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Chapter 1

Indiana Earthwork Sites

New Insights from LiDAR DEMs and Aerial Photographs

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Though not as well known for its Woodland period earthwork sites as neighboring Ohio, Indiana has dozens of earthworks spread all across the state. One of the larger concentrations occurs in a five-county area between the towns of Anderson, Richmond, and Winchester. These sites range from sizeable, lone squares to large clusters of small geometric enclosures, and they have been the focus of much archaeological attention, including early mapping campaigns in the nineteenth century. Large excavation efforts in the latter half of the twentieth century and into the twenty-first have yielded substantial amounts of subsurface information and select radiocarbon dates, making these some of the more intensively studied earthworks in the Middle Ohio Valley.

Mapping the shapes and layout of the enclosures has been a common theme for many of the previous site investigations. As mapping instruments have improved, so too have the site maps. Unfortunately, site preservation in the twentieth century quickly outpaced the capacity of local archaeologists to employ the latest mapping technologies before the effects of plowing and other types of erosion had diminished the earthworks so much that surface mapping was seemingly a thing of the past. However, new remote sensing data made available in the

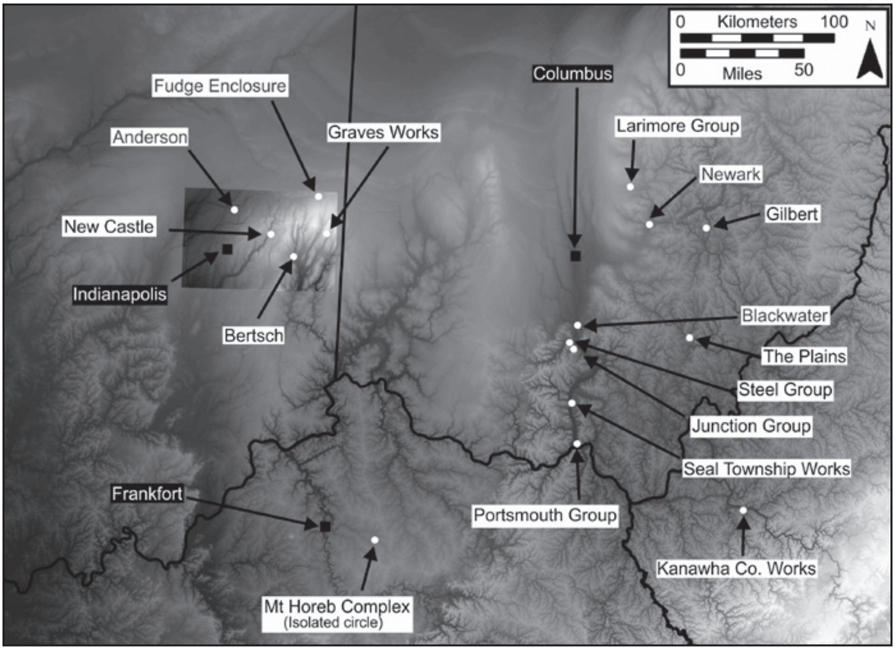

Figure 1. Sites mentioned in the text on a DEM of the Middle Ohio Valley.

last few years, in the form of Light Detection and Ranging (LiDAR) digital elevation models and aerial photography, are shedding new light on some of the most fundamental aspects of Indiana's earthwork sites, including the number, shape, and arrangement of enclosures.

New kinds of remote sensing data such as LiDAR data, satellite imagery, and drone-based images and photogrammetry have sparked a global archaeological revolution in reexamining the surfaces of sites for previously unseen topographic and visual details (e.g., see chapters in Comer and Harrower 2013; Corsi et al. 2013; Opitz and Cowley 2013). In this chapter, we bring some of these same kinds of remote sensing data and techniques to bear on the examination of five well-known Indiana earthwork sites: Anderson Mounds, New Castle, Bertsch, Fudge Works, and the Graves Enclosure (Figure 1). Using a mix of hillshade maps and localized digital elevation models, we reveal some of the clearest views yet of the enclosures at these sites. From redefining the shapes of many site features to finding completely new enclosures, this latest mapping effort at a selection of Indiana earthwork sites shows that we still have a lot to learn about these sites, even at the most basic level.

METHODS

The digital elevation models used in this project were created using LiDAR-based elevation data. While this technology is used for scanning objects, buildings, and other features on the ground, the topographic data presented here were collected from airplane-based LiDAR platforms. Along with drone-based photogrammetry, LiDAR is one of the latest ways to make relatively high resolution topographic maps of the landscape, and many states in the US have had LiDAR data flown and provide the data to the public for free. In Ohio it has revolutionized the visualization and analysis of topographically evident earthwork sites (e.g., Romain and Burks 2008a, 2008b, 2008c).

LiDAR data capture subtle topographic changes in the landscape by transmitting hundreds of thousands of light pulses per second and recording the time it takes for the reflected pulses to return to a receiver (Campbell and Wynne 2011; Opitz 2013). The elevation of the plane is measured with a high-grade global positioning system. The resulting laser pulse return time can be used to create a Digital Surface Model (DSM) of the Earth's surface, which includes all features "seen" by the LiDAR: trees, houses, cars, etc. Computer software is then used to analyze the LiDAR returns and assign each pulse a generic classification: usually ground, water, high vegetation, or unassigned. In addition, each LiDAR pulse can have more than one return, so the computer software assigns each pulse a return number as well (e.g., first, second, third, . . . , last). By filtering out all non-ground returns, the software can then create a Digital Elevation Model (DEM), otherwise known as a bare earth model. The DEMs and DSMs can be viewed as raster data sets, that is, colorized pixels. A raster data set consists of a grid of squares of a designated size (e.g., all LiDAR-rendered raster images used in this chapter have a resolution of one foot), and a color ramp applied to these data displays elevation differences as color differences.

Specialized software is needed to manipulate raw LiDAR point and raster data. All LiDAR rendered images in this chapter where created and manipulated from one data source: the Indiana Spatial Data Portal (ISDP) housed by Indiana University (ISDP 2014). Data presented in this chapter were collected in several counties (Henry, Madison, Randolph, and Wayne) by Woolpert, Inc. in 2012. The final product distributed by the State of Indiana has a resolution of one meter, meaning the spacing between data points averages one meter (ISDP 2014). Woolpert also classified the LiDAR data into four classes and ten returns. The classification codes include unassigned, ground, noise and overlap; the return classifications are first, second, third, fourth, last, single, first of many, last of many, and all. ArcGIS 10.2 was used to filter the LiDAR points by classification; the DEMs were then created from the filtered data. We used interpolation to increase the native data density from one elevation per meter to one elevation per foot.

