of the most researched Hopewell areas, it makes sense to describe additional patterns connecting to other cultural and natural points. Figure 19 documents several ninety-degree angles involving Miamisburg, Grave Creek, the confluence of Ohio/Big Sandy, the Erie inlet, Pelican Island, and less formally perhaps the Cheat

Mountain midpoint (the location of the ski area on the ridge). Grave Creek aligns with the Huron outlet—the north point on the Newark meridian—and the Cheat Mountain point. A ninety-degree pattern with the Miamisburg mound as vertex, associates the Erie inlet with Cheat Mountain. The Ohio/Great Miami confluence associates with the Newark confluence point via an alignment to the Ohio/Wabash confluence.

<u>2. Mackinac Strait – Erie inlet – Rowley Mound – Glenford Stone Mound – Hartman Mound</u>
The most accurate multiple three-point alignment pattern is documented in figure 20—a five point alignment in effect--among existing sites at or under 0.10º. This composite alignment of 10 three-point patterns runs from one of the possibly most powerful water thresholds, the strait between Lake Michigan and Lake Huron, and the Wolf Plains community (Hocking River /Sunday Creek). While the location of the interim point at the Erie inlet is less than obvious, given the large distances, minor variations here will not seriously disqualify its accurate participation in this overall line. Most precise is the shorter segment between the three mounds themselves, a 0.059º pattern. Running 64 meters from the Glenford Stone Mound, it comes close to hitting this feature. Again, however, any accuracy number can be random.

Included in figure 20 are the locations of two Hopewell squares near Rowley Mound and one of the more prominent circles at Wolf Plains. These features do not participate in the alignment of the three mounds, but create a second composite alignment between the Hocking / Sunday Creek confluence and the Erie inlet and Mackinac Strait up north. Including the immediate alignment of the Wolf Plains circle chosen (one among many) with the confluence point, the two Hopewell earthwork squares are very accurate in their alignment to the two northern water features.

Other existing patterns connect at Wolf Plains, figure 21. One first surmises a seemingly accurate extension of the five-point alignment south to the large Criel Mound in the Kanawha River community. This extension south is not at all accurate, however. Symbolically more interesting, perhaps, is the very accurate ninety-degree angle from the Hartman Mound as vertex to the Serpent Mound and Criel Mound. Also using Hartman Mound as vertex is a second very accurate pattern to the Fort Ancient N. point, and the Appalachian high point, Mt. Mitchell. The Criel Mound also accurately aligns as interim point with Mt. Mitchell and the Ohio / Muskingum

