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Terra incognita: terrestrial LiDAR documentation of Mound A at Kolomoki (9ER1)

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ABSTRACT
The manifest representation of space and place is essential to good archaeology. Our ability to document and relate these concepts, projected into the past and reflected in the present, has increased tremendously with the expansion and availability of technology. We present recent efforts to further document a well-known place in the cultural landscape: the Kolomoki site in southwestern Georgia, occupied primarily during the Middle and Late Woodland periods. Specifically, we summarize older investigations of Mound A, then present the results of recent terrestrial LiDAR documentation. Our work substantiates the claim that Mound A was the largest Woodland-period mound in Eastern North America in terms of overall volume.

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It is hard to really know a place. It is even harder to relate a place you know to someone else, clearly and accurately. Humans have an interesting ability to incorporate themselves into landscapes. Given that these spaces and places are among the most enduring artifacts of human behavior, we should strive to document and interpret them with great care and precision. Such challenges not only are at the heart of landscape archaeology, but of good archaeology. And the rewards are palpable. As Harbison (2000:xiii) notes in *Eccentric Spaces*:

> To put a city in a book, to put the world on one sheet of paper – maps are the most condensed humanized spaces of all … they make the landscape fit indoors, make us masters of sights we can't see and spaces we can't cover.

Mark Williams has devoted his career to knowing a place – the Oconee Valley of Georgia's Piedmont. Through his tireless efforts to document Mississippian-era sites (e.g., Kowalewski and Williams 1989; Williams 1984, 1994; Williams and Shapiro 1996), Williams helped turn the Oconee Valley from perhaps one of the least understood parts of the Mississipian-era Southeast to a named historical entity, the geo-political province of Ocute.

In the landscape of southeastern archaeology, Williams's work is a wonderful exception; *terra incognita*, literally "unknown land," surrounds us, even in the most familiar of places. Take Woodland-period platform mounds, for instance. Although obvious features, their existence was denied by the cultural historical paradigm, which secured such as Mississippian (né Temple Mound I and II Stages) (Ford and Willey 1941; Griffin 1952; see also Steponaitis 1986:388). Exceptions to this pattern were recognized by the 1950s (Williams 1958; cf. Sears 1956), but the evidence was systematically rejected or ignored (Knight and Schnell 2004; Pluckhahn 2007; for additional examples, see Jefferies 1994; Kellar *et al.* 1962a, 1962b; Kelly and Smith 1975; Pluckhahn 1996). Now recognized as a "general phenomenon" (Knight 1990, 2001; Mainfort 2013:230; Pluckhahn 1996) several Woodland-period platform mounds have been thoroughly documented (Boudreaux 2011; Kimball et al. 2010; Knight 1990; Milanich 1984; Rafferty 1990; Sherwood et al. 2013). The accurate dating of these monumental works, and careful documentation of their forms, functions, and integration with varying types of social landscapes allow us to appropriately address questions of cultural development in southeastern prehistory.

Even so, many of the largest remain *terra incognita* in one form or another. Some, such as the Great Mound at Troyville (16CT7) in Louisiana (Walker 1936), were destroyed. Others are extant but poorly understood, lacking detailed archaeological investigation. Sauls Mound at the Pinson site (40MD1) in Tennessee, likely the tallest regional Woodland platform at approximately 22 m, has been mapped at only a 0.61 m (2 ft) contour interval, is known internally by only a single soil core (possibly from a disturbed area), and has never been dated (Mainfort 2013:3–5).

Mound A at the Kolomoki site (9ER1) in Georgia – perhaps the largest extant Woodland mound in terms of

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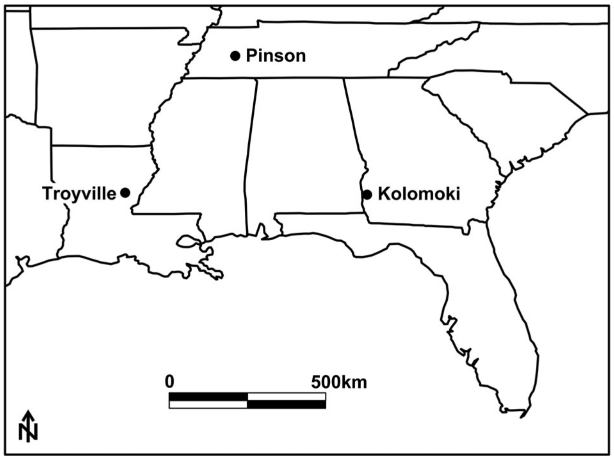


Figure 1. Sites referenced in text (based on Pluckhahn 2003).

overall volume – has remained even more poorly documented. Standing as the most impressive edifice at this complex of mounds, earthworks, occupational and activity areas, it provides an imposing object for pilot study in the further documentation of topography at Kolomoki. Such a study, employing modern technology and a non-invasive approach, has the potential to reveal one facet of the site's built environment, reflecting past human actors, communal efforts, and social complexity in monument.

This report is a summary of past and recent investigations of Mound A, with emphasis on topography and metrics generated through terrestrial LiDAR. As archaeologists, we are fortunate to benefit from such technological innovations. As friends and students of Mark Williams, we are fortunate to have a mentor who saw great value in using these technologies to remove more and more of the *incognita* from the *terra* we survey, test, and seek to know.

Kolomoki

Kolomoki is one of the most impressive archaeological sites in the southeastern United States, due in large part to its numerous mounds and earthworks, many preserved today in Kolomoki Mounds State Historic Park (Figures 1 and 2). Located along a small tributary of the Chattahoochee River, and covering approximately 80 ha, the site was occupied primarily during the Middle and Late Woodland periods, from around AD 300–900 (Pluckhahn 2003; Pluckhahn et al. 2017). These identified cultural periods are reflected clearly in diagnostic pottery from the site, with Swift Creek and Weeden Island types most dominant (Pluckhahn 2003; Sears 1956, 1992). Throughout its development, Kolomoki's population erected at least nine mounds (the total number is unknown), and one or more enclosing earthworks (Pluckhahn 2003; Trowell 1998).

Previous investigations

The site has long been of interest to the public, and early on drew the attention of antiquarians, surveyors, and

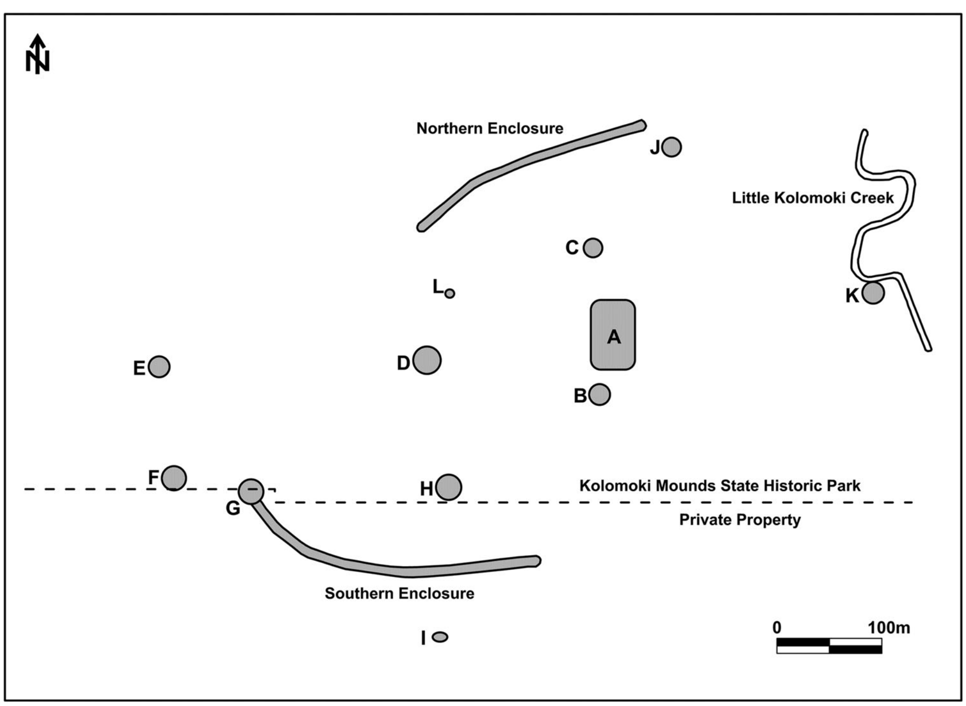


Figure 2. Kolomoki site map, mounds not to scale (based on Pluckhahn 2003).

