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ARTICLE

A Port by Any Other Name: A Preliminary Spatial Analysis of Ancient Infrastructural Landscapes and Settlement Organization at Macurany, Brazil

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Abstract

Complex human–environmental processes form identifiable, lasting features on the landscape that can illuminate past human behavior and human–environment interactions. We examine the anthropogenic landscape of the ancient port of Macurany, located along the middle Amazon River in Parintins, Brazil, and identify four classes of anthropogenic landscape features at the site: wharfs, middens, *terra preta* (dark or black earths), and cultural forests. Middens, *terra preta*, and cultural forests have been found at archaeological sites in regions surrounding Macurany, but wharfs have not previously been reported in Amazonian contexts predating European contact. Taken together, these features are clearly the result of anthropogenesis and represent a range of subsistence, settlement, and infrastructure-building activities pointing to an ancient society that was actively engaged in modifying the surrounding landscape for purposes beyond settlement and subsistence. Evidence for a permanent, extensive, continuously settled society practicing intensive landscape engineering in this region of Amazonia reinforces findings of dense habitation, infrastructure, and early urbanization in Amazonia prior to European contact. This research helps expand our understanding of human–environment interactions, landscape formation processes, and settlement organization in ancient Amazonia.

Resumen

Processos complexos de interação humano-ambiental geram feições reconhecíveis e duradouras na paisagem que podem iluminar o comportamento humano passado e as interações humano-ambiente. Examinamos a paisagem antropogênica do porto antigo de Macurany, localizado ao longo do médio rio Amazonas em Parintins, Brasil, e identificamos quatro classes distintas de feições antropogênicas da paisagem no local, incluindo: cais, lixeiras, terra preta e florestas culturais. Lixeiras, terra preta e florestas culturais já vem sendo evidenciados em sítios arqueológicos em regiões próximas ao Macurany, porém cais não foram relatados anteriormente em contextos Amazônicos que antecede o contato Europeu. Claramente resultante de atividades antropogênicas, este complexo de feições representa uma série de atividades de subsistência, assentamento e construção de infraestrutura que indica uma sociedade antiga intensamente envolvida na modificação da paisagem para fins além do manejo do assentamento e subsistência. Evidências de uma sociedade permanente, extensa, continuamente estabelecida praticando intensa modificação da paisagem nesta região da Amazônia reforça evidências de densa habitação, infraestrutura e urbanização incipiente na Amazônia antes do contato com Europeus. Esta pesquisa contribui para a ampliação dos conceitos de interações homem-ambiente, processos de formação de paisagens e organização de assentamentos no passado Amazônico.

Keywords: Amazonian archaeology; landscape formation processes; infrastructure; urbanization; geographic information systems (GIS)

Palabras clave: arqueologia da Amazônia; processos de formação da paisagem; infraestrutura; urbanização; sistema de informação geográfica (SIG)

Ancient Amazonians created vast, complex landscapes that materially preserve and reflect a mosaic of past human activity. Recent archaeological research has revealed that Amazonians did not just adapt to their tropical environment but also actively modified and engineered new landscapes to fit their needs and to facilitate social, economic, political, and religious relationships (Heckenberger 2008; Iriarte et al. 2017; Lombardo et al. 2020; Neves and Heckenberger 2019; Rostain 2012; Saunaluoma et al. 2021; Schaan 2011; Walker 2011; Watling et al. 2017). Landscapes are particularly valuable sources of information for Amazonian archaeologists interested in understanding these complex relationships because they materially preserve everyday activities and interactions between communities and surrounding environments (Bender 2002; Ingold 1993; Walker 2012). By geospatially analyzing ancient anthropogenic landscape features, archaeologists can identify activity patterns and elucidate past landscape formation processes, settlement organization, and human–environment interactions.

We analyze anthropogenic landscape features at the archaeological site of Macurany, an ancient port along the middle Amazon River in Parintins, Brazil, to understand landscape formation processes and settlement organization. We identify Macurany as an ancient port based on its location and its anthropogenic landscape features: wharfs, middens, *terra preta* (dark or black earths), and cultural forests. Macurany is situated in a relatively understudied region flanked by better-documented contexts along the central and lower Amazon River where extensive regional polities once thrived. Although the regional polities in the central (about 1300–500 BP) and lower Amazon (about 1500–500 BP) had differing chronologies and distinct trajectories, human habitation and interaction likely persisted in intermediate regions beyond the areas intensively studied. The location of Macurany at an intermediate point between two major regional polities would be ideal for a trading post. Transitional zones or politically weak spots are common attributes of archaeological ports of trade elsewhere in the world (Andrews 1990; Rathje and Sabloff 1973), like Tulum (Miller 1982) and Al-Mina (Woolley 1938), further corroborating the idea of Macurany as a trading port. The location of Macurany on an oxbow lake just off the main course of the river also makes it a safe harbor for trade. Finally, the astonishing frequency of ancient earthen wharfs at the site and the surplus of Brazil nut trees located around the site suggest interaction and trade. Taken together, these characteristics—surplus goods, storage capacity (in this case the trees), and transportation infrastructure—are very indicative of export (Andrews 1990; Keay 2012; Polanyi 1963), which means Macurany was likely a trading port.

Archaeological evidence from the port of Macurany can illuminate how residents of Macurany modified the landscape in comparison to neighboring polities and how these regional polities interacted. Survey and topographic data were collaboratively collected at Macurany in July 2017 by members of the University of Louisville, the Universidade do Estado do Amazonas, the Museu da Amazonia, and the Parintins community. We present preliminary results of geospatial analysis used to distinguish among ancient, modern, and historic landscape features at the site. Results suggest that Macurany was a permanent, densely settled society whose inhabitants deeply modified the landscape beyond subsistence and settlement purposes, possibly for trade. Overall, this analysis contributes to understandings of human–environment interactions, landscape formation processes, and early urbanization in ancient Amazonia.