Viewing DEMs with software such as ArcGIS or Surfer is straightforward, and some vertical exaggeration or a virtual, low-angle light source can help reveal subtle topography (Kokalj et al. 2013). But large scale DEMs tend to hide the small surface details often associated with earthworks, especially if a single color ramp of 256 shades of gray, for example, is used for viewing a large area. Hillshade renderings of the DEMs provide a means to circumvent the problem of missing details, and this imaging technique is used later in this chapter for the images related to the Anderson, Fudge, Graves, and New Castle sites. But even hillshade maps can miss small, subtle features. We first examined the hillshades to locate possible evidence of earthworks, then reduced the area of the DEM to focus in on each enclosure, separately. Making individual maps of each enclosure, each with their own color ramps, allowed for more of the subtle variability within each enclosure to be visible. The figures of the Anderson and New Castle sites include insets created in ArcGIS 10.2 that contain individual elevation areas for each earthwork or cluster of earthworks. The Bertsch site presented a challenge in that very little of the site appeared topographically evident in the LiDAR data; the site is quite flat, except for the larger enclosures. Therefore, we turned to aerial photographs to look for evidence of enclosures. This was not an option for New Castle and Anderson, which have been covered by trees and buildings (at New Castle) for quite some time. Individual enclosures were quite distinct in newer aerial photographs located for Bertsch. A 2007 photograph, obtained from the United States Department of Agriculture's (USDA) National Agriculture Imaging Program (NAIP) and accessed through the USDA National Resources Conservation Service's (NRCS) Geospatial Data Gateway (USDA-FSA), was the most useful.

The following sections present the results of our topographic and aerial photo investigations by site. Additional background details for each site are also provided. A subsequent discussion section highlights some of the important new results.

ANDERSON MOUNDS

Anderson Mounds is a well-preserved complex of earthworks located in Mounds State Park, overlooking the White River in Madison County, Indiana (Cochran and McCord 2001). As interpreted most recently, the complex consists

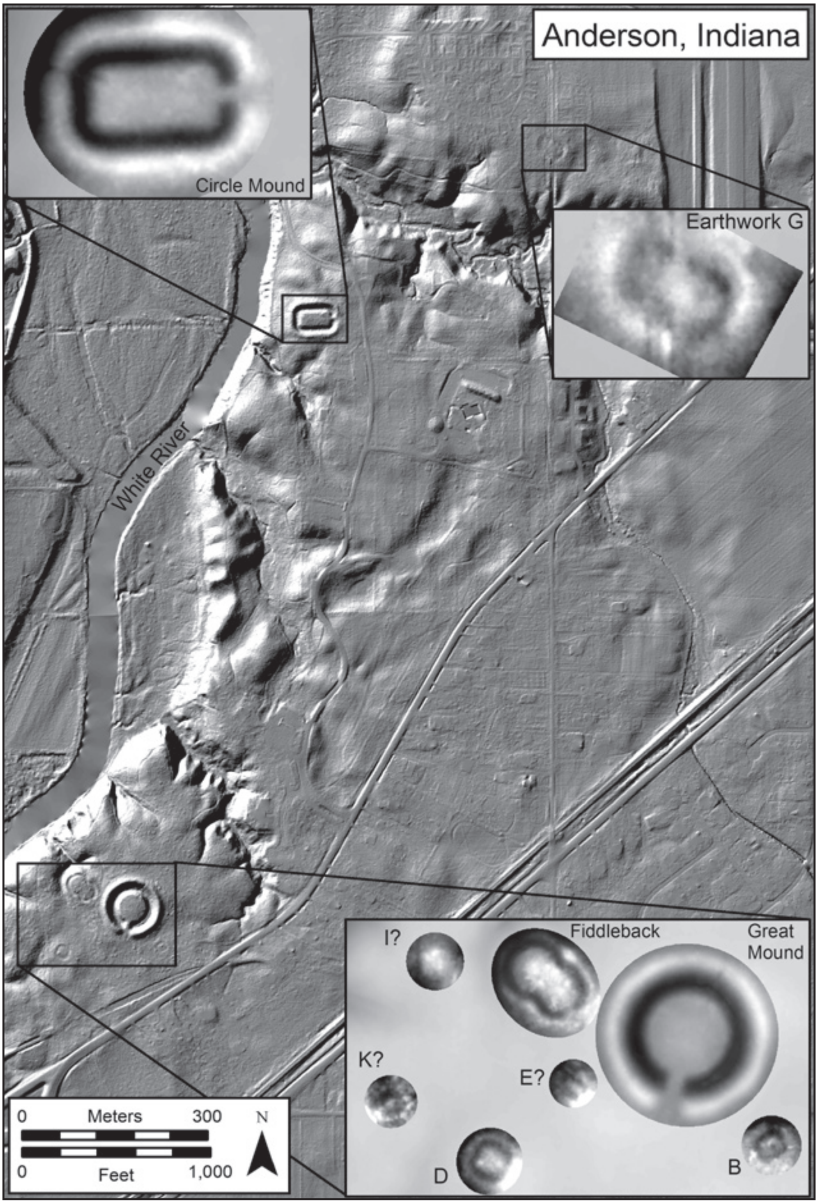

Figure 2. Anderson Mounds DEM with detail insets for individual enclosures.

of one large circle, the Great Mound; a well-preserved rectangle with rounded corners, the Circle Mound; a poorly preserved rectangle with rounded corners, Earthwork G; one panduriform, the Fiddleback Mound; and at least two other small squares known as Earthworks B and D. There may be three additional small enclosures, Earthworks E, I, and K (Figure 2; Table 1). The enclosures located within Mounds State Park are fortunate to have survived relatively unaltered from their original form; the enclosures located outside Mounds State Park have not fared as well, particularly Earthwork G, which has a road cutting through it. For the history of Mounds State Park see Cochran and McCord (2001).

Table 1. Enclosure areas for the Anderson Mounds site.*

Enclosure Name	Shape	Area (m²/acres)
Great Mound	Circle	2182.6/0.54
Enclosure B	Square/Rectangle	114.6/0.03
Enclosure D	Square/Rectangle	273.1/0.07
Fiddleback	Panduriform	909.5/0.22
Enclosure E?	Square/Rectangle	66.4/0.02
Enclosure K?	Square/Rectangle	59.4/0.01
Enclosure I?	Square/Rectangle	313.1/0.08
Circle Mound	Square/Rectangle	1436.9/0.36
Enclosure G	Square/Rectangle	442.4/0.11

* Measurements of space inside inner edge of ditch.