archaeologists (Pluckhahn 2003; Trowell 1998). The mid to late-nineteenth century saw 1847 investigations of the site by antiquarian Charles A. Woodruff, efforts in 1872 by William McKinley and James N. Evans on behalf of the Smithsonian Institution, mapping of mounds and features in 1873 by avocational archaeologist Charles Colcock Jones and civil engineer James A. Maxwell, investigations in 1883 by James P. Fleming of the Historical Society of Pennsylvania, and excavations by Edward Palmer in 1884 under auspices of the Smithsonian Institution (Pluckhahn 2003; Trowell 1998). These efforts were of varying quality and specific foci, but dealt generally with mapping the layout of extant mounds and earthworks, as well as limited test excavations in some of the mounds.

The modern archaeological era saw a number of investigations, again with varying foci, intensity, and duration (Pluckhahn 2003; Trowell 1998). In 1937, J. L. Valliant surveyed the site under the auspices of the University of Pennsylvania Museum and created a detailed map of observed earthworks and their relation to each other (Pluckhahn 2003:49). In response to numerous calls for investigation of Kolomoki, and under threat of damage to the site by the Civilian Conservation Corps' efforts to develop a state park, Robert Wauchope (University of Georgia) and Charles Fairbanks (Ocmulgee National Monument) conducted test excavations between July 1940 and March 1941 in proposed roadways and lake impoundment areas (Pluckhahn 2003:49; Trowell 1998:37–40). William Sears began his numerous surveys and excavations in 1948, mostly on behalf of the University of Georgia. His efforts included testing ahead of road construction south of Mound A, excavations of or into Mounds A, B, D, E, and F, direction of Lewis Larson's excavation of Mound H, excavation of numerous units in the area northwest of Mounds A and D, and of units south of Mound D (Pluckhahn 2003:51–81). In doing so, Sears uncovered evidence bearing on mound construction and use, as well as the nature of domestic/occupational portions of the site.

In the late 1970s, Dennis Blanton (then Kolomoki park naturalist), with the help of Frankie Snow, Chris Trowell, and Eli Willcox conducted numerous surface collections across the site, and excavated a pit feature south of the park, on privately owned property. Johnson (1997) conducted extensive test pit and backhoe stripping operations in 1995 as compliance testing ahead of parking lot construction south of Mound E. This work exposed numerous features, some of which included evidence of structures and disposal of occupational debris.

The most recent work at Kolomoki includes a large-scale, systematic survey, and testing program directed by Pluckhahn (2003, 2010, 2011, 2013, 2015, formerly with the University of Georgia, now the University of South Florida). Pluckhahn and his students conducted site-wide systematic shovel testing, controlled surface collections, and strategic test unit and block excavation of several locales (Pluckhahn 2003). These projects revealed much on the distribution and nature of activity areas at Kolomoki, the site's establishment, growth, and eventual decline, its role as a social and political center with far-reaching connections in the Woodland-period landscape of the Southeast, and insights to cooperative and competitive behavior among its occupants. Pluckhahn's students have expanded on these efforts with survey and testing of areas south of the state park, focusing on the nature of occupation and activities within and without the reported southern enclosure (Menz 2015; West 2016).

Kolomoki's mounds

Beyond Mound A, which is discussed in-depth below, Kolomoki contains numerous other mounds and earthworks (Figure 2; Table 1). Unfortunately, many of these were impacted by generations of farming and other damaging activities, looting, and full or extensive excavation, often with inadequate documentation or characterization.

Mound B, excavated extensively by Sears (1956:10), was reported as approximately 15.24 m (50 ft) in diameter, with a maximum summit height of 1.52 m (5 ft). He originally believed it to be evidence of a collapsed or destroyed earth lodge, but subsequently revised this interpretation, describing it as a collection (likely a series) of many large posts, with trenches for their erection and removal, with red and yellow clay piled up around their bases (Pluckhahn 2003:58–59; Sears 1956). The piled soil accumulated, likely producing the mound over time (Sears 1956:10).

Mound C, also extensively excavated by Sears, was approximately the same size as Mound B (Sears 1956:11). While he noted its construction through evidence of basket-loaded fill of several colors and kinds, its nature and function remain a mystery (Pluckhahn 2003:59; Sears 1956:11).

Mound D was completely excavated by Sears. At the time of his investigation, it stood approximately 6.1 m (20 ft) tall, was conical in shape, and had a circular base approximately 30.48 m (100 ft) in diameter (Sears 1956:11). Mound D was a complex construction, with evidence of many stages of activity and a focus on mortuary ceremony and interment. Sears's excavations revealed log-lined and rock slab tombs, wooden scaffolding, burial goods including ceramic vessels (some

Table 1. Kolomoki's mounds: reported metrics.

Source	Mound	Max height (m)	Max basal dimensions (m)	Basal circumference (m)	Basal diameter (m)	Max summit dimensions (m)	Volume (m^3)
Pickett (1896 [1851]:151–152)	A	21.30		182.90			
Trowell (1998:27)	A	21.30				77.7 × 27.4	
McKinley (1873:424–425)	A	29.00	106.7 × 65.2			55.2 × 25.2	
Jones (1873:168–173)	A	17.40	98.8 × 60.4				57341.60
Palmer (1884)	A	22.90	101.2 × 57.9			54.6 × 22.6	
Valliant (1937b)	A	22.00				56.7 × 24.4	
Fairbanks (1946)	A	18.30	99.1 × 61.0			47.6 × 20.1	
Sears (1956:10)	A	17.20	99.1 × 61.0				
Pluckhahn (2003:Table 7.3)	A						51000.00
This paper	A	19.00	127.8 × 97.2			55.8 × 23.3	67735.90
Sears (1956:10)	B	1.52			15.24		
Sears (1956:11)	C	1.52			15.24		
Sears (1956:11)	D	6.10			30.48		
Sears (1956:12)	E	3.35			24.38		
Sears (1956:13)	F	1.83	18.29 × 15.24				
Palmer (1884)	G	0.91	18.11				
Larson (1952:2)	H	0.91	28.96 × 22.86				
Hardman and Hardman (1991)	I						
Hardman and Hardman (1991)	J				9.14–12.19		
Fairbanks (1941:2)	K	1.52			16.76		
Palmer (1884)	L	0.91					

effigies), shell beads, mica disks, iron and copper ornaments and lithic items, and the remains of numerous individuals in a variety of burial treatment (fully articulated, partial skeletal, bundle burial, and cremation; Pluckhahn 2003:60–62). These remains, artifacts, and architectural features were found among numerous colors, layers, and types of soil. While Sears (1956:93) believed it was constructed rather quickly over a few weeks, Pluckhahn (2003:62–64) suggests it may have occurred over a much longer timespan.

Mound E, similar in nature to Mound D, was a dome or conical earthwork approximately 3.35 m (11 ft) tall and with a base approximately 24.38 m (80 ft) in diameter (Sears 1951:5, 1956:12). Excavated nearly in its entirety, the mound contained evidence of multiple construction stages, and with a function primarily devoted to human interment, including extended burials, partial skeletons, cremated remains, and associated burial goods (shell beads, ceramic vessels, and copper and pearl ornaments; Pluckhahn 2003:64–65). Its composition was a complex layering of varying soils and rock.