Anthropogenic Landscape Features at Macurany

Wharfs represent a feature class not previously documented in ancient Amazonia. The earthen wharfs reported and documented along the shore of Lake Parananema at Macurany are V-shaped structures carved into the side of the lake bluff at regular intervals, providing access to the water and boat landing and docking space. They are distinct from natural fluvial features in their

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morphology, placement, and frequency. Unlike natural rills, gullies, and channels, these earthen wharfs exhibit no dendritic network, pipe collapse, or evidence of head cuts (Huggett 2011; Wohl 2014), indicating they did not develop as a result of natural fluvial processes. Additionally, they are not found elsewhere along Lake Parananema, and their uniform spacing and structure are not characteristic of natural pipe collapse or gully and channel formation in tropical contexts. The wharfs were likely constructed before European contact because they co-occur with *terra preta* and middens and are coherent with sculpted earth landscapes of the ancient past. In contrast, colonial wharfs would be expected as masonry or wood constructions in the European tradition, as represented throughout the Luso-Brazilian world (Ossenbach 2018:Figure 44; Wiener et al. 1884:Figures pp. 1, 5). For example, the extensive works of the painter Benedito Calixto at the Port of Santos document consistent use of wooden piers before construction of the formal stone wharf.[1] Ancient earthmoving seems to cease about AD 1400 (Moraes and Neves 2020), even though earthworks continue to be used. Finally, construction before European contact is likely because the area surrounding Parintins has undergone significant demographic and economic changes since colonization (Becker and Lima 2013; Cavalcanti 2000), as seen elsewhere among floodplain communities in Amazonia (Green et al. 2019; Schaan and Rodrigues 2018; Stenborg 2016). This caused a shift in settlement away from Lake Parananema toward the north side of Parintins and construction of a new contemporary port, facilitating tourism and regional and global export along the main course of the Amazon River (Becker and Lima 2013).

Ancient anthropogenic earthen wharfs evidenced at Macurany represent infrastructural landscape features, which are typically associated with urbanization (Smith 2016). Early forms of urbanism in the tropics have been characterized as low-density, dispersed settlements interwoven with agricultural land and massive urban infrastructure (Fletcher 2012; Isendahl and Smith 2013; Lucero et al. 2015; Prümers et al. 2022; Scarborough and Isendahl 2020). Large-scale infrastructural networks were integral to maintaining social relationships, economies, and identities across dispersed urban settlements in the tropics, as evidenced in Amazonia (de Souza et al. 2018; Heckenberger 2005; Heckenberger et al. 2003, 2008; Prümers et al. 2022), southeast Asia (Evans et al. 2013; Fletcher 2012; Fletcher et al. 2003), and Mesoamerica (Chase et al. 2019; Isendahl and Smith 2013). The frequency of wharfs and their scale as a complex make them massive connective infrastructural projects, challenging western perceptions of complexity and urbanism in ancient Amazonia.

The presence and spatial distribution of middens and the thickness of *terra preta*, an enriched anthropogenic soil, suggest permanent, dense habitation at Macurany. The middens exhibit uneven surface morphology, scatters of ceramics, and reportedly deep (>1 m) tracts of *terra preta*. Middens and *terra preta* formed at Macurany through intensive deposition and likely continuous occupation. Their formation indicates intentional creation (Browne Ribeiro 2017; Kern et al. 2017), but this cannot be confirmed at Macurany based on surface morphology alone.

Finally, cultural forests observed at Macurany comprising dense concentrations of Brazil nut (*Bertholletia excelsa*) stands, palms (Arecaceae), and fruit trees suggest management by ancient inhabitants, as seen elsewhere (Balée 2013; Lins et al. 2015; Neves 2016; Watling et al. 2017). Local narratives indicate that Brazil nut stands were once continuous across the site but have been dissected by recent development. Additionally, Brazil nut trees can live up to 500 years in stands of up to 100 individuals (Neves 2016). Growing in such dense concentrations requires clearing for saplings and stand management, practices that persist among contemporary inhabitants of Macurany. The density, size, and distribution of surviving Brazil nut stands at Macurany point to long-term management over generations. Considering the current landcover and local accounts of previously more extensive Brazil nut stands, the forests were likely intensively managed by ancient populations.

Archaeological and oral historical evidence from the port of Macurany hence indicate a permanent, densely settled ancient society that profoundly modified the landscape for purposes beyond subsistence. Recognizing Macurany as a port sheds new light on trade, social integration, and urbanization in Amazonia and moves discussions of infrastructure beyond subsistence and settlement and deeper into regional interaction.

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Amazonian Landscapes

Amazonian landscapes have traditionally been portrayed as pristine ecosystems untouched by humans (Lathrap 1970; Meggers 1954, 1971), but archaeological research, especially from the late twentieth and early twenty-first centuries, shows that these ecosystems have been engineered by Amazonians for at least 10,000 years (Clement et al. 2015; Neves 2016; Rostain 2012; Schaan 2011). Such landscapes materialize the complex history of human–environment interactions and are characterized by anthropogenic features ranging from roads and causeways (Erickson and Balée 2006; Saunaluoma et al. 2021; Schmidt et al. 2014) to ponds (Blatrix et al. 2018; Prestes-Carneiro et al. 2016; Stenborg et al. 2018), mounds (Carson et al. 2015; de Souza et al. 2018; Lombardo and Prümers 2010; Roosevelt 1991; Walker 2008; Watling et al. 2017; Wüst and Barreto 1999), agricultural earthworks (Clement and Junqueira 2010; Clement et al. 2015; Denevan 2001; Moraes and Neves 2020; Rostain 2012), and anthrosols (Arroyo-Kalin 2014; Browne Ribeiro 2017; Kern et al. 2017; Lima et al. 2002; Schmidt et al. 2014). Amazonian archaeologists like Walker (2011) and Rostain (2012) group landscape features according to function, such as settlement, subsistence, defense, and cosmological.

However, one important category has received little attention in Amazonian literature: infrastructure. Infrastructural landscapes provide fundamental necessities for large-scale populations, regional polities, and urbanization (Graham and Marvin 2001; Harvey et al. 2016; Smith 2016). Large-scale communities with long-distance communication and trade networks require infrastructure to manage cultural, political, cosmological, and economic flows (Harvey et al. 2016; Larkin 2013). Infrastructure emerges through interactions, planning, and collective labor investments that require social organization, political connections, and collaboration (Harvey et al. 2016; Smith 2016). Unlike other landscape features, infrastructure is built to last for generations and represents an investment in permanence. Infrastructural landscape features include waste management systems, such as sewers and drains; subsistence structures, such as reservoirs, irrigation canals, and terraces; and communication networks, such as highways and roads. They are rarely mentioned in discussions about Amazonia (for an exception, see Heckenberger et al. 2003; Prümers et al. 2022), and when they are, they primarily appear in discussions of subsistence and agricultural production (Arroyo-Kalin 2010; Carson et al. 2015; Iriarte et al. 2020; Lombardo and Prümers 2010; Walker 2011). This is likely because debates about Amazonian cultures traditionally revolved around agriculture (Denevan 1998; Lathrap 1970; Meggers 1954, 1971; Steward 1948), carrying capacity (Beckerman 1979; Gross 1975; Smith 1980), and food scarcity (Carneiro 1970), rather than urbanization.