Documentation and excavation of Anderson Mounds began as early as the 1890s and continued sporadically up to 1999 (Cochran and McCord 2001; and McCord and Cochran 2008). Ball State University conducted the majority of the excavations in the 1960s and again in the 1990s (Cochran and McCord 2001). Radiocarbon dates from the Ball State University excavations indicate that the area of the platform within the Great Mound served as a ceremonial space as early as 250 BC and that the circular ditch and embankment enclosed that space about 100 years later in 160 BC (Cochran and McCord 2001). The 1960s Ball State University excavations uncovered a burial location on the platform of the Great Mound. The burial consisted of a log tomb containing a bundle burial covered with bark and a cremation burial. Within the log tomb, the excavations recovered flint flakes, fire-cracked rock, a plain-surfaced pot sherd, mica fragments, and a platform pipe. Charcoal associated with one of the burned logs produced a radiocarbon date of AD 50 (Cochran and McCord

2001). In addition, excavations found a copper breastplate and a Snyders point in mound fill above the log tomb, but the provenance of the breastplate and point could not be confidently determined due to earlier disturbances (Cochran and McCord 2001). This tomb represents an interesting mix of things commonly associated with Adena *and* Hopewell contexts—like many of the Indiana earthwork sites. The log-lined tomb and bark covering resembles numerous such crypts commonly found in what are generally considered Adena burial mounds throughout Ohio, Kentucky, and West Virginia (Dragoo 1963; Webb and Snow 1945). The form of the platform pipe, the Snyders point, and the copper breastplate, on the other hand, are more representative of what are generally considered Hopewellian artifacts and are similar to pipes and breastplates found in Ohio at Hopewell Mound Group, Mound City, and Tremper, among others (Mills 1916, 1922; Moorehead 1922). Excavations conducted by Ball State University at the Circle Mound produced a radiocarbon date of 5 BC from the base of the embankment wall (Cochran and McCord 2001). So, the radiocarbon dates and artifacts obtained from the Anderson Mounds suggest that the complex's construction and use occurred during what most would consider the late Early Woodland or early Middle Woodland period.

Today, tree canopy covers most of Mounds State Park and all of the prehistoric enclosures. But due to the enclosures' large size and excellent preservation, and the collection of the Indiana LiDAR data during the cold months when the leaves were off the trees, the earthworks show up quite clearly in the LiDAR-based DEMs. A hillshade representation of the LiDAR elevation data (Figure 2, background) shows the larger enclosures with much detail, but the smaller enclosures appear less obvious or virtually invisible due to their small size and the subtle clutter in the LiDAR data created by the trees. However, by reducing the rendering area around each individual enclosure, and providing each area with its own color ramp, subtle details previously unseen become apparent, and more importantly, the contrast between the high elevation embankment tops and the low elevation ditch bottoms become more obvious (Figure 2, insets). The isolated imaging approach does not help the Great Mound or the Circle Mound much, and in fact, they lose minute details as compared to the hillshade. For example, the hillshade image shows that the sides of the platforms for both the Great Mound and the Circle Mound slope away from the center of the enclosure, creating a platform with a base wider than its top, but this detail disappears in the individual elevation areas (Figure 2, insets). On the other hand, the hillshade renders Enclosures B and D barely discernable and the possible Enclosures E, I, and K completely invisible; but the insets clearly show the outline of the ditches for Enclosure B and D and show what appear to be ditches for the possible Enclosures E, I, and K. Areas of the Fiddleback render well in the hillshade, but the gateway into the panduriform only appears obvious in the inset image. The inset of Enclosure B is interesting because the old maps indicate that this enclosure has two gateways, one from the northeast and one from the southwest, and Cochran and McCord tested the two-gateway system and found that the enclosure does indeed contain two gateways; however, the inset shows an uninterrupted ditch around the entire enclosure except a possible gateway on the northeast side (Cochran and McCord 2001; McCord 2008).

Enclosures E, I, and K represent the uncertainty sometimes associated with LiDAR data and prehistoric earthworks, but these enclosures do appear on Eli Lilly's 1937 map of the Anderson Mounds (Lilly 1937). Lilly mapped Enclosure E in the same general location and at the same general size as the possible earthwork present in the LiDAR data, although Lilly's orientation had the gateway facing the Great Mound even though it clearly does not; Cochran and McCord each separately tested the possibility of Enclosure E being a prehistoric earthwork in 1987 and 1999, respectively, and they both determined Earthwork E to be a natural part of the landform (McCord 2008). Geophysical survey with a magnetometer or an electrical resistance meter may be needed to reveal the true nature of the possible Enclosure E. Possible Enclosure I occupies a similar location as mapped by Lilly, but the current topographic data remain too subtle to determine the presence of a prehistoric earthwork. Lilly mapped an Enclosure K in the same general location as Enclosure I, but mapping errors have been shown to be common in the early maps of prehistoric earthworks (Lilly 1937). McCord, interestingly, marked the possible location of Earthwork K on a figure in her 2008 report in roughly the same location as the possible enclosure seen in the topographic data, although the reasoning for her location remains unclear (McCord 2008).

Whether the possible enclosures represent prehistoric earthworks remains unclear, but the LiDAR data demonstrate for certain that only one circular enclosure exists at Anderson Mounds: the Great Mound. All other enclosures, besides the panduriform, and even the possible enclosures are squares or rectangles with rounded corners. The panduriform even seems to represent a mixture of both circular and squarish forms, as noted by Cochran and McCord (2001). The LiDAR-based image of the panduriform shows that the southern half of the enclosure has a ditch that is squarish in form, similar to Enclosure D, while the northern half of the composite enclosure clearly represents a circle. Circle-square pairing is seen at many earthwork sites in the Middle Ohio Valley.

NEW CASTLE

The New Castle site is located approximately 28 kilometers southeast of Anderson Mounds, on a terrace overlooking the Blue River in Henry County, Indiana (McCord 1999, 2008). Much like the Anderson Mounds, initial documentation of the New Castle site occurred in the late 1800s, but the first detailed map of the site did not occur until Eli Lilly's 1937 publication (McCord 1999). The early accounts described a large circular enclosure similar to the Great Mound at Anderson associated with as many as nine smaller enclosures and various numbers of mounds. All of the early descriptions described the small enclosures as being circular, except Mound 4, which was described as elliptical or a possible panduriform with an elongated mound located within the enclosure (McCord 1999). The exact nature of the entire site, however, will never be known because of disturbances caused by the construction of buildings related to an epileptic colony in the early 1900s, prior to the creation of Lilly's map. At the very least, the hospital complex buildings erased the surface features of the reported large circular enclosure and possibly two smaller enclosures (McCord 1999). Ball State University surveyed the site and conducted extensive excavations in the late 1960s and early 1970s, then returned for another round of work in the late 1990s (McCord 1999).