Mound F, partially excavated by Sears, is described as ovoid in shape, approximately 18.29 m (60 ft) long, 15.24 m (50 ft) wide, and 1.83 m (6 ft) tall (Sears 1956:13). It was constructed in at least three layers, including a platform, but its function was not determined (Pluckhahn 2003:67; Sears 1956:13).

Mound G is among the least understood at Kolomoki. Its existence and location is marked on several early maps of the site, and it is reported as joining or intersecting with an earthen embankment or enclosure in the site's southern portion (Pluckhahn 2003:67). The mound was described by Palmer (1884) as having a flat top, was 18.11 m (59 ft, 5 in) long, and rose 0.61–0.91 m (2–3 ft) high). The mound contains several historic graves from the late-nineteenth and early twentieth century, and no reported archaeology has been conducted there (Pluckhahn 2003:67).

Mound H, excavated by Lewis Larson under Sears's direction, was a low mound, possibly ovoid in shape, measuring approximately 28.96 m (95 ft) long, 22.86 m (75 ft) wide, and about 0.91 m (3 ft) tall (Larson 1952:2). It was constructed in at least two layers, and had numerous post and pit features on a platform surface, as well as below the mound at ground level (Larson 1952:5–10; Pluckhahn 2003:68).

Mound I, reported by Clark and Marjorie Hardman (Hardman and Hardman 1991), and potentially by Palmer (1884) and Steinen (1998), is unfortunately unmapped, unconfirmed and untested. It lies on private property south of the state park, on the southern boundaries of the site. Pluckhahn (2003:69) observed a small rise in the general area described by others, and also reports several anomalies in this area on previous aerial photos.

Mound J, also reported by Hardman and Hardman (1991), remains unconfirmed. The authors indicate it as possibly a leveled or plowed down mound, approximately 9.14–12.19 m (30–40 ft) in diameter.

Mound K references the dome-shaped sand mound excavated by Fairbanks in 1941 prior to the construction of a dam on Little Kolomoki Creek (Fairbanks 1941:2; Pluckhahn 2003:69–72). He described the mound as 1.52 m (5 ft) high, with a circular base measuring approximately 16.76 m (55 ft) in diameter. It was constructed in three stages, and was potentially a burial mound, although no graves or remains were observed (Fairbanks 1941; Pluckhahn 2003).

Mound L is a designation given to a small rise north of Mound D by Pluckhahn (2003:72). This is possibly the same one noted by Palmer (1884), Valliant (1937a), Hardman and Hardman (1991), and tested by Pluckhahn (1998:80–87, 2003:72). If this corresponds to the rise noted by Palmer (1884), he reported it as 0.91 m (3 ft) tall.

In addition to these named mounds reported in Pluckhahn (2003), there are other possible mounds noted on early maps of the site. There are also several reports of enclosing earthworks (sometimes referred to as breastworks or walls), on the northern and southern portions of the site (McKinley 1873; Palmer 1884; Pickett 1896; Pluckhahn 2003:53–56; Valliant 1937a). These additional potential mounds and earthworks are not well understood.

Previous investigations of Mound A

Pickett (1896 [1851]:151–152) published the earliest known account of the "remarkable artificial elevations" on Judge Mercier's plantation, in *History of Alabama and Incidentally of Georgia and Mississippi*. In this publication, Mound A was described by Dr. Charles Woodruff:

> No. 1. The large sacrificial mound, seventy feet in height [21.34 m] and six hundred feet [182.88 m] in circumference. The mound is covered with large forest trees, from four hundred to five hundred years old. A shaft has been sunk in the center to the depth of sixty feet [18.29 m], and at its lower portion a bed of human bones, five feet [1.52 m] in thickness, and in a perfectly decomposed state, was passed. (Pickett 1896 [1851]:151)

Notably, Woodruff also describes the gully adjacent to Mound A's southern flank extending to the east. This feature remains undated and unexplained as natural, cultural (e.g., borrow pit), or both. The stylized view of these "ancient works" (Pickett 1896 [1851]:165), likely sketched by Woodruff, was subsequently reproduced with a description in White's (1854:424–425) *Historical Collections of Georgia*. Clearly not accurate or to scale, the illustration nonetheless notes one mound significantly larger than the others.

McKinley's (1873:424–426) account of Kolomoki in the 1873 *Annual Report of the Smithsonian Institution* includes a site map created by Early County, Georgia Surveyor James N. Evans, which emphasizes an exceptionally large mound (labeled *Pyramid*). McKinley (1873:424–425) described Mound A as rectangular in form (both base and summit), aligned 10° west of north, and measuring 106.68 by 65.23 m (350 by 214 ft) at its base, 55.17 by 25.15 m (181 by 82.5 ft) on its summit, rising around 28.96 m (95 ft) tall. Like others before him, McKinley (1873:425) noted a previous excavation in the center of the mound, " … probably in search of treasures, but apparently without success." Also, like Pickett, he made note of the "pit" at the south end of Mound A, " … from which it is supposed the earth of which this mound is composed was originally excavated" (McKinley 1873:425). On McKinley's map, the annotation describes this "Great Ditch" as "40 by 20 ft. [12.19 by 6.1 m] 400 yds. [365.76 m] long."

That same year, Jones's (1873) *Antiquities of the Southern Indians* included an account of Kolomoki, based on survey by Major James Maxwell, then engaged locally in railroad construction near Blakely. A detailed illustration, with a focus on Mound A (Figure 3), accompanies his rich description, and reflects Maxwell's civil engineering background:

> The form of this mound is that of a frus-tum [*sic*] of a four-sided pyramid; the top surface a level plane---a

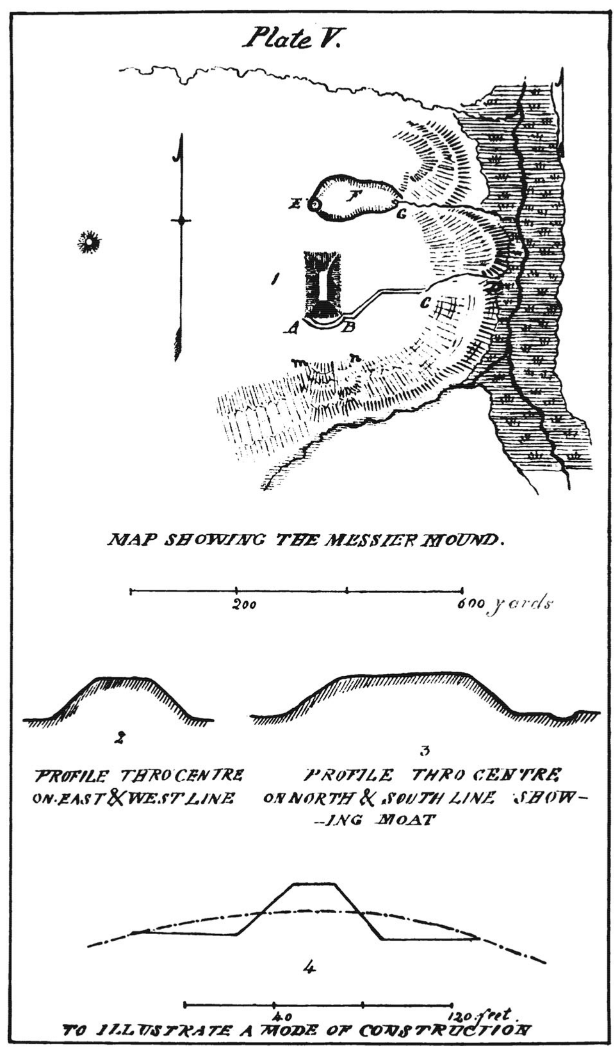


Figure 3. Site illustration from Jones (1873); Mound A is indicated by the numbers 1–4.