We argue that studying these features as evidence of infrastructure building reveals a different dimension across and between Amazonian settlements, making them visible as pieces of larger systems of places. Further, such landscape features can be studied as traditional units of analysis, like ceramics or lithics. For example, managed forests can be analyzed and compared to understand ancient subsistence and resource extraction, and wharfs can provide insights into infrastructure, trade, communication, and regional interaction. Landscape features thus form the focus of this study. At the ancient port of Macurany, we identified four classes of landscape features—managed forests, *terra preta*, middens, and wharfs—and classified them as associated with subsistence, settlement, or infrastructure. Although we recognize landscape features can serve multiple functions, classifying them helped methodologically to illuminate different aspects of each feature.

In Amazonia, managed forests like Brazil nut stands and palms are primarily associated with subsistence, suggesting forest management was a common practice (Balée 2013; Denevan 2001; Clement and Junqueira 2010; Neves 2016; Shepard and Ramirez 2011; Stahl 2015; Watling et al. 2017). In a standardized species-level tree inventory across lowland Amazonia, ter Steege and colleagues (2013) found that 227 species accounted for half the trees of approximately 16,000 identified species. Among these hyperdominant species, a disproportionate number of individuals come from families of palms and Brazil nut (Neves 2016; ter Steege et al. 2013). Brazil nut stands have also been found in association with *terra preta* (Balée 1989; Neves 2016) and geoglyphs (Shepard and Ramirez 2011). The present distribution of Brazil nut trees is likely anthropogenic because of the thickness and weight of the seed capsule (Neves 2016; Shepard and Ramirez 2011). Brazil nut trees occur in

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dense stands and require ample sunlight, suggesting that ancient Amazonians cleared space for saplings to generate existing stands. Numerous other economically and symbolically useful tree species have been associated with ancient forest management (Balée 2013; Erickson and Balée 2006; Neves 2016; Neves and Heckenberger 2019; Watling et al. 2017), further supporting the notion that managing trees was an integral part of Amazonian subsistence systems.

Middens and *terra preta* are landscape features resulting from ancient settlement. *Terra preta* is an Amazonian anthropogenic soil formed through in situ processes and characterized by high levels of soil organic matter, biochar, and ceramics (Arroyo-Kalin 2014; Browne Ribeiro 2017; de Oliveira et al. 2020; Hecht 2003; Kern et al. 2017; Schmidt et al. 2014). It has been associated with large, permanent settlements along the main channels of the Amazon River and other major tributary rivers and lakes (Arroyo-Kalin 2014; Levis et al. 2014; Petersen et al. 2001; Schaan 2011). Some archaeologists (Browne Ribeiro 2017; Kern et al. 2017; Sombroek 1966) distinguish between *terra preta*, associated with ancient settlement and habitation, and *terra marrom*, an anthrosol linked with ancient subsistence practices. *Terra marrom* (brown earth) is characterized by lighter-colored soil and few to no ceramics.

In Amazonia, middens accumulated in rounded or ringed mounds near habitation areas. Although commonly formed of *terra preta*, middens may have varied composition. Rounded middens have been evidenced in and near Marajó (Schaan 2011). Ring-shaped middens have been recorded in the upper Xingu region (Heckenberger 2008; Schmidt et al. 2014), at the Amazon–Xingu confluence (Browne Ribeiro et al. 2016), the lower Amazon (Lima et al. 2002), the Trombetas River (Schmidt et al. 2014), and in the central Amazon (Browne Ribeiro 2017; Chirinos 2007; Kern et al. 2017; Moraes 2010; Moraes and Neves 2012; Neves 2013; Schmidt et al. 2014).

Wharfs are infrastructural landscape features commonly associated with ports. Wharfs, shoreline structures for landing boats, and ports—places where boats load or unload—must have been crucial to trade, communication, and social and political networks in riverine environments; yet their incidence in Amazonian archaeological reports is scant. This is likely because the material evidence for wharfs and ports in Amazonia defies western expectations for form and materiality. Additionally, ports may be associated with the class of complex societies from which Amazonian cultures were historically excluded. Schmidt and colleagues (2014) report large linear depressions leading from bluff to water at sites along the Solimões River and in the central Amazon but provide no systematic feature descriptions. Browne Ribeiro and colleagues (2016) also documented riverine access routes on the lower Xingu. Lipkind (1948) ethnographically recorded port use among Carajá populations on Bananal Island.

An anthropological archaeology of ports can enhance understandings of settlement, trade, and subsistence, as well as the integration of places in landscapes dissected by water. Earthen wharfs, which govern access to water, aquatic resources, and communication and trade routes, constitute intentional landscape modification. Ports are zones of social interaction among community members and between insiders and outsiders. Therefore, their morphology, size, and distribution can illuminate internal settlement dynamics, including social, political, and economic organization, and index communication strategies with neighboring or distant settlements.