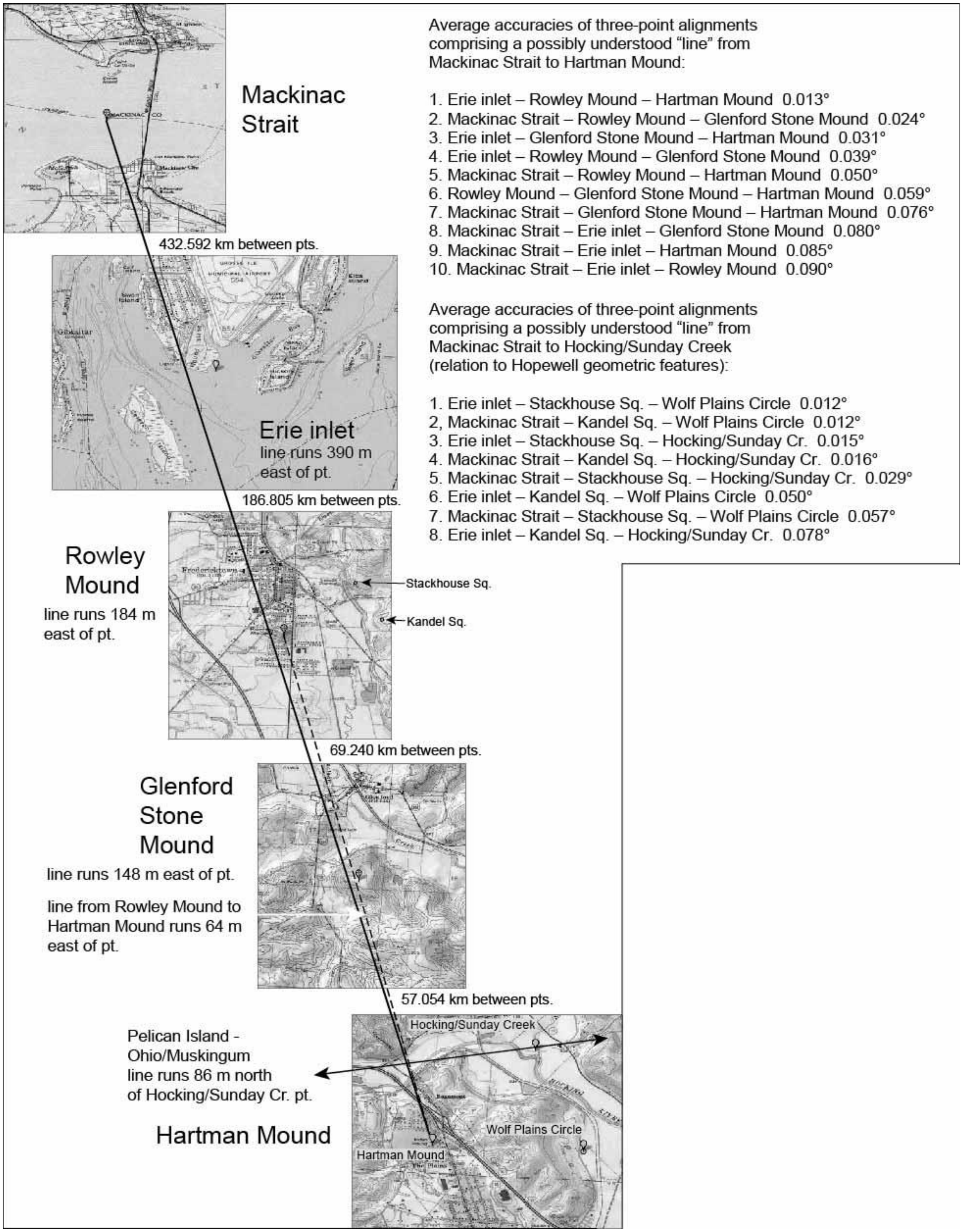


Figure 20. Accuracy of existing line between the Mackinac Strait and Hartman Mound with major interim sites.

confluence point (Marietta). This point in turn runs west to Pelican Island passing accurately through the Hocking River / Sunday Creek confluence (inaccurately north of Hartman Mound).