rectangular parallelogram---the north and south sides being each sixty-six feet [20.12 m] in length, and the east and west sides each one hundred and fifty-six feet [47.55 m] long. The base plan is not precisely level, but declines somewhat from the north toward the south, so that the vertical height of the mound at the northeast and northwest corners is fifty-three feet [16.15 m], while the vertical height at the southeast and southwest corners is fifty-seven feet [17.37 m]. The northern boundary of the base of this pyramid is one hundred and eighty-eight feet [57.3 m] long---the southern boundary about one hundred and ninety-eight feet [60.35 m], while the eastern and western boundaries are each three hundred and twenty-four feet [98.76 m]. The slope of the east, west, and south sides is about one and a quarter to one---or steeper than the natural slope of earth---while the north side slopes rather more than one and a half to one, which is about the natural slope of the earth of which this mound is composed … It must be remembered, however, that no earthwork can be said to conform precisely to any mathematical figure. The angles are always more or less rounded, and the slopes and surfaces to a greater or less degree convex or concave … The form of this mound agrees as accurately with the description given as does that of any modern earthwork with the shape prescribed by the civil engineer. The slopes are even more perfect than those of railway embankments. The fact that they are steeper than the natural slope must be explained upon the hypothesis of superior construction---as by through the packing of the earth in successive, thin layers. The greatest departure from mathematical conformity to the pyramid occurs at the angles, which are rounded by curves of from five to fifteen feet [1.52 to 4.57 m] in length. This may have been the result of design rather than the effect of time. (Jones 1873:168–169)

Echoing previous accounts, Jones (1873:172–173) described evidence of disturbance:

Some years ago a well was dug from the top of the mound, passing along its centre [*sic*], to the depth of fifty feet [15.24 m]. This investigation was not undertaken in the interest of science, but with the hope of finding precious metals and valuable stones. Disappointed in their expectations, the workmen subsequently closed this opening; and from them no useful information has been gathered touching the contents and stratification of the tumulus.

Maxwell's account, as reported by Jones (1873:169–170), is also notable for estimating the volume of Mound A and the amount of labor entailed by its construction:

This tumulus contains about seventy-five thousand cubic yards [57,341.61 m^3] of earth, and would weigh from ninety thousand to one hundred thousand tons. By means of modern appliances its erection could be compassed [*sic*] at a cost of some fifty-thousand dollars, provided the earth was taken from the excavations from which the ancient mound-builders obtained it. The industrious labor of one thousand savages, properly applied for the space of one year, would have accomplished this work with the aid of baskets or even earthenware pots for the transfer of earth.

Maxwell identified probable sources of mound fill in the depression to the north (the areas marked E, F, and G on the map) (Jones 1873:170), and described the ditch, which he suggested was in part "clearly artificial" (from B to C) and in other parts "seemingly not so" (Jones 1873:170–171). Referring to the section nearest the Mound (between A and B on the map) as a "moat" varying from 0.61 to 3.05 m (2 to 10 ft) deep (Jones 1873:171), he suggests it is close to its original form, perhaps having been a "fish-preserve" (Jones 1873:175).

Trowell (1998:27) reports an account of Kolomoki, attributed to J.P. Fleming, appearing in the *Early County News* on June 27 1882, which repeats the earlier claim of a central shaft dug in Mound A that revealed human bones at a considerable depth. Beyond this, Trowell (1998:27) cites the characteristics of the mound as related in the newspaper: a flat, oblong summit 73.15–77.72 m (80–85 yd) by 22.86–27.43 m (25–30 yd), somewhat lower in the north than the south, and narrower in the middle; 21.34 m (70 ft) height; and a west-of-north orientation on the long axis. Further, Fleming was purported to have returned in 1883 to conduct excavations on the mounds, but no account of this has been located (Trowell 1998:27).

Edward Palmer investigated several mounds at Kolomoki in 1884, under auspices of the Bureau of American Ethnology. As reported in the *Savannah Morning News* (March 31 1884):

After passing around the big one he concluded not to attack it without further instructions from headquarters. He had been instructed to cut a trench right through it in two directions. To do this, he thought, would cost more than the department had counted on, hence his decision not to undertake it without further orders.

The veracity of this account is attested to by a letter Palmer wrote to Cyrus Thomas on March 21 1884 (on file at the National Anthropological Archives, Smithsonian Institution, Washington, DC; spelling and emphases, except bracketed additions, are in the original by Palmer):

… the work on the small mounds and house sights [*sic*] shall be done well and thoroughly but as to that <u>large mound</u> the <u>lesser Andees</u> [*sic*] an earthquake and dinamite [*sic*] will be required. This large mound is 75 or 80 feet [22.86 or 24.38 m] high, nearly or quite 300 feet [91.44 m] long 150 feet [45.72 m] long at the ends (is square) on the summit it is one fourth of an acre [0.1 ha]. To open this monster as you desire Mr. Fleming and the owner estimate the cost as between 800 to

> 1000 dollars and declare it cannot be done for less---four months the least time---a small cut already made show the interior to be very hard clay …

Palmer also bemoaned the lack of available mule teams and carts, to express doubt that he had " … the strength to take on such a gigantic job," and to reiterate the formidable size of Mound A – describing it as "the largest ever seen by me."

Thomas's response is not documented, but work in several mounds and occupation areas was completed the same year, as detailed in a handwritten report on file at the National Anthropological Archives of the Smithsonian Institution. Palmer described Mound A:

> Mound 6 … is 178 feet [54.25 m] long at north end. 190 feet [57.91 m] at south end. With a general length of 320 feet [97.54 m] on the west side on the east side 332 feet [101.19 m] long.

> It is heighest [*sic*] at each end where it is 75 feet [22.86 m] but in the center it is but 70 feet [21.34 m] this difference in height owing to a depression in the center on the west side hear [*sic*] both sides slope towards the center as seen in the diagram of Mound 6 (Figure 4).

> On the East side in the center there is no depression but instead there is an enlargement outward hear [*sic*] the top measures diameter 74 feet [22.56 m]. The North end has diameter on top of 58 feet [17.68 m]. The South end 60 feet [18.29 m].

Later in the report, Palmer describes the length of the mound summit as 179 feet [54.56 m]. He notes irregularities in the mound's flanks, possibly related to its construction:

> At one hundred feet from the South end but on East side there is a depression on the top with sloping sides to center extending from top to bottom like there is in center of mound on West side. At the North end there is a depression on top extending to base like that in the center of West side and on East side. These three depressions up the mound would indicate they where [*sic*] the passes up mound used while pileing [*sic*] up its earthy structure. Facing these ascents is plainly seen the immence [*sic*] holes from which the earth was taken.

Palmer also provides a more authoritative account of the pit that had been dug into the center of the mound, correcting information presented by White:

> In the center of the mound summit several years ago a circular pit was dug to the depth of 51 feet [15.54 m] by Mr. Lisbon Everett who informed me he found nothing but soil until at the depth mentioned pieces of rotten wood were found. Whites [*sic*] historical recollection of Georgia speaking of this shaft says it was dug 60 feet [18.29 m] and at its lower portion a bed of human bones 5 foot [1.52 m] thick and in a perfectly decomposed state was found. The digger of this shaft Lisbon Everett and there has been no other dug says this statement is entirely false for not a trace of bone was seen nor did he go below 51 feet [15.54 m].