The Ball State University excavations conducted from 1965 to 1971 focused on Mound 1, Mound 4, and Enclosure 6 (McCord 1999; Swartz 1976). Excavation in Mound 1 encountered human remains but few artifacts, though red ocher, lithic debitage, and a sheet of uncut mica were recovered (Swartz 1976). The excavations at Enclosure 6 found Archaic projectile points, flint debris and pottery sherds (McCord 1999; Swartz 1976). It was the excavation of Mound 4 that proved to be the most intriguing at the New Castle site. Ball State University excavated a substantial portion of the mound from 1965 to 1971 and found it to be conjoined mounds with distinct east and west lobes (McCord 1999; Swartz 1976). Swartz designated three primary areas within the conjoined mounds: the cremation area, the burial area, and the ash area (Swartz 1976). The cremation and burial areas occurred within the west lobe, while the ash layer centered on the east lobe, with an unnamed central area separating the two lobes (McCord 1999; Swartz 1976). Among many varying types of artifacts, the excavations recovered numerous New Castle Incised ceramics from the cremation area; a complete plain vessel from the burial area; a clay platform pipe and partial copper panpipe from the unnamed central area; and a partial Hopewell Zoned Rocker Dentate Stamped vessel, as well as copper-sheathed wood imitation bear canines from the ash area (McCord 1999; McCord and Cochran 2008; Swartz 1976). This apparent association of earlier Adena-like artifacts found in the western portion of Mound 4 and later Hopewell-associated artifacts found in the eastern portion inspired Cochran in the mid-1990s to conclude that Mound 4 was constructed from west to east in time and altered from Adena to Hopewell (Cochran 1996). The 1965–1971 excavations produced a radiocarbon date from both the east and west portion of the mound, with the west portion dating to AD 10 +/-140 and east portion dating to AD 40 +/-140 (Swartz 1976).

In 1998, McCord re-excavated portions of Mound 4. A trench on the east side and a trench on the west side of the mound reopened the previous excavations with the intention of viewing a profile of the unexcavated portions of the mound (McCord 1999, 2008). McCord found that the mound construction occurred over a significant period of time with multiple construction episodes. She also found that on the west side of the mound multiple burials occurred in sub-mound pits, as well as burials being added during the different construction episodes (McCord 1999, 2008). A radiocarbon sample resulted in a date of AD 55 to AD 135 for the base of the west side of the mound, and a separate sample gave a date of 40 BC to 75 AD for the base of the east side of the mound (McCord 2008). These dates and the multiple construction episodes caused McCord and Cochran to reconsider Mound 4's construction, and they interpreted the east and west sides of the mound as occurring simultaneously without an Adena to Hopewell progression; but they do agree that each side of the mound accommodated separate activities (McCord 1999, 2008; McCord and Cochran 2008).

The LiDAR data indicate that thick brush covers most of the landform occupied by the New Castle site; the many spikes and fuzzy, blank areas in the hillshade of the overview image represent LiDAR points that never reached the ground due to the thick vegetation (Figure 3). Despite the obstacles, most of the enclosures of the New Castle group appear obvious in the hillshade image and in general seem to have been well preserved (Table 2). The individual insets of the enclosures show many subtle details and reveal an unexpected feature of the New Castle site: almost all of the extant small enclosures at the site are square or rectangular in shape with rounded corners. All previous interpretive maps have depicted the small enclosures as circular in shape (e.g., Lilly 1937; McCord 1999; Swartz 1976). Enclosure 7 represents the only circle remaining at the site (Figure 3). The disturbance to Enclosure 3 (from a road) destroyed almost half of its southern portion, making its exact shape unclear; but the east and west portions of the ditch seem to be parallel much like

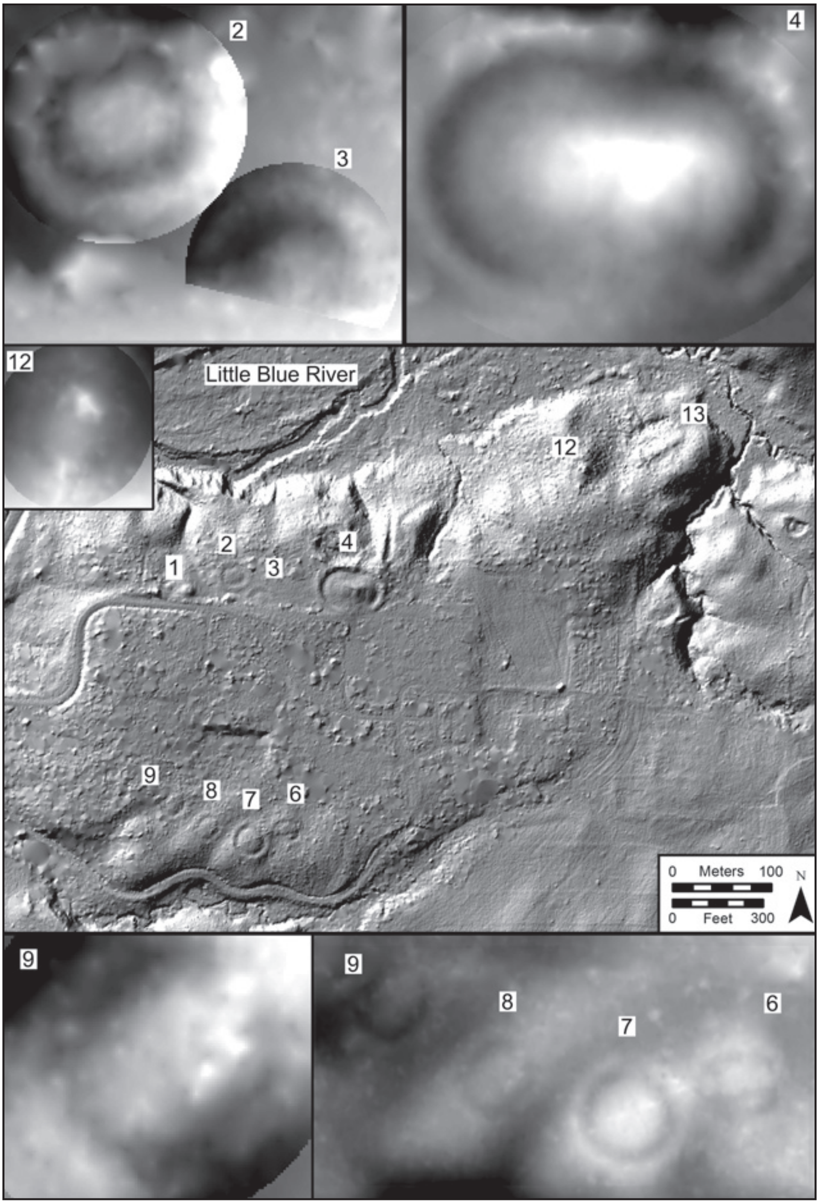

Figure 3. New Castle DEM with detail insets for individual enclosures.