Regional Background

The region surrounding Macurany stretches from the confluence of the Negro and Solimões Rivers, where the Amazon River forms in the central Amazon near the city of Manaus, to the city of Santarém on the lower Amazon River (Figure 1). The region is characterized by lowland tropical forests, high temperatures, rainfall, humidity, and poor, leached, and acidic soils (Moran 1993). Nutrient-rich whitewater rivers dominate the region, with nutrient-poor blackwater rivers contributing to the hydrology in the central Amazon and clearwater rivers appearing in the lower Amazon (Hoorn et al. 2010). Channel meandering and seasonal flooding continually modify the landscape, forming natural levees, islands, and lakes; creating floating forest and grassland habitats; and increasing biodiversity (Hoorn et al. 2010; Moran 1993). In the central Amazon, the Amazon River is wide, and floodplains extend for greater distances, providing more nutrient-rich soils for

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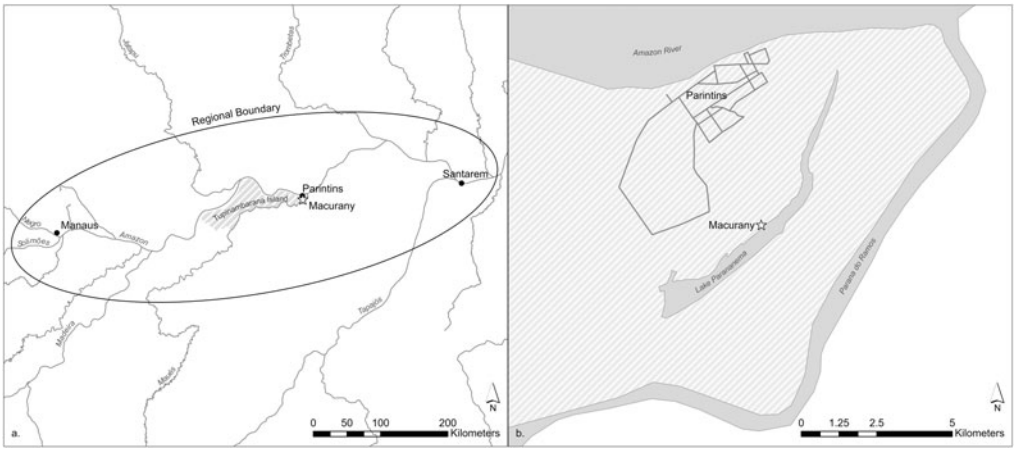

Figure 1. (a) Region surrounding Macurany; (b) location of Macurany.

agricultural production. In contrast, in the lower Amazon, the river channel narrows along with the floodplains.

Early Amazonian archaeologists (Lathrap 1970; Meggers 1954, 1971) argued that permanent agricultural societies could develop only on floodplains, whereas contemporary scholars (Lima et al. 2002) cast active floodplains as unlikely settings for intensive settlements. *Terra preta* and other anthropogenic features on bluffs overlooking floodplains and lakes further suggest that ancient Amazonians lived on stable upland environments.

In the central Amazon, intensive landscape modification dates to approximately 2000 BP (Arroyo-Kalin 2014; Browne Ribeiro 2014; Neves and Petersen 2006; Schaan 2011) and includes features like *terra preta*, *terra marrom*, plazas, habitation and funerary mounds, defensive structures, agricultural areas, and wetland and forest management systems. *Terra preta*, a major marker of archaeological sites in the region, was created through long-term occupation, the internal restructuring of habitation sites, and the intentional charring of refuse in middens (Arroyo-Kalin 2014; Browne Ribeiro 2017; Kern et al. 2017; Schmidt et al. 2014). These middens sometimes formed around domestic spaces in a ringed, linear, or honey-combed pattern forming a middenscape (Schmidt et al. 2014).

Settlement patterns identified in the central Amazon include ringed and linear villages with central plazas, which appear with the emergence of regional polities (about 1300 BP; Browne Ribeiro 2014, 2017; Kern et al. 2017; Neves 2013; Neves and Peterson 2006; Schmidt et al. 2014; Wüst and Barreto 1999). Some villages were enclosed by defensive ditches (Neves and Petersen 2006; Schaan 2011; Schmidt et al. 2014). Ancient inhabitants seem to have lived in a dispersed regional pattern with smaller settlements linked with larger residential and ceremonial centers (Heckenberger et al. 2007; Neves 2013). Neves (2013) attributes the lack of evidence for centralized authority or institutionalized social inequality to an abundance and predictability of resources in the central Amazon.

The lower Amazon exhibits some similarities in settlement and landscape modification patterns with the central Amazon. Landscape features include habitation mounds, ritual caches, trail networks, *terra preta*, *terra marrom*, and managed forests and wetlands. Sites are also commonly situated on bluffs along lakeshores and tributary rivers (Heckenberger 2008; Levis et al. 2014; Roosevelt 1999; Schaan 2011). However, anthrosol formation in the lower Amazon diverges from the middenscape model. Instead, large *terra marrom* gardens suggests intentional preparation for cultivation (Neves 2013; Schaan 2011).

The lower Amazon was regionally organized from 1500 BP onward (Schaan 2011), where settlement patterns reveal a highly stratified society and large tributary polity (Heckenberger 2008; Heckenberger et al. 2007; Schaan 2011). Roosevelt (1999) concluded that Santarém was of urban scale and complexity given the arrangement of long houses, low mounds, ceramic caches, and large

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terra preta middens. Smaller settlements along local tributary rivers, lakes, and interfluves were likely nodes in regional trade networks (Schaan 2011).

Although inhabitants of the lower and central Amazon occupied similar environments and actively managed the landscape, the archaeological evidence indicates distinct regional polities. Central Amazonian ringed villages demonstrate intensive landscape modification by inhabitants living in permanent, dense settlements without institutionalized political centralization, in contrast to the stratified and centralized tributary society of the lower Amazon. These regional differences position Macurany as a potential borderland or zone of interaction between societies that shared technological innovations like *terra preta* and likely exchanged material goods, people, and ideas. This region along the middle Amazon River, where Macurany is situated, could be key to understanding the relationships and frontiers that existed between these two regional polities.

The Port of Macurany

The port of Macurany is located on the eastern edge of Tupinambarana Island in the middle Amazon River in the city of Parintins where small river channels and inland lakes meet the Amazon River (Figure 1). Macurany sits on a bluff along the shores of Lake Parananema, an oxbow lake just south of Parintins, and stretches from the northwestern lakeshore to a modern road that connects the recently constructed Vila Cristina neighborhood to Parintins in an otherwise rural zone. Brazil nut stands and inajá palms (*Attalea maripa*) enclose the site to the northwest, while a small portion of the lakefront and the southwestern extent is kept mostly clear of vegetation by rural smallholders who own and maintain the property surveyed for this study (Figure 2).

Earthen wharfs were identified at regular intervals along the lakeshore. Of the 18 wharfs reported by Parintins community members, nine were verified by project members, although one was almost completely destroyed by recent construction. *Terra preta* extends from the lakefront and decreases in depth and color toward Vila Cristina. Elevated *terra preta* middens are found a few meters inland from the wharfs.