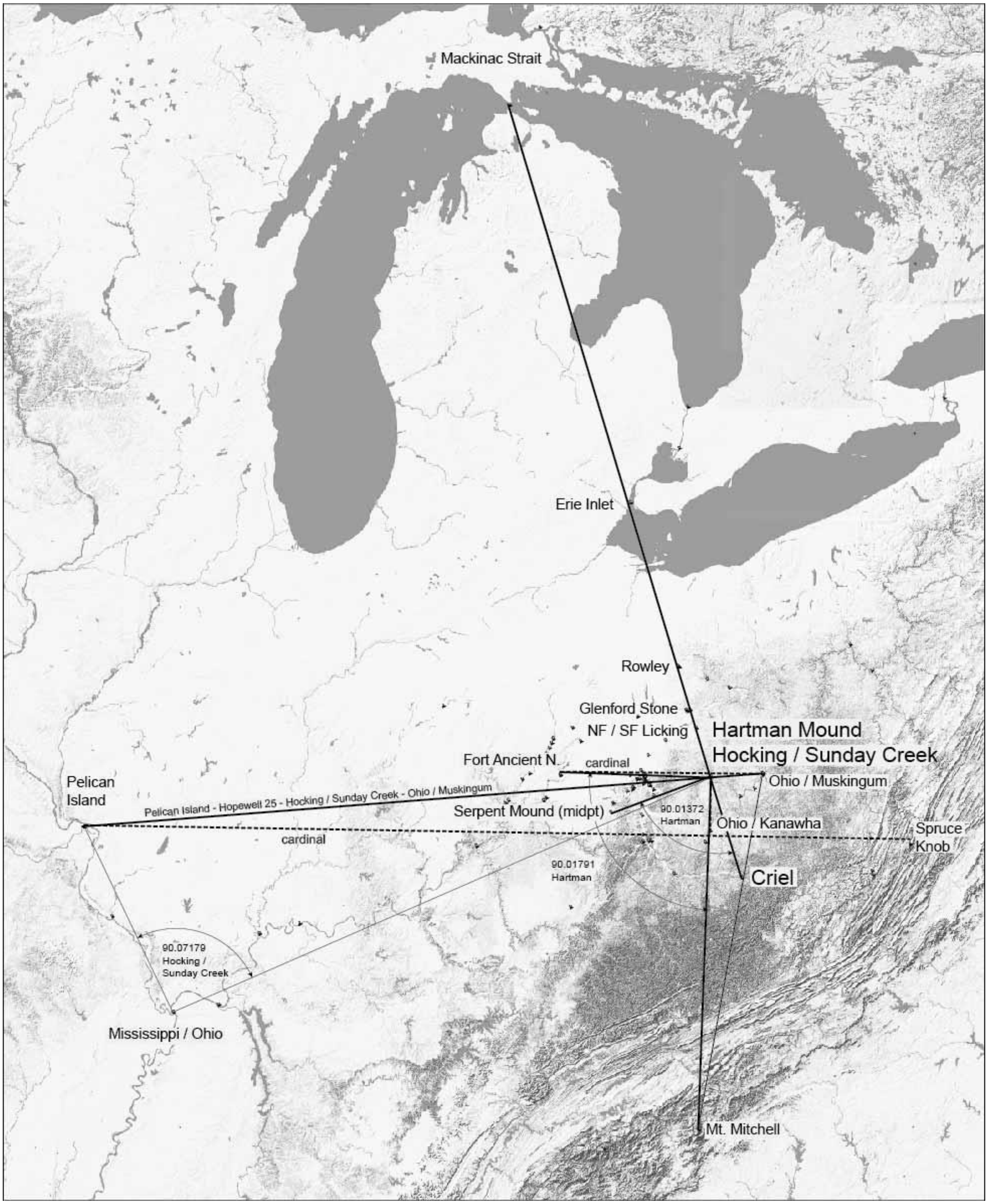


Figure 21. Selected existing patterns associated with the Hocking / Sunday Creek area (Wolf Plains).

3. Pelican Island – Hopewell – Hocking River/Sunday Creek – Ohio River/Muskingum

From the intentionally aligned tri-confluence point "Pelican Island", a line runs accurately through the large Hopewell Mound Group enclosure, east to the Hocking River/Sunday Creek confluence, terminating at the Ohio River /Muskingum point. It does not pass accurately by either the Scioto River / Paint Creek confluence, or the Hartman Mound, as shown in figure 22.