Enclosure 2, indicating a rectangular shape (Figure 3, inset). The southern line of Enclosures 6, 7, 8, and 9 exhibit a peculiar placement, incorporating the natural topography of the landform; the Ball State University 1965 excavation of Enclosure 6 is visible in the DEM, where the southern half of the enclosure looks slightly lower. Enclosure 6 displays another peculiarity in that it faces almost ninety degrees east of Enclosure 7, while Enclosures 7, 8, and 9 have gateways that point at an angle following the main axes of the landforms they are on. The isolation of Enclosure 12 seems odd, and the vegetation renders the earthwork nearly invisible in the hillshade image; but the inset of Enclosure 12 clearly shows the subtle shape of a rectangle with rounded corners. Earthwork 4 seems to indeed be a panduriform, but as McCord demonstrated in her 1998 excavations, the mound and enclosure hold little resemblance to the original forms after the Ball State University excavations of the late 1960s and early 1970s (McCord 1999). Earthwork 13 represents a form unlike any other at New Castle and possibly unlike any other in the entire region. The LiDAR data indicate Earthwork 13 to be a long linear embankment wall on the side of a hill with what appears to be ditches on either side of the wall (Figure 3). Although small enclosures on hillsides are uncommon, at least one other is known to exist: the Newlove Group in Clark County, Ohio. McCord excavated a 1x1 meter test unit in the inner ditch of Earthwork 13 and determined that the earthwork appeared to be prehistoric in nature (McCord 1999).

Table 2. Enclosure areas for the New Castle site.*

Enclosure Name	**Shape**	**Area (m^2/acres)**
2	Square/Rectangle	234.6/0.06
4	Panduriform	1388.4/0.34
6	Square/Rectangle	291.6/0.07
7	Circle	504.1/0.12
8	Square/Rectangle	317.2/0.08
9	Square/Rectangle	299.3/0.07
12	Square/Rectangle	378.7/0.09

* Measurements of space inside inner edge of ditch.

BERTSCH

Located along the White River in Henry County, Indiana, the Bertsch site follows the same general form as the Anderson Mounds and New Castle sites: a large circular enclosure (Earthwork 1), a panduriform, and numerous small enclosures. And much like most earthwork sites in Indiana, the first documentation of the Bertsch site occurred in the late 1800s, with continued, sporadic research until the mid-1990s; however, unlike the Anderson and New Castle sites, Bertsch has received far less attention in the way of excavations, resulting in less being known about the site. The first map of Bertsch depicted two large circular enclosures with five associated small enclosures (Macpherson 1879). A 1980 aerial photograph identified several additional enclosures, and the site grew even larger when McCord and Cochran examined a 1936 USDA aerial photograph (McCord and Cochran 1996, 2000, 2008). Using the 1936 aerial photograph, McCord and Cochran correctly identified Macpherson's second large circular enclosure as a panduriform. Ultimately, they identified 17 enclosures at the Bertsch site: one large circle, one panduriform, and 15 small circular enclosures in no discernable pattern (McCord and Cochran 1996, 2008).

As mentioned above, few excavations have occurred at the Bertsch site. The 1968 excavations by Heilman focused on the platform area within the large circular enclosure (Heilman 1976; McCord and Cochran 2000). These excavations found a rectangular pit that contained two cremated skeletons; a linear feature, interpreted as a wall trench; a dark circular stain approximately 30 feet in diameter; two pit features; and several postholes (McCord and Cochran 2000). This excavation recovered but a few artifacts, including two flakes, a polished horn coral fossil, animal bone, burnt daub, and ten pottery sherds (McCord and Cochran 2000). In 1978, Ball State University attempted to excavate one of the small enclosures by following Macpherson's 1879 map, and not surprisingly given the accuracy of most 1800s maps, these excavations did not find anything (McCord and Cochran 2000). Another attempt was made again in 1981, based on a 1980 aerial photograph. This excavation found three features, but a radiocarbon date from one of those features yielded a modern date (McCord and Cochran 2000). The 1981 excavation produced 113 flint flakes and no other artifacts (McCord and Cochran 2000). A wood charcoal sample collected from the 1968 excavations produced a radiocarbon date of BC 50 to AD 115 (McCord and Cochran 2000).

The LiDAR data reveal little of the Bertsch enclosures except for the large circle and the panduriform. However, a USDA National Agriculture Imaging Program (NAIP) image captured in August of 2007 showed a sharp contrast between the enclosure's ditches and the surrounding area—the ditches created distinctive vegetation growth patterns (Figure 4). The NAIP image, however, has a resolution of two meters, making the small enclosures' ditches difficult to discern

Figure 4. Bertsch site pansharpened aerial photo with detail insets of (1) a portion of a 2015 aerial photo clearly showing some of the enclosures in the large circular pattern, and (2) magnetic gradiometer data collected in 2016 that shows two of the enclosures in the large circular pattern.

at high zoom levels. This problem was overcome using *pansharpening*, or digitally combining, the NAIP image with a second high-resolution black and white aerial photograph. Once the enclosure ditches could be more clearly determined, the astounding pattern of the Bertsch site became apparent. The image revealed at least 25 enclosures, and even more remarkable, many of the small enclosures are arranged in a large circular pattern. Additional aerial photographs, namely the 2015 ESRI base map image, corroborated the pattern seen in the 2007 image (Figure 4, inset). In addition, geophysical survey of the property adjacent to the Bertsch site by Burks located two additional enclosures, confirming the large circular arrangement of small enclosures (Figure 4, inset magnetic data). Given the results of the geophysical data, the aerial imagery and geophysical survey confidently confirms the presence of 27 enclosures with a twenty-eighth enclosure likely and a twenty-ninth most likely destroyed by the farm house and barn (Figure 4).

The geophysical survey and aerial photographs also confirm that the vast majority of enclosures at the Bertsch site are small square/rectangles with rounded corners (Figure 4; Table 3). In fact, of the 28 possible individual enclosures, only two circles exist: Earthwork 1 and a small circle within the large circular conglomerate directly opposite Earthwork 1. These two circles seem to be strategically placed: the gateways of the two circles seem to face each other, passing directly through the center of the large circular arrangement. Using the centers of the two individual circles as measuring points, the large circular arrangement of small enclosures has a diameter of approximately 970 feet, suspiciously close to the well-known 1054 ft diameter for large Ohio Hopewell circles. The large conglomerate circle may also have a "gateway" south of Earthwork 1. The space within the gateway could house two additional enclosures and maintain the spacing observed between the other small enclosures within the conglomerate circle; but no aerial photographs indicate any enclosures at that location, leaving the empty space currently interpreted as a gateway. No doubt additional magnetic survey at Bertsch would reveal more enclosures and other features of note.

Table 3. Enclosure areas for the Bertsch site.*

Enclosure Name	Shape	Area (m^2/acres)
1	Circle	2887.6/0.71
2	Panduriform	2002.9/0.49
3	Square/Rectangle	426.2/0.11
4	Square/Rectangle	426.2/0.11

Enclosure Name	Shape	Area (m²/acres)
5	Square/Rectangle	232.9/0.06
6	Square/Rectangle	426.2/0.11
7	Square/Rectangle	401.4/0.1
8	Square/Rectangle	401.4/0.1
9	Square/Rectangle	401.4/0.1
10	Square/Rectangle	401.4/0.1
11	Square/Rectangle	194.6/0.05
12	Square/Rectangle	504.8/0.12
13	Square/Rectangle	194.6/0.05
14	Square/Rectangle	401.4/0.1
15	Square/Rectangle	194.6/0.05
16	Square/Rectangle	401.4/0.1
17	Square/Rectangle	380.2/0.09
19	Circle	471.4/0.12
20	Square/Rectangle	454.7/0.11
21	Square/Rectangle	454.7/0.11
22	Square/Rectangle	454.7/0.11
23	Square/Rectangle	454.7/0.11
24	Square/Rectangle	454.7/0.11
25	Square/Rectangle	454.7/0.11
26	Square/Rectangle	454.7/0.11
27	Square/Rectangle	454.7/0.11

* Measurements of space inside inner edge of ditch.