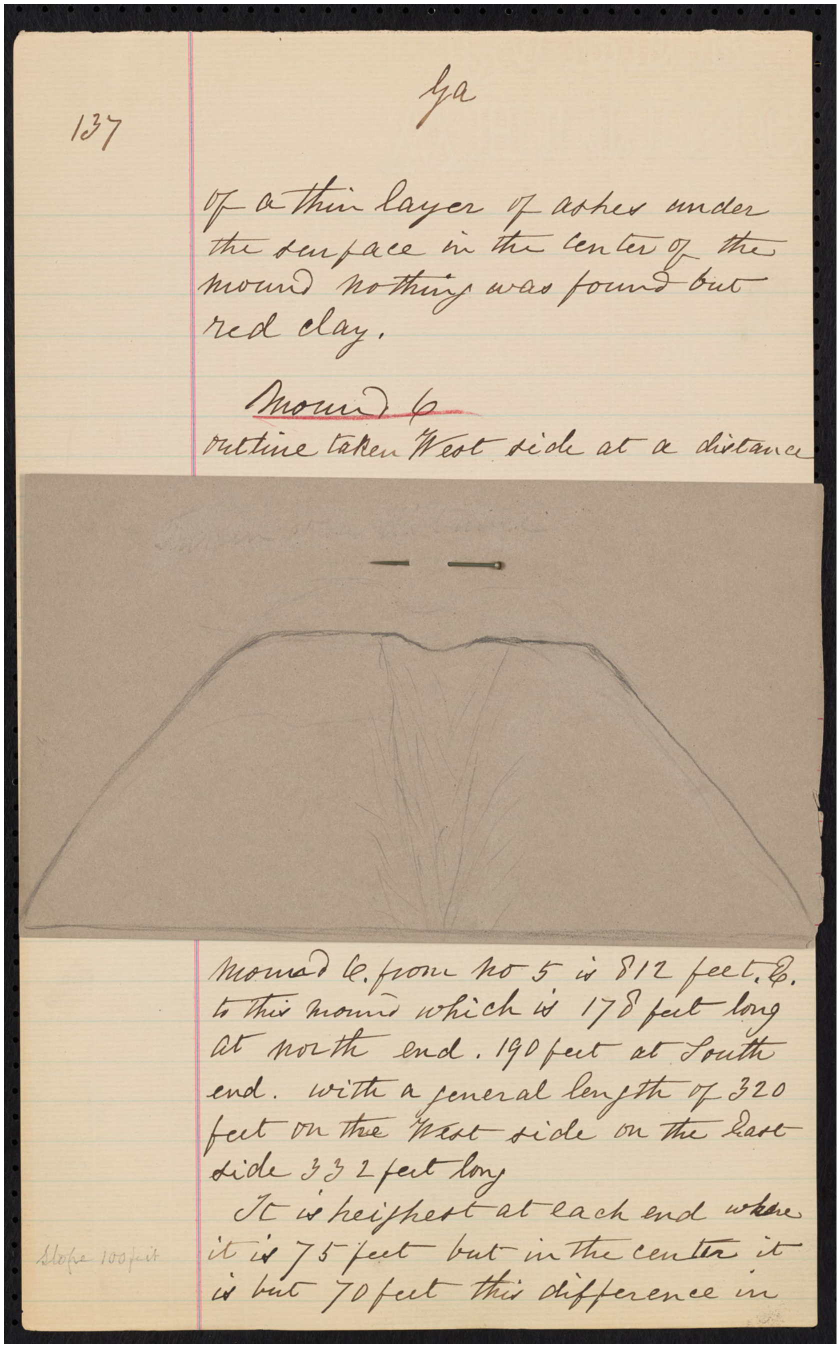
Palmer also countered the notion that a burned structure was present on top of the mound:

> The same authority says that charred wood was found on the summit that the mound must have been used for sacrificial purposes. When the father of the present owner took up the land in its wild state 60 years ago there was no charred wood on the mound then it was before Whites account was written that gentleman cut the timber on its summit piled it up and burnt it thus the charred wood on the summit. Several crops was [*sic*] raised on the top before and since Whites [*sic*] book was written.

Palmer excavated two 3.66 m (12 ft) squares on Mound A's summit, located one-third the lengths from the north and south end. The northern unit was placed "toward the center," and dug 4.57 m (15 ft) deep. The southern unit was dug 4.65 m (15 ft, 3 in.) deep. He also dug a "cut," presumably a trench, 2.44 m (8 ft) wide and 3.86 m (12 ft, 8 in.) deep, "near the base" at the south end of the mound. He placed this cut just below (likely downslope) a prior excavation made by Fleming. Palmer's profiles and description provide our best window on the stratigraphy of Mound A. Based on these, the upper portion appears constructed primarily of brown clay, with inclusions of yellow and "salmon colored" sand and occasional charcoal and ash. The southern summit square and southern flank trench each encountered a layer of yellow clay that could represent an earlier mound stage. The latter excavation also included a layer of yellow sand above brown clay. Palmer recovered a few pottery fragments and stone implements, as well as a charred post from the uppermost layer of the southern summit square.

Fifty-three years after Palmer, Lieutenant J. L. Valliant spent four days at Kolomoki on behalf of the University of Pennsylvania Museum, and reported his observations to University of Georgia archaeologists (Valliant 1937b). While lacking elevations, his map (Valliant 1937a) is detailed and includes mounds no longer recognized at the site today. In his letter, Valliant briefly described Mound A:

> The Great Mound is larger than the dimensions published. It is 186 feet [56.69 m] greatest length (on top) and 80 ft. [24.38 m] wide. It is 100 feet [30.48 m] down the slope to the "Platform" at the South end. This slope is steep enough to cause me two falls descending … I estimated the average at 45 degrees. This would mean a height of 72 feet [21.95 m]. The west face is somewhat lower but the East face is still higher.



Ga

137

of a thin layer of ashes under
the surface in the center of the
mound nothing was found but
red clay.

Mound 6
outline taken West side at a distance

Mound 6. from no 5 is 812 feet E.
to this mound which is 178 feet long
at north end. 190 feet at South
end. with a general length of 320
feet on the West side on the East
side 332 feet long
It is heighest at each end where
it is 75 feet but in the center it
is but 70 feet this difference in

Slope 100 feet

Figure 4. Mound A western flank illustration from Palmer (1884), used by permission of the National Anthropological Archives, Smithsonian Institution.

Trowell (1998:33) reports James W. Bonner was hired in 1938 to map the site in conjunction with the development of the Kolomoki State Park. Bonner's map (1938) is entitled "Kolomoki Mound Park General Development Plan," with the notation "Topography furnished by the State Highway Department." The map contains 1.52 m (5 ft) contours for most of the site, including Mound A. However, Mound A's contours were based on only six summit points and 12 around the base.

Sears (1956:10) conducted extensive excavations at Kolomoki in the late 1940s and early 1950s. He apparently did not map Mound A, but described it as about 99.06 by 60.96 m (325 by 200 ft) at its base and around 17.22 m (56.5 ft) high (Sears 1956:10). He made two excavations into Mound A: Cut 1, 3.05 by 6.1 m (10 by 20 ft), at the toe of the southern end of the western flank, and Cut 2, 3.05 by 3.05 m (10 by 10 ft), into the higher, southern end of the summit. The former revealed wash over a small portion of red clay that Sears felt was the final capping layer. Below this was a white clay layer which he interpreted as "the last completely buried cap." The latter revealed several feet of red clay, underlain by a hard packed white clay with occasional pockets of topsoil. Sears (1956:10) reported there was good evidence that the two capping layers date to the Kolomoki period, now understood to be the earlier range of Middle Woodland occupation at the site.

Approximately 50 years after Sears's last work at Kolomoki, Pluckhahn (2002, 2003) initiated a program of minimally invasive investigations in the off-mound areas to better define the domestic occupation of the site. Additional mapping also was conducted, but with limited emphasis on the mounds. Pluckhahn's examination of Sears's collections from Mound A revealed no charcoal samples for radiometric dating, but did locate just over 400 potsherds, with limited early Weeden Island types and no later varieties (Pluckhahn 2003:58). On this basis, Pluckhahn suggests that the capping layers were probably added relatively early in the occupational sequence (his Kolomoki II phase, roughly dated to AD 450–550).