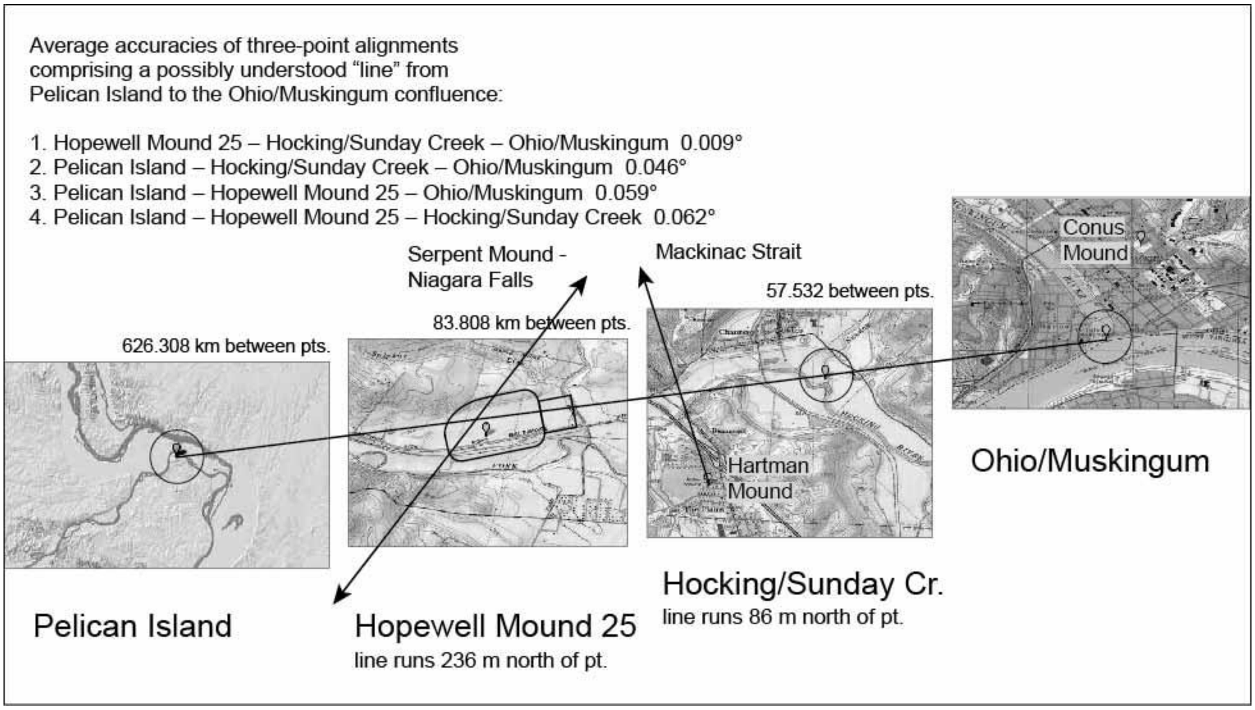


Figure 22. Accuracy of existing line from Pelican Island to Ohio/Muskingum (Marietta) with major interim sites.

Numerous other selected existing patterns associate with the Pelican Island – Ohio/Muskingum line, figure 23. While the Hopewell Mound Group is apparently not an Adena site *per se*, it has a unifying location, including associations to both the Serpent Mound – Niagara Falls, and Mackinac Strait – Hartman Mound (Hocking/Sunday Creek) lines. Elsewhere, given the number of mound sites upstream on the Great Miami River, one seeks existing connecting patterns. Less accurate, but interesting from the perspective of "meridian" symbolism at Chaco and Tikal, is a general north-south relationship between the Mackinac Strait and the Ohio/Great Miami confluence. The precise line from the strait point used presently runs about 1,600 meters west of the Conrad Mound, itself just east of the confluence. The confluence point accurately aligns

Figure 23. Selected existing patterns associated with the Hopewell earthworks (including Mound 25).

with Serpent Mound and Spruce Knob, whose cardinal west runs through the Ohio / Kanawha confluence point and on to Pelican Island (figure 21). These patterns with the Ohio / Great Miami confluence only connect with the Hopewell Mound Group via the Serpent Mound – Niagara Falls line.

A second less than precise meridian exists between the Hopewell Mound Group and the purportedly very large Rouge Mound in historic Detroit. The precise meridian from the tentative Rouge Mound location runs about 850 meters west of the west edge of the 1,180-meter-wide Hopewell enclosure. Roughly on this axis about 70 north of Paint Creek lies the Shrum Mound, whose precise meridian south runs about 420 meters east of the east edge of the Hopewell Mound Group. The importance of the Rouge Mound would lie in its size and location on the threshold Detroit River (between Lake Huron and Lake Erie), while the Shrum Mound has an unusual number of right-angles to important sites. One extends from the site as vertex out to Pelican Island and ninety degrees to both the Mt. Logan Mound and Mt. Mitchell which, with the Shrum Mound form a three-point-alignment. Another right angle connects the Ohio/Great Miami point with Ohio/Kanawha. Two other vertexes work with side angles to the Shrum Mound, one from Ohio/Big Sandy (other leg to the Mississippi/Ohio), and Ohio / Muskingum (other leg to Niagara Falls).

Conclusion

A good probability exists that among three geographically large prehistoric cultures in the New World - Chaco, Maya, and Adena - *some* geometric patterns among prominent natural features and ceremonial sites were designed and surveyed at large scales of landscape. In the Adena it is also highly likely that these symbolic, probably ritually related patterns expressed the spiritual power of major water features. Unlike the Southwest Puebloans or Mesoamericans, however, specific patterns among the many used in probability tests cannot yet be integrated into any unified "cosmic" frame (as hypothesized in Chacoan and Mesoamerican landscapes).