FUDGE WORKS AND GRAVES ENCLOSURE

The Fudge Works and Graves Enclosure differ from the previously discussed enclosure groups in that rather than numerous small enclosures they each consist of a single large earthwork and associated mounds. Both are large square/rectangles with embankment walls but no ditches. Much like the previous sites, initial documentation of these sites occurred in the late 1800s, and the Fudge Works represents the only Indiana earthwork site included in Squier and Davis' *Ancient Monuments of the Mississippi Valley* (Squier and Davis 1848). Some excavations have occurred at the Fudge site, but no known excavations or modern mapping have occurred at the Graves site (McCord and Cochran 2008).

Located along the White River in central Randolph County, the Fudge Works remains the most studied of the two large rectangular enclosures. The 1848 John McBride map published in Squier and Davis (1848: Plate XXXIII) depicts a square with rounded corners created from embankment walls without a ditch. There are gateways along the east and west edges, with a small ditch and embankment rectangle protruding orthogonally away from the main enclosure. An elliptical mound is located at the center of the enclosure. Various early reports describe the embankment walls as being anywhere from six to ten feet tall and the mound 100 feet in diameter and 8–15 feet tall, but agriculture, a fairgrounds, and a gravel quarry began diminishing or destroying parts of the walls by 1865 (McCord 2006). Frank Setzler excavated the central mound in 1936, finding a central sub-mound covering a log-lined burial tomb containing one adult male placed on a layer of bark (McCord 2006). The burial had no associated artifacts, but a human skull lay on the midsection of the main burial. Two lines of nearly parallel posts surrounded the central burial in a rectangular shape with rounded corners. Within the inner line of posts, Setzler found a layer of red ocher and bark, and two artifact caches. One cache contained burned animal bone, a Cresap and a Snyders projectile point, a sandstone tablet, and a concave gorget, while the other cache contained two decomposing leather pouches that each had eight copper bracelets placed around human forearms (McCord 2006; McCord and Cochran 2008).

In 2005 Ball State University conducted limited excavations along the northern embankment wall and performed small scale, targeted geophysical surveys with a magnetometer (McCord 2006). The magnetometer survey covered portions of the northern wall; a small portion of the eastern wall and northeast corner of the embankment; a tiny portion of the southern wall near the southeast corner; the area of the mound towards the center of the enclosure; and the area of the ditch and embankment rectangle by the western gateway (McCord 2006). The magnetometer survey seemed to detect the edges of the embankment wall and the footprint of the central mound, but the results were subtle. The more remarkable find of the magnetometer survey occurred over the western gateway. The survey clearly captured the rectangular extrusion protruding from the western gateway, and the results show that the rectangle has rounded corners and probable posts lining the interior ditch (McCord 2006). The magnetometer survey guided the excavations along the northern embankment wall. The excavations found very few prehistoric

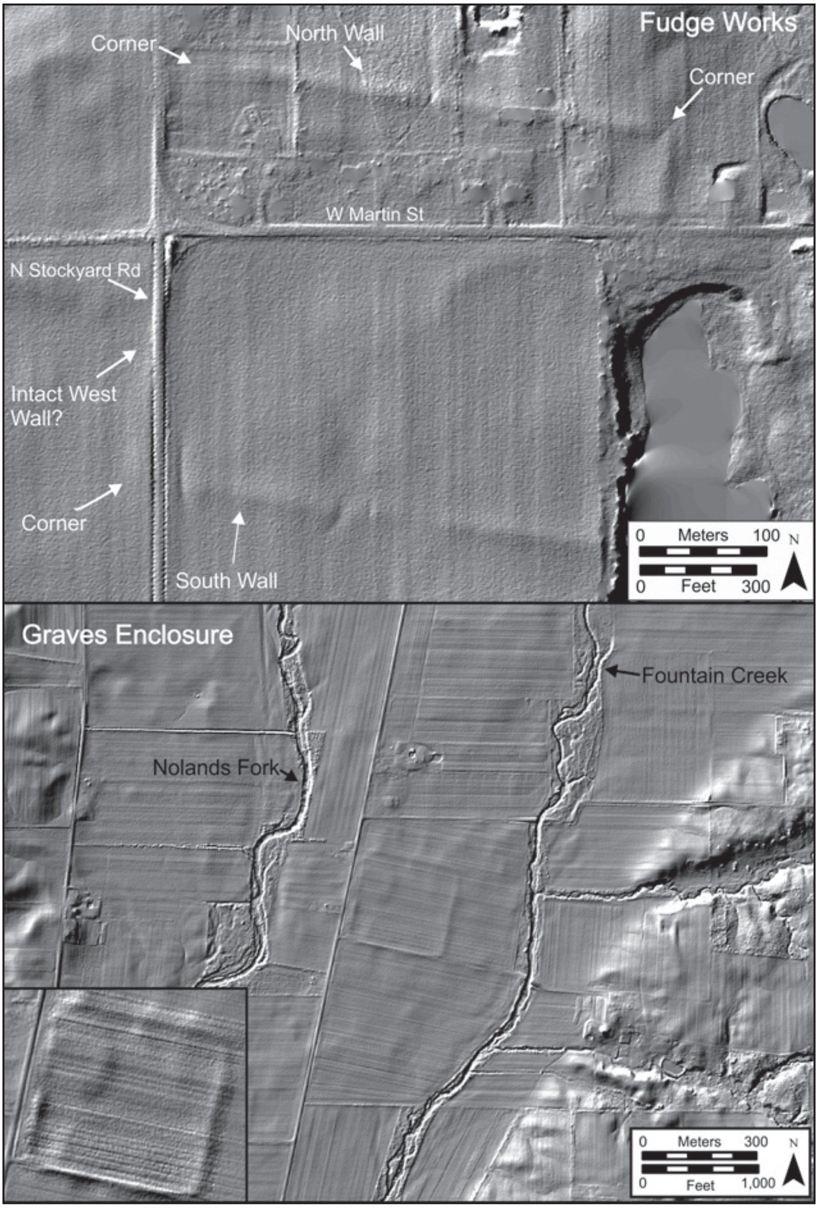

Figure 5. Fudge Works and Graves Enclosure DEMs.

artifacts and those most likely predated the earthwork, but the excavations did recover charcoal used to obtain three radiocarbon dates from the base of the mound: AD 20 to AD 220, 110 BC to AD 70, and 50 BC to AD 220 (McCord 2006).