Contemporary housing and work structures dot the site (Figure 2). Two wharfs are used by inhabitants for swimming, playing, and docking boats. Inhabitants also maintain gardens on the land between the wharfs and cultivate manioc on portions of *terra preta*. They maintain diverse and mixed managed forests closer to home and Brazil nut stands farther from domestic areas, where they harvest Brazil nuts for consumption and shells for fuel.

Survey of Macurany

The 10-day survey in July 2017 included mapping site topography and modern features; it covered approximately 110,600 m^2 from the lakeshore to the roadside (Figure 2). Property access was negotiated with members of the smallholder family, who engaged with the survey and provided information about recent site use. Access, time, and research priorities determined the survey extent.

We prioritized determining site extent and topographic mapping of anthropogenic features in areas with high surface visibility; in particular, the clear-cut zone near the lakeshore because it permitted high-resolution topographic mapping and *terra preta* identification. Three wharfs were selected for mapping because of accessibility and visibility. Fifteen other wharfs reported in the area were excluded due to dense vegetation, limited visibility and accessibility, and time constraints. Other areas that were surveyed were not mapped as extensively. A northwest transect from lakeshore to roadside yielded two site boundaries.

Mapping

Site topography and features were mapped using a Sokkia CX-103 series total station and a Trimble Nomad 1050 handheld computer to create a 3D point cloud. Data were collected using an open-source software, EDM-mobile, created by Shannon McPherron and Harold Dibble. We used an adaptive sampling technique to map topography, permitting higher-resolution mapping for areas with greater surface heterogeneity. Three distinct topographic areas were delineated for the survey (Figure 3) and mapped according to surface heterogeneity. The wharf area was mapped at the highest resolution,

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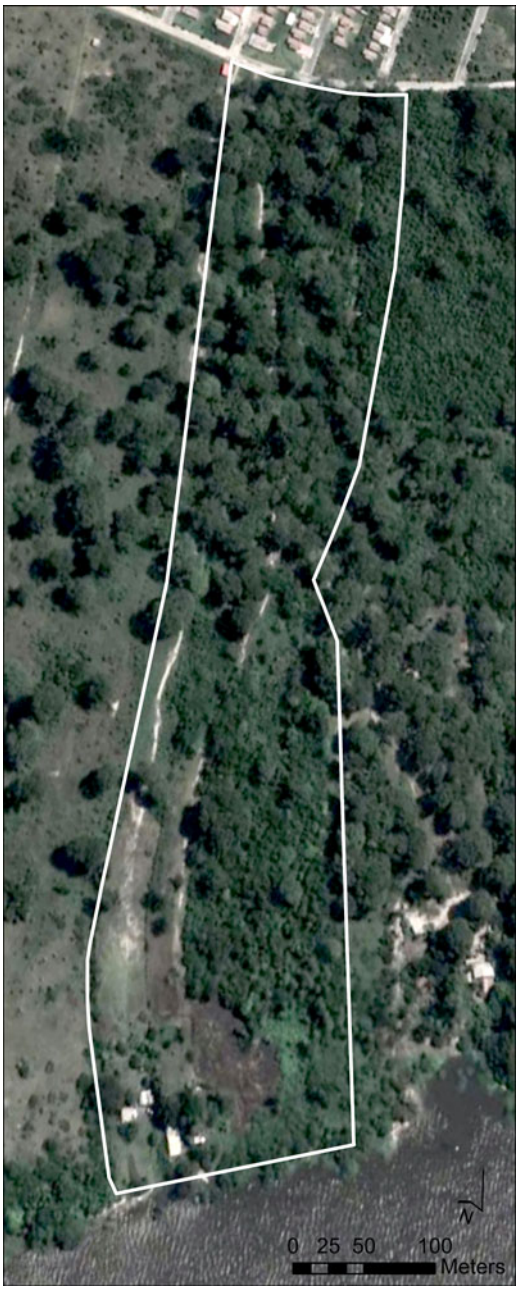

Figure 2. Extent of surveyed area at Macurany.

with an average of 1.5 point/m^2. The second topographically distinct region, located just northwest of the wharfs, exhibited variations in elevation and large, deep (up to 40 cm as evidenced by opportunistic soil probes) tracts of *terra preta* with numerous ceramic sherds above and below the surface. Topography was taken for this area at an average resolution of 0.25 point/m^2. The final area was mapped with an average resolution of 0.04 point/m^2. This area was used as a horse pasture and was relatively flat.

We mapped contemporary features to elucidate recent disturbances in topography. Most modern features were located within 90 m of the lakeshore. We also created hand-drawn maps to document features, vegetation, and site layout. Property owners supplemented our knowledge of recent landscape use.

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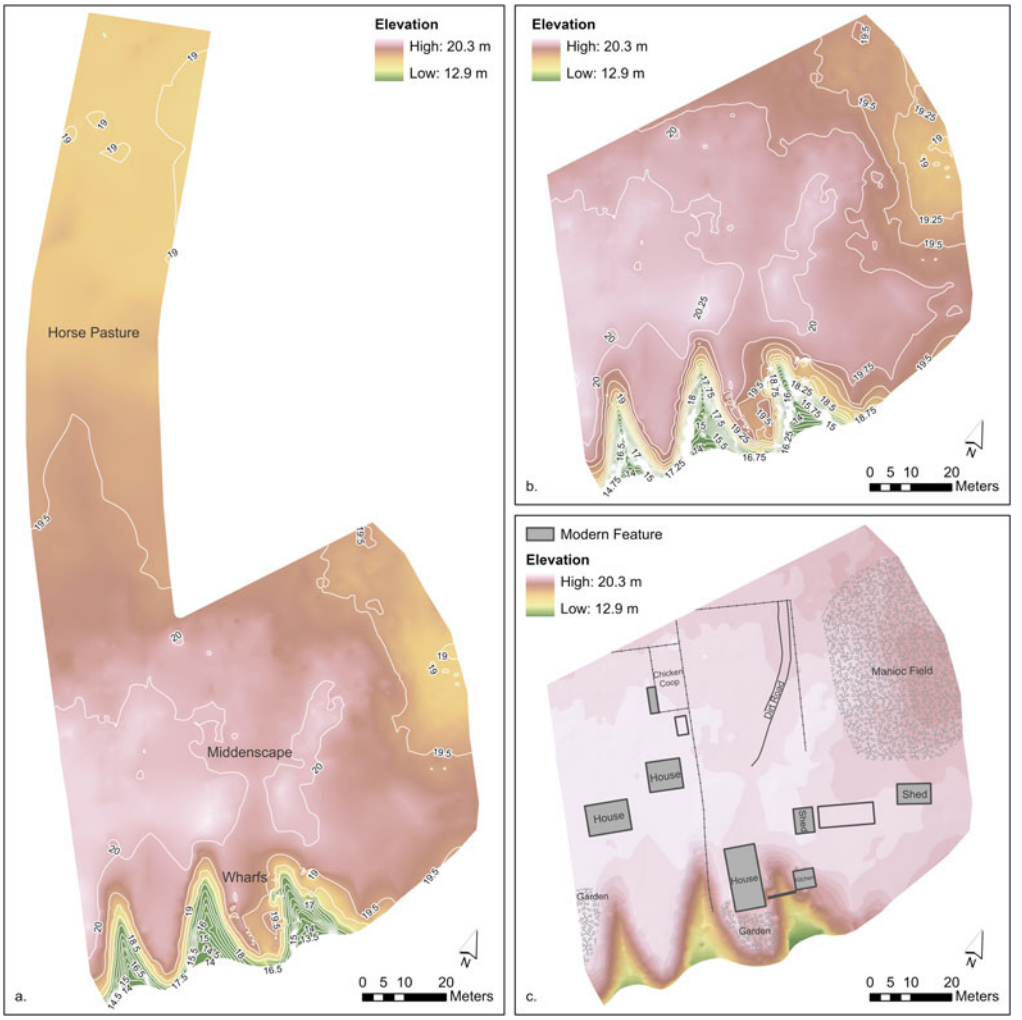