Pluckhahn (2010, 2011), Menz (2015) and West (2016) subsequently tested further domestic areas on site, while also obtaining new radiocarbon dates from previously collected samples. Recently, Pluckhahn and Neill Wallis obtained Optically Stimulated Luminescence (OSL) dates from Swift Creek pottery at Kolomoki. Bayesian modeling of these acquired dates provides a revised chronology, beginning as early as AD 200 and continuing as late as AD 900 (Pluckhahn et al. 2017). Most pertinent for the present study, a Swift Creek sherd recovered from Levels 13 and 14 of Sears's Cut 2 in Mound A produced an OSL age of 2360 ± 200 (UW-3226), or 550 to 150 BC. This is 100–200 years older than the generally accepted range for Swift Creek (Stephenson et al. 2002), but consistent with a Woodland-period association for Mound A. This OSL date is significantly earlier than the site chronology reported by Pluckhahn et al. (2017), and may indicate that Kolomoki was established as a regional center earlier than previously thought.

Recent documentation of Mound A

Methods

Despite 160-plus years of intermittent attention to Kolomoki, Mound A has never been sufficiently mapped, due primarily to its imposing size and dangerously steep flanks. As Major Maxwell noted, "It is only at some risk, and with indefatigable industry that the exact form of this huge earthwork can be determined" (Jones 1873:168). Not much has changed along these lines, but fortunately, our available technology has.

A relatively recent boon to the archaeologist in search of accurate topographical data is the use of LiDAR. A portmanteau of laser "light" and "radar," this approach most often employs the scanning of objects or landscapes with rapid pulses of laser light and measuring time-of-flight, creating highly accurate three-dimensional point clouds of all unobstructed surfaces (Goyer and Watson 1963; Opitz 2013; Weber and Powis 2014). Airborne laser scanning (ALS) collects point data from aerial mounted scanners, such as on airplanes or unmanned aerial vehicles (UAVs), and terrestrial laser scanning (TLS) collects data from scanners mounted on fixed surfaces or mobile supports such as tripods (Opitz 2013). Archaeologists worldwide have increasingly and successfully used LiDAR in site prospection, documentation of known features, ongoing assessment of resources and their degradation, and overall heritage management (Devereux et al. 2005; Harmon et al. 2006; Randall 2014; Richter *et al.* 2012; Romero and Bray 2014; Thompson et al. 2016; Weber and Powis 2014).

ALS and TLS, while operating on the same principles, offer different advantages and limitations. ALS is often used to cover vast geographical areas, but may introduce higher cost of deployment (airplane, fuel, flight crew, etc.), and generally provides data of lower resolution unless multiple scans, and scans from different trajectories, are used (Harmon et al. 2006; Opitz 2013; Weber and Powis 2014). ALS can provide excellent general topographic data, even in areas with heavy vegetation, and reveal both natural and cultural landscapes (Devereux et al. 2005), although microtopography often is not revealed. ALS is perhaps used more frequently by archaeologists, compared to TLS, because many ALS datasets are freely available for download online, provided by governmental entities in their collection of environmental data for resource management. ALS users, then, need not pay for the equipment or survey itself, and must only become proficient in data sampling and surface modeling with commonly used GIS software programs.

TLS is generally used to capture dense topographical data of smaller geographical areas, such as individual sites, and more readily provides data of higher resolution since greater amounts of local scan data are collected in each setup location than found in a typical flyover (Opitz 2013; Richter *et al.* 2012; Romero and Bray 2014). It also provides the ability to scan areas such as caves, ravines, and restricted spaces where ALS is difficult or impossible (Weber and Powis 2014). TLS regularly reveals microtopographic variation not seen in coarser ALS datasets. TLS, however, often requires the archaeologist to become proficient with the entire workflow process, from survey design, to data collection, to point cloud registration/processing/filtering, data sampling, and finally, surface modeling. The cost of terrestrial LiDAR equipment and post-collection computing requirements can be prohibitive, whether through purchase or rental. In general, TLS is less frequently used in favor of ALS, despite its advantage of richer and more revealing local datasets; this is true for archaeology in the American Southeast, and appears to be a worldwide trend (Romero and Bray 2014).

In January 2016, the authors conducted a terrestrial LiDAR survey of portions of Kolomoki, with specific focus on Mound A (Figure 5) and the southern enclosure wall, using a Leica Geosystems ScanStation C10 terrestrial LiDAR system. TLS, rather than ALS, was chosen to capture as much topographical data as possible; while Mound A is relatively well preserved, the authors hoped to document past and present impacts from excavations, other historic activities on and around the mound, and erosion. The southern enclosure, affected by many generations of farming activities, is so subtle it likely would not be captured by ALS. TLS, with its ability to document even microtopographical relief with normal scanning procedures, could easily and accurately provide data for basic metrics on the earthworks, while also reflecting historic impacts.

Mound A's overall size and steep gradient required 31 360° scans for high resolution, full coverage (Wood and Pluckhahn 2016). All scan data were registered, georeferenced to local grid coordinates, and point clouds unified and exported, using Leica Cyclone software. Unified data were imported to Hexagon 3DReshaper, vegetation and extraneous points removed, and approximately 61 million points retained for Mound A and its immediate vicinity. Contour maps were created in Surfer software by Golden, and triangulated irregular network (TIN) meshes in 3DReshaper. Automated sampling for TIN creation yielded 624,000 points; the generated TIN is composed of 1,248,714 triangle faces in a solid terrain surface.

Results

In geo-referencing to the local grid, the highest three-dimensional error recorded in LiDAR target agreement scan-to-scan was 9 mm; this was in a singular instance. The great majority of target error ranged from 0 to 4 mm, providing an accurate overall dataset for Mound A. Major and minor topographic relief is evident in the results. Figure 6 shows Mound A in 1 m contour intervals; lesser intervals obscure detail at this scale, due to the steep flank gradient at the current reporting resolution. Figures 7 and 8 offer aerial and tilted views, respectively, of the TIN mesh. Beyond mound features discussed here, the notable "gully" adjacent and southeast of Mound A, is readily evident. This significant topographic feature, reported first by Harrold (Pickett

Figure 5. Mound A western flank photograph.