At first glance, the LiDAR data from the Fudge Works suggest that the majority of the site has been heavily disturbed or destroyed (Figure 5). A gravel quarry destroyed most of the eastern wall south of West Martin Street, and the intersection of West Martin Street and North Stockyard Road probably destroyed portions of the western wall. But, the northern wall, most of the southern wall, and small portions of the eastern and western walls remain visible. A row of houses north of West Martin Street stopped just short of the north embankment wall with one small barn sitting on the wall; the remaining enclosure walls are within agricultural fields. It even seems possible that North Stockyard Road traverses an intact portion of the western wall just south of the intersection with West Martin Street. The location of the extrusion from the western gateway remains unclear, but the Ball State University magnetometer survey demonstrated that it remains intact below the surface. Overall, the enclosure seems to resemble a parallelogram more than a square, and the centers of the northern and southern walls are approximately 1090 feet apart, while the centers of the eastern and western walls are approximately 1250 feet apart.

The Graves Enclosure sits between Nolands Fork and Fountain Creek in the Northeast Corner of Wayne County, approximately 15 miles southeast of the Fudge Works. Since no known excavations have occurred at the Graves Enclosure, the temporal affiliation of the earthwork remains unknown, but given the enclosure's proximity to other earthworks in Indiana and Ohio, an early Middle Woodland association seems likely. The LiDAR data prove MacPherson's 1897 drawing of the enclosure to be fairly accurate (McCord and Cochran 2008). MacPherson mapped the Graves Enclosure as a square with rounded corners and sides 780 ft in length with a gateway in the middle of the west wall. The LiDAR-based hillshade shows a squarish enclosure with rounded corners and gateway in the middle of the western wall (Figure 5). The distance between the middle of the north and south walls is approximately 790 feet, but the east and west walls are approximately 830 feet apart, making the enclosure not quite square. Macpherson mapped two mounds within the enclosure and several west of the gateway, but no mounds appear obvious in the LiDAR data. The walls of the enclosure have been reduced by plowing, but the wall segment just south of the gateway is less deflated, with the southern wall perhaps close to its original form thanks to a farm lane that crosses directly over it.

The Fudge Works and Graves Enclosure appear to be local attempts at large scale architecture similar to the large earthworks found throughout southern

Ohio. These larger Indiana enclosures are dwarfed in comparison to the massive earthwork complexes found in southwest and central Ohio, but they are much larger and very different than the small enclosure groups discussed earlier. The artifacts found at the Fudge Works continue to suggest that these large enclosures incorporate what most would consider Adena *and* Hopewell elements. The log-lined tomb, Cresap point, and copper bracelets seem suggestive of what would normally be considered Adena-type artifacts, but the Snyders point and the shape of the enclosure would generally be considered Hopewell type features.

DISCUSSION

Reexamination of Middle Ohio Valley earthwork sites using recent remote sensing data is leading to many new discoveries. The results of new geophysical surveys are especially dramatic (e.g., Burks 2014; Burks and Cook 2011; Henry 2011; Weinberger 2009). But distinctive new features in aerial photos and topographic data also are emerging. The new discoveries range across many levels of site organization, including strategically placed pit type features (e.g., Ruby, this volume), post circle patterns (e.g., Burks 2014; Komp et al., this volume), new enclosures at known sites (e.g., Burks 2014; Burks and Cook 2011; Komp et al., this volume; Weinberger 2009), and finding entirely undocumented earthwork sites with one or more enclosures (e.g., Burks 2015; Nolan et al. 2008).

Our examination of aerial photographs and digital elevation models based on relatively new LiDAR data have also yielded important new results, including numerous new enclosures at the Bertsch site and modifications to the shapes of known enclosures at Bertsch, New Castle, and Anderson. Most notable among the new observations is the prevalence of *squircles*, that is, small rectilinear enclosures with rounded corners. The Bertsch site has as many as 23 small squircles; the New Castle site has at least five (Figure 6). At all three sites with small enclosures, what clearly are squircles have been repeatedly recorded as circles.

With our modifications to enclosure shape and the filling in of the maps with all of the known enclosures to date, the new site plans for Anderson, New Castle, and Bertsch begin to reveal two kinds of patterns showing the clear relatedness of these three sites. First, all three sites appear to have three classes of enclosures based on size and shape: (1) a large circle, (2) a panduriform, and (3) sundry other small enclosures (Figure 6). The sizes of enclosures in these three classes are consistent from site to site. The second major pattern revealed by the new site plans involves the arrangement of enclosures. Clearly the New Castle and Bertsch enclosures are arranged in a circular pattern. This has long been apparent for the New Castle site,

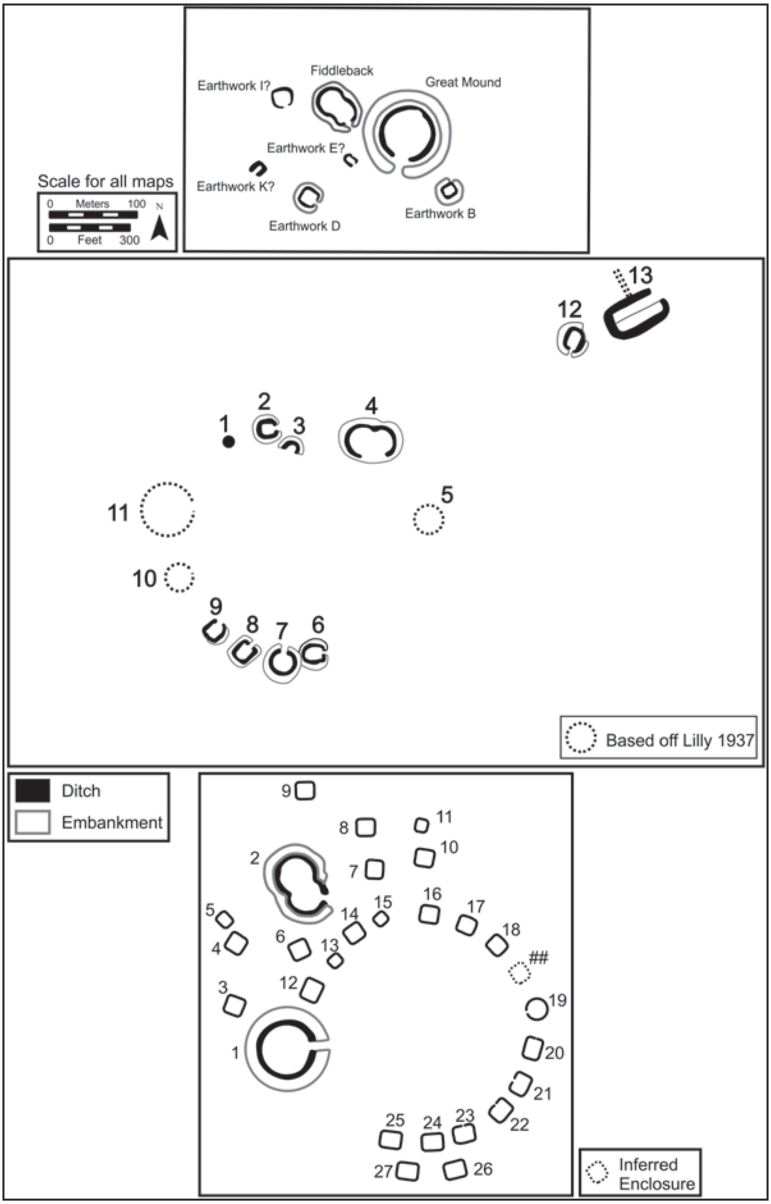

Figure 6. Interpretive map showing arrangement of enclosures in the Great Mound area at Anderson Mounds (top), New Castle (center), and Bertsch.