This exploratory paper could expand the scale at which anthropological researchers consider religiously formalized social organization in the Adena – Hopewell landscape. Useful might be the theoretical idea of "intension" – "extension", where ceremonial sites may have been positioned by "spirit" lines flowing from great natural features on the periphery, rather than by more territorial manipulation at much smaller scales of social space. At present, the mapping of astronomical observation among Hopewell enclosures as ritual timing—skillful as it is--tends to leave the impression of “extension”, where an expressive observation effect comes primarily from projecting earthwork features out to modest rise/set phenomena in the local viewshed.

One technical hurdle in future research is the possibility that GIS based applications are not particularly well adapted for more vector oriented, large scale, essentially design analysis of relationships among precise points. Some fifteen years ago, the author hired a GIS expert working with academic units at the University of Arizona to create a vector-based application. At the end of some 3K, it couldn’t be done (at that time). Finally, a small software company with a principal with an academic background in mathematics was found. Also unanswered in this paper is how Hively & Horn’s and Romain’s software overlay with that presently used?

Above all, large scale cultural landscape work in anthropology should focus on how major ceremonial sites are symbolically positioned, common ecological determinants notwithstanding. Despite remarkable mapwork by Hopewell archaeoastronomers, the larger scale landscape location of these enigmatic geometric enclosures does not seem to be determined primarily by astronomical aspects of their religion. Research needs to understand in greater detail interesting large-scale patterns that exist between Hopewell enclosures, prominent natural features, and Adena mounds. Might, for example, the greater number of existing right-angle patterns than three-point alignments among the mounds somehow lead to additional understanding of the Hopewell squares? Beyond confirmed astronomically oriented elements, could square earthworks symbolize large-scale right-angle patterns laid out collectively in their religious past?

Will future research be able to determine that like hypothetical Chaco and Mesoamerica, a landscape frame or frames provided the religious impetus and social organizational purpose to journey large distances to build mounds as part of pilgrimage ritual?

REFERENCES CITED

Bernardini, Wesley. 2003. Hopewell geometric earthworks: a case study in the referential and experimental meaning of monuments. *Journal of Anthropological Archaeology* 23 (2004) 331-336.

Bradley, R. 2006. Can archaeologists study prehistoric cosmology? In Andrén, Anders; Jennbert, Kristina; and Raudvere, Catharina (eds) *Old Norse Religion in Long-Term Perspective*. Lund: Nordic Academic Press, pp. 16-20.

Carlsen, Robert 2009. Footpath of the Dawn, Footpath of the Sun: Maya Worldview at Lake Atitlán. *In Maya worldviews at conquest*. Leslie G. Cecil and Timothy W. Pugh (Eds.). Boulder: University Press of Colorado, pp. 298-314.

DeBoer, Warren 2010 Strange sightings on the Scioto." *In Hopewell settlement patterns, subsistence, and symbolic landscapes*, edited by A. Martin Byers and DeeAnne Wymer, pp. 165-198. University Press of Florida, Gainesville.

Detroit Urbanism blog (Dec. 21, 2015). The Mound Builders. http://detroiturbanism.blogspot.com/2015/12/the-mound-builders.html (accessed 9/24/2019)

Doxtater, Dennis 2020a. *Minnesota Matrix: "non-discursive" alignments of immigrant churchyards on center lines in a New Norwegian Landscape, ca 1870-1900.* (under review by University of Minnesota Press).

-------------------- 2020b. *Chaco's place in a formalized landscape: design and surveying of large- scale geometries as ritual practice* (book under review by University of Colorado Press).

-------------------- 2020c. *Designing the Olmec Frame: sacred surveying of Mesoamerican volcanos, pyramid shaped landscape domains, major site locations, hearth maps and positioning of site features and orientations*. (recently completed manuscript).

-------------------- 2019a. "Axis Mundi" in *Encyclopedia of Vernacular Architecture of the World* (forthcoming revised edition), Bloomsbury, UK.

-------------------- 2019b. "Norwegian-American" in *Encyclopedia of Vernacular Architecture of the World* (forthcoming revised edition), Bloomsbury, UK.

-------------------- 2009. Rethinking the Sacred Landscape: Minoan Palaces in a Georitual Framework of Natural Features on Crete. *Landscape Journal* 28:1, pp. 1-21.

-------------------- 2007. A Report on Geopatterns Software: describing and analyzing large-scale geometry between Chacoan and natural sites. In *Digital Discovery: Exploring New Frontiers in Human Heritage*. CAA 2006, pp. 200-216.