Figure 3. (a) Extent of topographically mapped area with 50 cm contours; (b) topography of middens and wharfs with 25 cm contours; (c) topography of middens and wharfs with modern features.

Data Processing

Point cloud data were processed in ArcPro 2.9 (ESRI 2021). A geodatabase was created to manage data, produce topographic maps, and delineate modern features. To represent site topography, we created a digital elevation model (DEM) by interpolating elevation points using Nearest Neighbor. Other datasets were derived from the DEM using the Spatial Analyst tool, including contour lines, hillshades, and slope rasters. Modern features were digitized using the Editor tool (Figure 3).

Results

We identified two site boundaries and four types of distinct ancient landscape features: wharfs, middens, *terra preta*, and anthropogenic forests (Figure 4). Site boundaries were determined based on the extent of *terra preta* and remnant cultural forest to the northeast, and the southeast was defined by the shores of Lake Parananema. The habitation zone extends northwest approximately 200 m from the lakefront, with areas of managed landscape extending 600 m from the habitation zone to Vila Cristina. Due to access limitations, the southwestern and northeastern extents of the site were undetermined.

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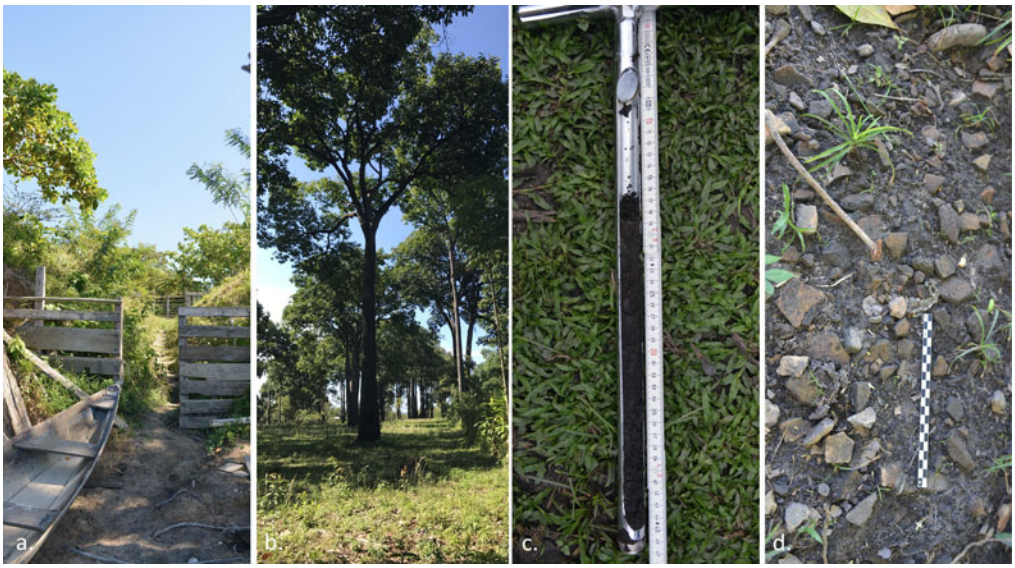

Figure 4. Anthropogenic features at Macurany: (a) northwest view of earthen wharf leading up to lake bluff; (b) cultural forest featuring Brazil nut stand; (c) *terra preta* soil probe; (d) midden surface with ceramic scatter. (Photographs by Anna T. Browne Ribeiro.)

Anthropogenic features (Figure 3) were distributed as follows: the wharfs line the southeastern boundary of the site providing direct access to Lake Parananema, with middens just inland of the wharfs that coincide with the deepest tracts of *terra preta*, and anthropogenic forests enclose the clear-cut zone. Modern features are concentrated within 90 m of the shoreline, coinciding with ancient habitation areas.

Wharfs

Three ancient earthen wharfs were mapped (Figures 5 and 6), each a V-shaped structure with a footpath leading between the water and bluff. Trampling from continuous foot traffic down the center of the wharf has compacted the earth, creating an unnaturally smooth and straight path. The sides of the wharfs are extremely steep, covered in vegetation, and unwalkable. The heavy vegetation and compacted footpaths direct the flow of rainwater runoff, preventing slope erosion and rill formation while preserving the shape of the sculpted earthen wharfs. The wharfs are consistently spaced about 15 m apart along the lakeshore. Those mapped exhibit little variation in size and slope (Table 1).