but the distinctive circular pattern at Bertsch is new and based on new aerial photographs and magnetic survey. While the Anderson site has similar elements to the other two sites, it does not exhibit the larger circular arrangement of enclosures. However, we would argue that this is perhaps because not all of the enclosures have been documented at the site. As at Bertsch, a magnetic survey may be needed to reveal additional enclosures at Anderson.

The prominence of squircles over circles at earthwork sites containing clusters of small enclosures was previously noted by Burks based on his surveys in Ohio (e.g., Burks 2014; Burks and Cook 2011). While not all enclosures previously recorded as circles are actually squircles, these findings in Indiana support the growing trend of the importance of this distinctive enclosure shape. Thanks to the radiocarbon dates run on the Indiana sites discussed here, we suggest that squircles mark a transition in the tradition of earthwork construction: squircles become common during that period when "Adena" begins to transition to "Hopewell" and earthworks start taking on truly massive sizes. And, like ear spools, copper plates, and platform pipes, squircles may be a horizon marker, though one writ large on the landscape. Furthermore, we suggest that the large circular arrangement of enclosures at Bertsch is another indicator of time and tradition—an attempt to *go big* with earthwork construction, not unlike what groups to the east were doing in the river valleys of Ohio. Large clusters of small enclosures are present at a number of sites in Ohio, such as Steel Group (Figure 7), which has many of the same elements as the Indiana sites—a large circle, numerous small squircles, and unique enclosure shapes. Clusters of small enclosures at other sites could be similar. At some of these (Figure 1), for example the Seal Township Works and much of the Portsmouth Group, the ground containing the enclosures has been destroyed. At other sites, such as Gilbert and The Plains, we would argue that future geophysical surveys are going to fundamentally change our understanding of enclosure shape and site layout. In fact, it seems likely that continued work with remote sensing data is only going to fill in the spaces between today's known sites and reveal a pan-regional tradition of earthwork building beyond a scale we have yet to comprehend. Squircles are going to be the primary shape for smaller enclosures, with a small percentage of other unique shapes, such as the quatrefoil at the Junction Group site in Ohio (Burks 2010). Also, many more of the single-enclosure sites recorded today will be revealed to contain multiple enclosures. While we continue to make progress on the mapping of earthwork sites using the latest remote sensing data available, landscape-scale geophysical surveys are going to completely change the way we envision the ancient landscape, filling it in with many previously undocumented sites.

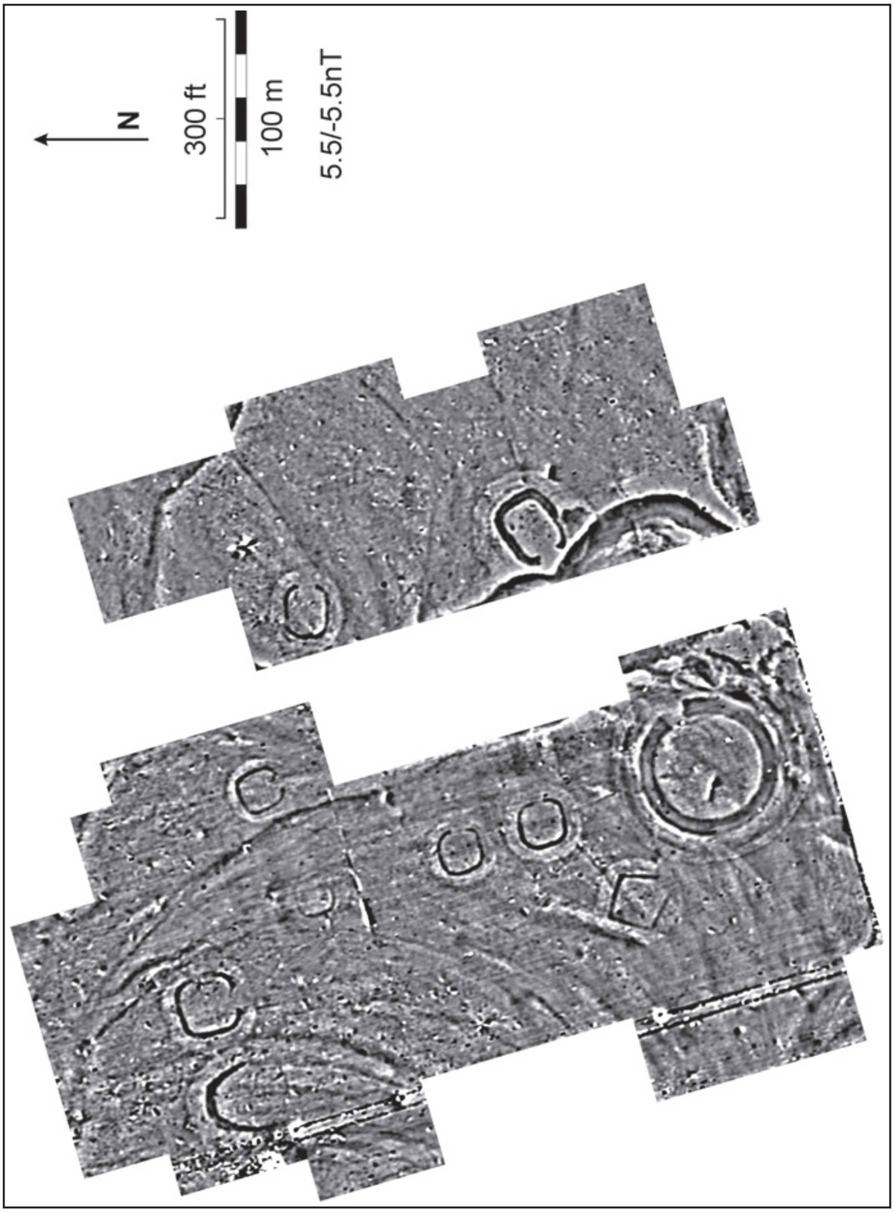

Figure 7. Magnetic gradiometer data from the Steel Group site in Ross County, Ohio.

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