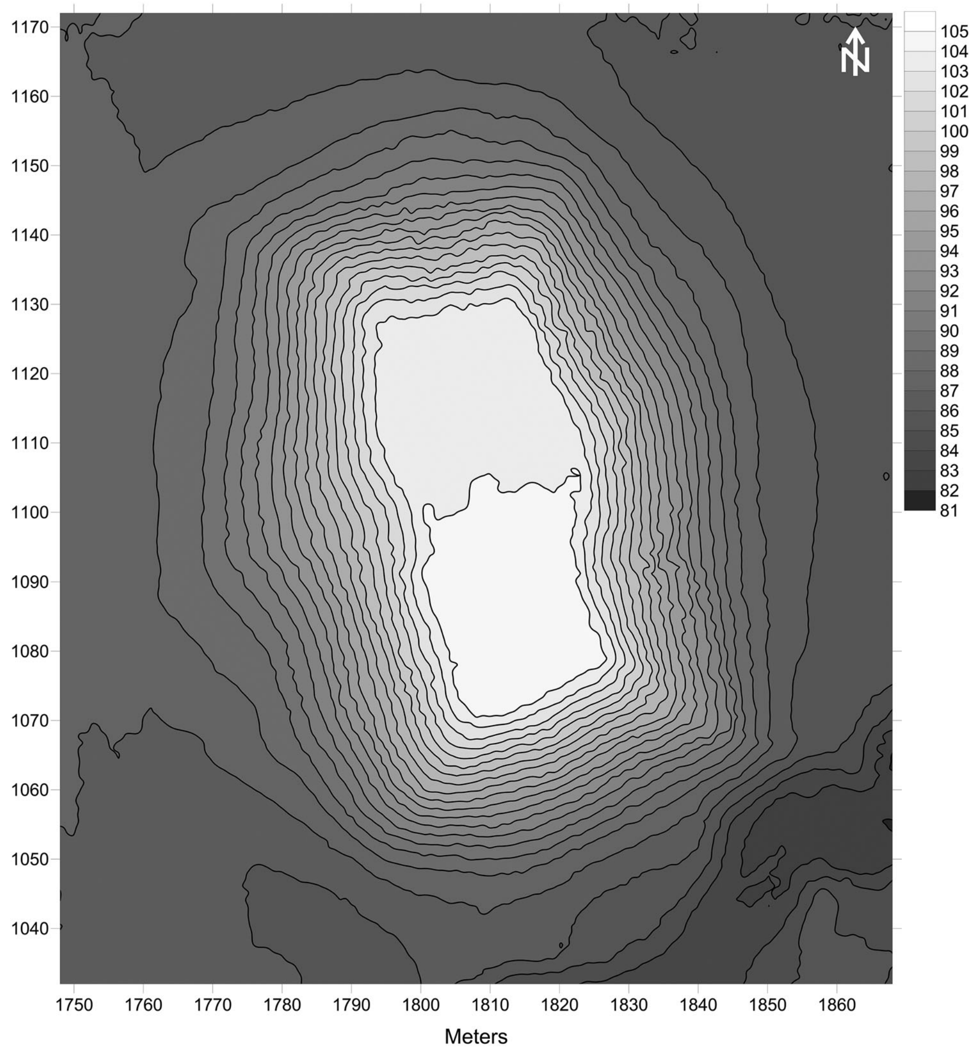


Figure 6. Mound A shaded relief map, 1 m contours.

1896 [1851]), is still unexplained and requires further mapping and testing to address its source, whether anthropogenic or natural.

The summit of Mound A is slightly sloped, rising from north to south, as reported in the 1882 *Early County News*. Historic alterations to the summit include gardening/agriculture, tree removal and burning, multiple excavations, modern signage, and decades of foot traffic; not all are topographically apparent. Most noticeable are the west-east saddle crossing the central mound summit, and the summit-edge circuit path. The latter undoubtedly is a product of modern visitors, while the former may have some antiquity. As noted by Trowell (1998:27) in the 1882 *Early County News*, the summit was "rather narrower in the middle than at the ends," and as Palmer illustrated, the central, western flank depression peaked in a concavity at the summit's edge. While no indisputable evidence of former summit excavations is apparent, there is a square depression in the northern third area that may correspond to one of Palmer's 3.66 m (12 ft) summit units (Figure 9). Measuring 3.6–4 m on a side, it is oriented to the cardinal directions, rather than to the mound's orientation, and its location corresponds to Palmer's description.

Current topographic features of Mound A's flanks (Figure 10) may have some antiquity; these are also apparent in the Figure 6 contours. Palmer (1884) notes base-to-summit depressions on the center of the west side, the north side, and the southern end of the east side that are reflected in the current data (Figure 10A–C), as is the "enlargement outward" he notes in center of the east flank (Figure 10D). Palmer (1884) notes no such depression on the south flank. There is a slight concavity to the eastern portion of the south flank; this may be due in part to Fleming's and Palmer's trenches in that part of the mound. It is certainly possible that one or more of these linear, summit-to-base features represents a ramp from Mound A's construction and use, although

Figure 7. Mound A TIN planview perspective.

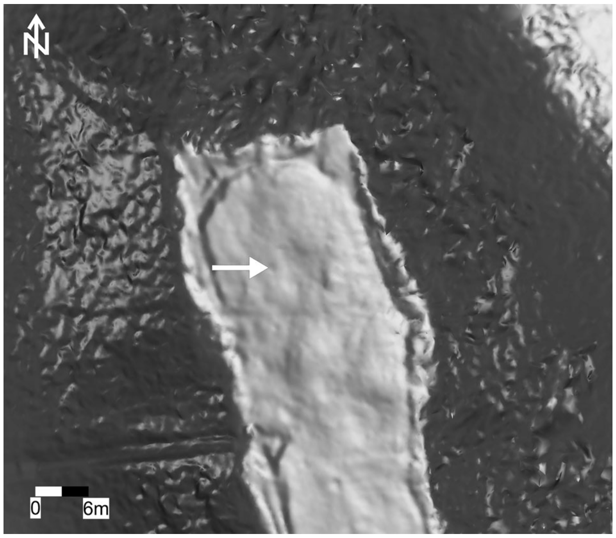


Figure 9. Mound A, summit close-up. Arrow indicates a square depression that is possibly one of Palmer's excavation units.

we cannot rule out the effects of historic slope wash, the construction of the western-flank stairwell (contracted in 1946; Trowell 1998:43), and the reported use of the Mound's flanks for football training exercises in 1960 (Trowell 1998:51).

The processed dataset also allows exceptional capability to measure Mound A; current and previous metrics are reported in Table 1. Erosion has undoubtedly altered the original footprint of Mound A, and slope wash is evident. Here, demarcation of the mound's limits is based on the visual estimation of point-of-rise from surrounding, relatively level ground surface, and contour intervals indicating slope rise. While this approach may create a larger footprint of the mound overall, it allows for inclusion of eroded mound soil at the toe slopes for volume calculations. It may also more truly represent the mound's current limits.

Using this approach, Mound A's base measures 127.7 m through the long axis, and 97.2 m through the short. This estimate is larger than any previously reported, and may reflect the inclusion of slope wash accumulated at the toe slopes. The summit's maximum dimensions are 55.8 m through the long axis and 23.3 m through the short. These are almost the same as McKinley's and very close to Palmer's dimensions,

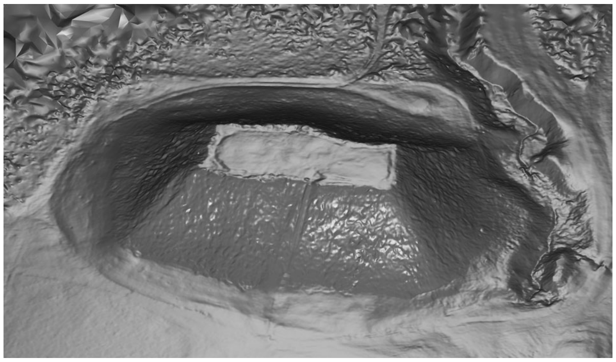


Figure 8. Mound A, TIN tilt perspective.

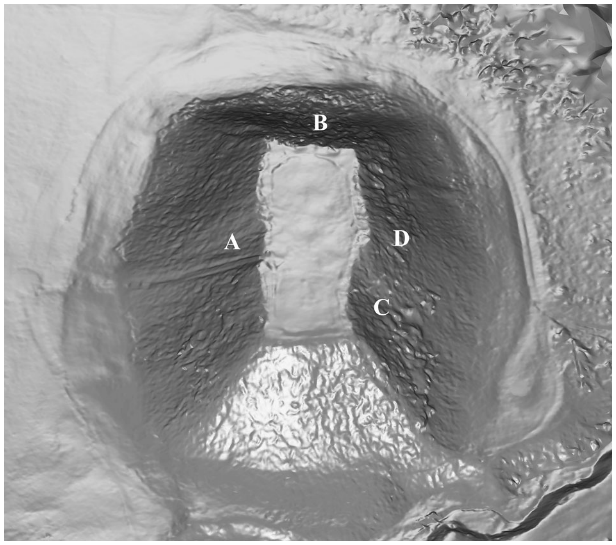


Figure 10. Selected Mound A topographic features. The base-to-summit depressions are indicated by the letters A, B, C. The flank protrusion is indicated by the letter D.