Wharf 1 exhibits the highest degree of preservation, followed by Wharf 2 and then Wharf 3. Wharf 1 was frequently used by site inhabitants during the time of our survey for docking boats, swimming, and playing (Figures 4a and 6a). The landowners also maintained a garden on the bluff area between Wharf 1 and the unmapped wharf to the southwest, which does not seem to have affected the original topography of Wharf 1. Wharf 2 was least used by contemporary site inhabitants during the time of our survey, despite being the largest wharf surveyed (Figure 6b). A contemporary house/workshop and garden are located on the bluff between Wharf 2 and Wharf 3 and seem to have eroded the original topography of that area, as well as the southwestern side of Wharf 3. Wharf 3 was the most heavily used and seems to have suffered the most degradation due to contemporary use (Figure 6c). Damage was likely caused by the construction of a bridge over the wharf and the use of modern features, including drainage of a sink directly into the side of the wharf. Wharf 3 also has the steepest footpath, which may be due to recent erosion related to contemporary wooden steps that are embedded into the pathway.

Middens

Topographic data show elevated areas along the southeastern extent of the site near the wharfs and lakeshore (Figure 7). We identified this area as a middenscape by its soil composition and high frequency of ceramics observed eroding out of these elevated areas (Figure 4d). Midden morphology

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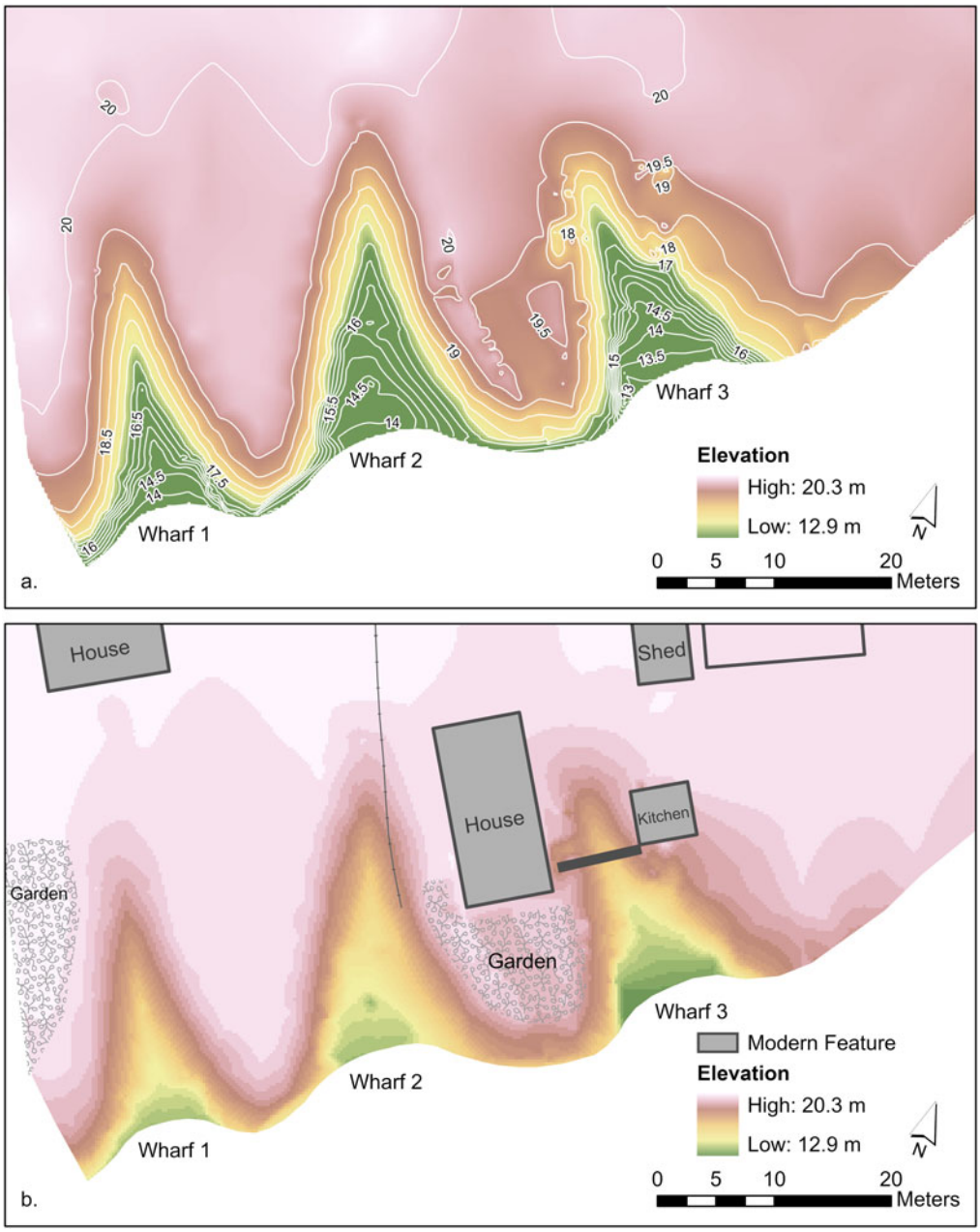

Figure 5. (a) Topography of wharfs at Macurany with 50 cm contours; (b) topography of wharfs at Macurany with 25 cm contours and modern features.

and elevation are irregular, likely a result of modern use. A contemporary dirt road has cut through the middenscape, leaving a linear, 0.5 m deep impression in the surface, possibly enhancing elevation on either side of the road (Figure 7). Similarly, houses and other heavily trafficked areas have disturbed the original topography of the middenscape (Figure 7).

Terra Preta

Terra preta was variably distributed across the site and was identified through visual observations and opportunistic soil probes (Figure 4c). The most intensely modified *terra preta* co-occurs with the

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Figure 6. (a) Southeast view of Wharf 1 from lake bluff; (b) south view of Wharf 2 with house constructed on bluff; (c) north view of Wharf 3. (Photographs by Anna T. Browne Ribeiro.)

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Table 1. Measurements of Wharfs Surveyed at Macurany.

	Wharf 1	Wharf 2	Wharf 3
Length	24 m	29 m	24 m
Width	14 m	21 m	18 m
Area	280 m^2	387 m^2	297 m^2
Slope	6°	9°	13°

middenscape. The elevation and likely thickness of *terra preta* decrease across the surveyed area as it approaches the Brazil nut stand to the northwest.