-------------------- 2003. Parallel Universes on the Colorado Plateau: Indications of Chacoan Integration of an Earlier Anasazi Focus at Canyon De Chelly. *The Journal of the Southwest* Vol 45, No. 1 & 2, Spring/Summer, pp. 33-62.

-------------------- 2002. A Hypothetical Layout of Chaco Canyon Structures Via Large-Scale Alignments Between Significant Natural Features. *Kiva* Vol. 68, No. 1: 23-47

--------------------1991. Reflections of the Anasazi Cosmos. *Social Space*. edited by Gron, Engelstad and Lindblom, Odense University Press, Odense. pp. 155-184.

--------------------1990. Socio-Political Change and Symbolic Space in Norwegian Farm Culture after the Reformation. In *On Vernacular Architecture: Paradigms of environmental response.* Mete Turan (ed) Ethnoscapes Series, Vol. 4. London: Gower.

--------------------1984. Spatial Opposition in Non-Discursive Expression: Architecture as a Ritual Process. *Canadian Journal of Anthropology*, Vol. 4, No. 1 Summer, pp. 1-17.

--------------------1981. *The Symbolism, Structure and Politics of "Center" in the Old Scandinavian Farm Culture.* Dissertation: University of Michigan, Ann Arbor.

------------------ 1978. The Hopi Ritual Landscape. In *Megaliths to Medicine Wheels: Selected Papers of the 11th Annual Chacmool Archaeology Conference*, pp. 313-331. University of Calgary Press, Calgary

Doyle, James, A. 2012. Regroup on "E-groups": Monumentality and Early Centers in the Middle Preclassic Maya Lowlands. *Latin American Antiquity*, Vol. 23, No. 4, pp. 355-379.

Eiseman, Fred. B. Jr. 1959. The Hopi Salt Trail. *Plateau*, Vol. 32, No. 2, pp. 25-32.
Ellis, A. 1991. Towers of the Gallina Areas and Greater Southwest. In *Puebloan Past and Present: Papers in Honor of Stewart Peckham.* Duran, M. S. and Kirkpatrick, D. T. (eds) pp. 57-70. Albuquerque: Archaeological Society of New Mexico.
Fowles, Severin M. 2009. The enshrined Pueblo: villagescape and cosmos in the Northern Rio Grande. *American Antiquity* 74(3), pp.448-466.
Gallo, I.M. 2004. Roman Surveying. *Proceedings of the European congress "Las Obras Públicas Romanas"*. Tarragona, Spain.
Gossen, Gary: 1972. "Temporal and spatial equivalents in Chamula ritual symbolism". *Reader in Comparative Religion,* William Lessa & Evon Vogt (eds). New York: Harper and Row, pp. 135-148.
Hayes, A.C. and Windes, T.C. 1975. An Anasazi Shrine in Chaco Canyon, in *Papers in Honor of Florence Hawley Ellis,* ed Frisbie, T.R, 143-156. Santa Fe: Papers of the Archaeological Society of New Mexico, No. 2.
Hively, Ray & Horn, Robert 2013. A New and Extended Case for Lunar (and Solar) Astronomy at the Newark Earthworks. *Midcontinental Journal of Archaeology*, Vol. 38, No. 1 (Spring), pp. 83-118.
Hively, Ray & Horn, Robert. 1982. Geometry and Astronomy in prehistoric Ohio. *Archaeoastronomy*, no. 4, pp. 1-20.
Kelly & Francis 2005. Traditional Navajo Maps and Wayfinding, *American Indian Culture and Research Journal*, Vol. 29, No. 2, pp. 85-111.
Knapp, Joseph M. 1998. On the Great Hopewell Road. (website accessed 9/24/2019)
Lange, Richard C. 2001. Tactful tactical insights from the Sierre Ancha, East-Central Arizona. *The Arizona Archaeologist*, 32: 67-76.
Lankford, George E. 1987, editor. *Native American Legends*. August House, Little Rock, Arkansas.
Lekson, S. 1999. *The Chaco Meridian*. Walnut Creek: Altimira Press.
Lepper, Bradley T. 2010. The Ceremonial Landscape of the Newark Earthworks and the Raccoon Creek Valley. In *Hopewell settlement patterns, subsistence, and symbolic landscapes*, edited by A. Martin Byers and DeeAnne Wymer, pp. 97-127. University Press of Florida, Gainesville.
Lewis, M. J. T. 2001. *Surveying Instruments of Greece and Rome*. Cambridge University Press, Cambridge.
Lindström, Jonathan 1997. The Orientation of Ancient Monuments in Sweden: A Critique of Archaeoastronomy and an Alternative Interpretation. *Current Swedish Archaeology*, Vol 5. Pp 111-125.
-------------------------2005. Påsk, höstblot och jul: sambandet mellan årliga högtider och forntida gravars orienteering. *Fornvännen* 100. pp. 13-28
Marshall, James A. 1980. Geometry of the Hopewell earthworks. *Ohio Archaeologist*, Vol. 30, issue 2, pg. 8 – 12.
O'Carroll, M.J., 1979. On the probability of general and concurrent alignments of random distributed points. *Science and Archaeology* no. 21.
Oestigaard, T. and Goldhahn, J. 2006. From the Dead to the Living: Death as Transactions and Re-negotiations. *Norwegian Archaeological Review*, Vol. 39, No. 1. pp. 27-48.
Ortiz, Alfonso. 1969. *The Tewa world: Space, time being and becoming in a Pueblo society*. University of Chicago Press, Chicago.