Table 2. Mound A labor estimates.

Kolomoki Mound A (67735.9 m^3)	Excavation days (1 person, 5 h)	Transport days (1 person, 5 h)	Spreading/leveling days (1 person, 5 h)	Total earth moving days	50 person workforce days	100 person workforce days	200 person workforce days
Erasmus (1965) formula	26052.27	38706.23	3984.46	68742.96	1374.86	687.43	343.71
Muller (1986) formula	37631.06	38706.23	3984.46	80321.75	1606.43	803.22	401.61
Hammerstedt (2005) formula	46714.41	38706.23	3984.46	89405.11	1788.10	894.05	447.03

suggesting no major alterations to summit size since the mid- to late-nineteenth century. Maximum mound height, measured as the difference between the lowest elevation perimeter point and the highest elevation summit point, is 19 m. This is significantly taller than estimates by Sears (17.22 m; 1956:10) and Jones (17.37 m; 1873), but shorter than those of McKinley and Palmer. This elevation reflects z-values georeferenced to the local site grid, not necessarily meters above sea level.

Mound volume is calculated in 3DReshaper by removing all surrounding terrain, closing the "open" base of the surface TIN model of the mound, and calculating the interior volume of the resultant form. At 67,735.9 m^3, Mound A is the fourth largest "late prehistoric" mound in eastern North America, behind only Monks Mound at Cahokia (11MS2), Mound A at Etowah (9BR1), and Mound A at Angel (12VG1), as reported by Muller (1997:Table 6.6). This is considerably larger than the 51,000 m^3 estimated by Pluckhahn (2003: Table 7.3). The next largest Woodland mound, after this, was probably Sauls Mound at the Pinson site in Tennessee, estimated at 60,500 m^3 (Mainfort 2013:3; Shenkel 1986:214).

Applying soil excavation formulas reported for laborers using digging sticks in Mexico (Erasmus 1965), modern construction with hand tools (Muller 1986), university students using a replica chert hoe (Hammerstedt 2005), and earth moving and leveling estimates assuming a source within 100 m (Erasmus 1965), we estimate the effort required to construct Mound A (Table 2). These tabulations assume a 5-hour work day. With a workforce of 200 people, and contiguous construction days, Mound A could be completed in approximately a year to a year and 3 months. This estimate reflects one-fifth the amount of effort conjectured by Maxwell (Jones 1873:170), and roughly 1.7–2.2 times that calculated by Pluckhahn (2003:193).

Discussion

Dating back at least 5000 years before present and continuing to the early historic period, mound building in the Southeast is viewed by many as a correlate for social and organizational complexity (Anderson 2004; Gibson and Carr 2004). As time progressed, mounds became a nearly ubiquitous and expected part of the cultural landscape of the region. However, the specific architectural expressions and functions of mounds varied as they were created and imbued with layered meanings by dynamic kin groups, communities, and polities. Our struggle to understand them has opened many productive avenues of discussion, including: cosmology and symbolism; competition and collaboration; power, authority, and inequality; and political economy, among others (Hamilton 1999; King et al. 2011; Knight 2006; Lindauer and Blitz 1997; Mainfort 1988; Rodning 2009; Wilson 2010; Wright 2014).

Occupying a seemingly remote location in the Woodland-era landscape of the Deep South, Pluckhahn (2003:46) suggests the site was a "nexus" and important regional center for ceremony and mediation of relationships between or among spatially distinct communities in a segmentary society. The built environment of Kolomoki, including its mounds, was undoubtedly a medium to facilitate and influence these interactions, and the earthworks a physical manifestation and reminder of motive and meaning. As we have shown, the site of Kolomoki is conclusively home to one of the largest earthen monuments in North America: Mound A. It is unlikely we will ever fully understand all of what this mound and the other mounds meant, but it is possible that size (sometimes) matters. Mound A's considerable and imposing prominence may reflect the importance and influence of the actors and kin group(s) responsible for its construction, the successful mediation and mobilization of segmentary groups for common cause, and/or the re-creation of some cosmic character *in situ*. It is impossible to address these larger questions without accurate physical documentation, as we have done here.

There is considerable variability in the measurements provided for Mound A in historic reports and manuscripts (Table 1). It is difficult (perhaps impossible) to account for this, but likely factors include the skill of each surveyor, the equipment used (or lack thereof), the presence or absence of survey assistants (and their level of skill), and clear lines of sight for accurate measurements. It is also possible that historic impacts to the mound (test excavations, erosion, etc.) between documentation episodes somewhat affected individual results. Although Mound A is located on a relatively flat plain, there is a slight grade to the topography surrounding it; and each surveyor's subjective decision regarding where the mound's base began and end necessarily affected overall size and volume calculations.

None of the previous reports on Mound A metrics discuss the methods applied, which is unfortunate. We might expect McKinley (1873), Jones (1873), and Valliant (1937a) to provide the most accurate previous estimates, given that each was a trained surveyor or civil engineer. It is certainly confusing that McKinley (1873) would report a height for Mound A approximately 10 m greater than reality; could this be a typographical error? Regardless of reason for these differences, our current measurements are unquestionably the most accurate to date.

Concluding thoughts

Among his many contributions to the archaeology of the American Southeast, and to that of Georgia specifically, Mark Williams's dedication to documenting the unknown places that surround us is commendable. Human action grounded in spatial contexts, and then expressed in measurable and observable ways, is key to our efforts as archaeologists.

While certainly not a definitive study of Mound A at Kolomoki, this exercise allows us to see a seemingly known place from a new perspective, and to quantify and document essential characteristics of such an imposing edifice that remained elusive in the past. These findings further validate not only the importance of advanced technologies in archaeology, but the value of revisiting historical accounts of well-known sites, as well as the sites themselves.

There is much to learn about this site beyond Mound A, however. Kolomoki is a complex of a domestic and public past, of commerce, cooperation, and perhaps competition, set in a vast natural and cultural landscape. Our current efforts to document portions of the site through LiDAR reveal numerous topographical features of interest; some previously unknown, others unconfirmed in the modern era. Whether historic or prehistoric, these features should impact any discussion of site formation processes in Kolomoki research. Perhaps through additional scan surveys, and the implementation of other mapping technologies (ALS, photogrammetry, etc.), we will one day recreate the entirety of Kolomoki's incredible landscape, allowing us to virtually explore its extent, while removing more and more *incognita* from this *terra*.

Acknowledgements

We would like to thank several individuals and organizations for their inspiration and support of this research. Mark Williams instilled in us not only the appreciation of advanced technologies and their applications in archaeology, but the initiative to both learn and apply them despite potentially steep learning curves. He also emphasized the importance of doing good archaeology "in our own backyard;" Kolomoki is certainly one of those places. We are grateful to the National Anthropological Archives, Smithsonian Institution, for permission to print Figure 4 and to cite extensively from Palmer's unpublished field notes. Archaeologist Bryan Tucker, Georgia Department of Natural Resources, Historic Preservation Division, provided the necessary permit for fieldwork. Jeff Bryant, Kolomoki State Park Manager, and Lauren Lambert, Assistant Manager, provided access and facilities support for the survey. Shaun West, Marty Menz, and Christine Bergmann assisted in the field. Technical support was provided by Hexagon Metrology and Leica Geosystems. We also thank the reviewers of our manuscript, and the editorial staff of the journal, for their thoughtful critiques which improved this submission.

Data availability statement

Data referenced and used in this study are available at the Georgia Southern University Laboratory of Archaeology (LiDAR data, Wood and Pluckhahn 2016), the University of Georgia Laboratory of Archaeology (Kolomoki data from Pluckhahn 2002, 2003), and the University of South Florida Department of Anthropology (Menz 2015, West 2016).

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