Papadopoulos, Jason 2003. Ley Lines and Coincidence. Web publication (www.boo.net/~jasonp.leyline.html), accessed 2008.
Romain, William F. 2015. *An Archaeology of the Sacred Adena-Hopewell Astronomy and Landscape Archaeology* (The Ancient Earthworks Project, www.amazon.com).
Schele, Linda & Freidel, David. 1990. *A Forest of Kings: the Untold Story of the Ancient Maya*. William Morrow, New York.
Scully, Vincent 1962. *The earth, the temple, and the gods: Greek sacred architecture*. New York, Praeger.
Snead, James E. & Preucel, Robert W. 1999. The ideology of settlement: ancestral Keres landscapes in the Northern Rio Grande. In Ashmore, Wendy & Knapp, B ernard A. (eds) *Archaeologies of Landscape*. Oxford: Blackwell Publishers, pp. 169-197.
Söderman, I. 1989. *Från lertavla till satellitbild*. Uppsala: Geographica.
Stanzione, Vincent James 2003. *Rituals of Sacrifice: Walking the Face of the Earth on the Sacred Path of the Sun, A Journey through the Tz'utujil Maya World of Santiago Atitlán.* Albuquerque: University of New Mexico Press.
Stuart, David 2009. *Maya Decipherment* (web blog April 30, accessed 5/16/2018).
Swanson, S. 2003. Documenting Prehistoric Communication Networks: A Case Study in the Paquime Polity. *American Antiquity*, 68 (4), 753-767.
Toohey, Jason L. 2013. Feeding the Mountains: Sacred Landscapes, Mountain Worship, and Sacrifice in the Maya and Inca Worlds. *Reviews in Anthropology*, 42:161-178.
Wilbert, Johannes. 1993. *Mystic Endowment: Religious Ethnography of the Warao Indians.* Harvard University Center for the Study of World Religions, Cambridge.
Williamson, Tom, & Bellamy, Liz. 1983. *Ley Lines in Question*. Surrey: World's Work Ltd.
Wills, W. H. 2000 Political Leadership and the Construction of Chacoan Great Houses, 1020-1140. In *Alternative leadership strategies in the Prehispanic Southwest*, ed. Barbara J. Mills, pp. 19-44.
Wilson, Richard 1995. *Maya resurgence in Guatemala: O'eqohi' experience*. Norman: University of Oklahoma Press.
Windes, Thomas C., Anderson, Rachel, Johnson, Brian K., and Ford, Cheryl (2000) 'Sunrise, Sunset: Sedentism and Mobility in the Chaco East Community', in John Kantner and Nancy Mahoney (eds) *Great House Communities Across the Chacoan Landscape,* pp. 39-56. Tucson: The University of Arizona Press.
Witherspoon, Gary and Peterson, Glen. 1995. *Dynamic Symmetry and Holistic Asymmetry in Navajo and Western Art and Cosmology*. Peter Lang, New York.