Anthropogenic Forests

Anthropogenic forests were identified through visual observations and informal conversations with the property owners; they are dominated by Brazil nut trees (Figure 4b). Brazil nut stands are located along the northern perimeter of the surveyed area. Mixed managed forest or horticultural zones situated closer to domestic areas of the property include inajá, cashew (*Anacardium occidentale*), guava (*Psidium guajava*), genipapo (*Genipa Americana*), acerola (*Malpighia emarginata*), and other palm and fruit tree species. Residents report historically actively managing the Brazil nut stands and palms, regularly burning plant debris, and harvesting fruit.

Discussion

Spatial Patterning of Landscape Features

The spatial patterning and structure of wharfs at Macurany are highly standardized (Figure 5), with slight variations in form, size, placement, and orientation. Each wharf opens toward the lake with a moderately sloping footpath leading to the water and is surrounded on two sides by steep, unwalkable bluff edges. Unlike naturally occurring rills caused by erosion as seen in Figure 6c, the compacted, straight paths and smooth, steep slopes suggest that the earthen wharfs are anthropogenic.

The wharfs lead from the lake up to the midden area, which is concentrated toward the edge of the bluffs. The middenscape, however, exhibits no identifiable spatial pattern (Figure 7). Current and

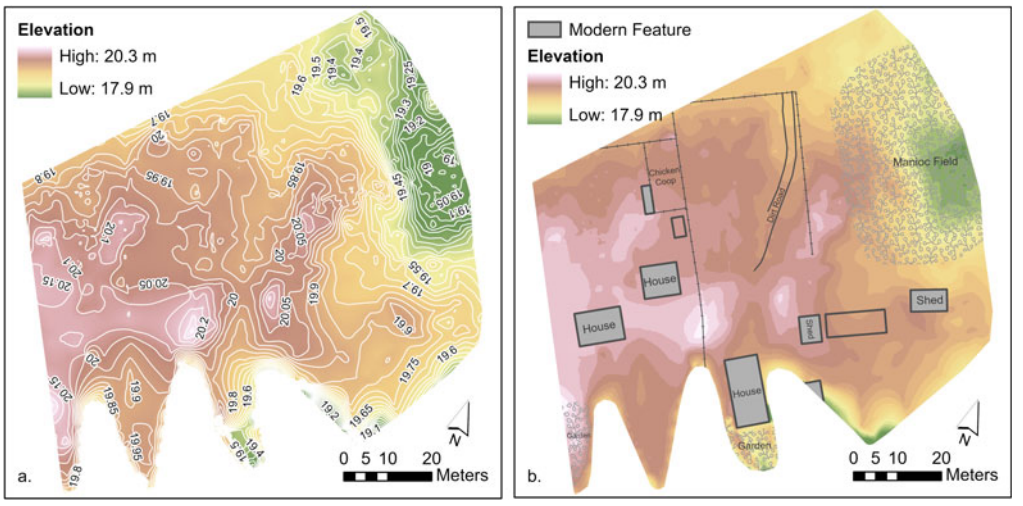

Figure 7. (a) Topography of middenscape at Macurany with 5 cm contours; (b) topography of middenscape at Macurany with modern features.

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historical features may be obscuring earlier middenscape patterning, and enlarging the survey area and excavation may yield comprehensible patterns.

Terra preta varies in depth and distribution, with the deepest and most intensely modified tracts coinciding with the midden area. It seems to decrease in depth and fade out beyond the horse pasture (approximately 200 m northwest of the lakeshore), although its boundary has not been determined.

Anthropogenic forests emerge around the edges of the middenscape and increase in density toward the northwestern site boundary. Brazil nut stands dominate the northern perimeter of the site, with mixed managed forests appearing closer to the midden area and along the southeast site boundary. Local narratives suggest that Brazil nut stands were formerly more extensive.

Landscape Formation Processes

Geospatial analysis of the wharfs and their frequency, standardized morphology, and association with *terra preta* indicates they are the result of intentional human activities. Ancient construction is suggested by their earthen, sculpted nature. The wharfs would have functioned as infrastructural landscape features built into the lake bluff and provided inhabitants with access to aquatic resources and communication and trade routes. They would have been maintained through daily use because abandoned wharfs observed during survey exhibited erosion and dense vegetation, making them impassable and unusable.

Current site use and construction, like the modern bridge across Wharf 3 and the stepped wooden footpath, continue to affect these landscape features, disturbing the original structure and causing heavy erosion (Figure 5). This suggests that earlier inhabitants refrained from erecting permanent structures in bluff areas, especially given that wharfs without modern structures exhibit less erosion (Figure 5). Ancient inhabitants would likely have made similar observations about landscape preservation and built structures in other areas to limit erosion near wharfs. Otherwise, the wharfs would not be so standardized or identifiable as they are today. Bluff areas between wharfs may have been used as gardens. *Terra preta* soils are concentrated in these areas and contemporary observations suggest gardening is less detrimental to wharf structure, making these protected spaces likely and ideal locations for house gardens.

Geospatial analysis showed that middens and *terra preta* at Macurany are spatially coupled landscape features that resulted from human settlement. These features form a sculpted soilscape, but the intentionality of deposition cannot be determined because no spatial pattern was identified. Excavation would make it possible to distinguish between habitation and refuse areas and provide a clearer understanding of middenscape morphology and ontogeny. Topographic inconsistencies within the middenscape may be due to ancient settlement reorganization, contemporary site use, or both. Repeated occupation or internal settlement restructuring would have led to overlapping of houses and middens with demographic shifts (Erickson 2003). The impact of contemporary disturbances like the modern dirt road and structures cannot be underestimated.

Ancient and modern habitation have also affected the surrounding anthropogenic forest that, according to local accounts of earlier land cover extended across larger parts of the island. The occurrence of Brazil nut stands in association with archaeological sites elsewhere in Amazonia (Balée 1989, 2013; Neves 2016) suggests that ancient Macurany inhabitants may have also actively managed encompassing forests. The Brazil nut was an integral part of subsistence systems in the broader Amazonian past (Neves 2016) and recently at Macurany, as reported by site inhabitants, for consumption, fuel, and market sales.

Settlement Organization and Regional Comparisons

Located on a lake bluff (Figure 8) like many sites in the region, Macurany features middens, *terra preta*, and anthropogenic forests. However, well-defined, enduring anthropogenic wharfs, especially at this frequency, seem to be a landscape feature unique to Macurany. The occurrence of *terra preta* in a middenscape aligns with formation processes observed in the central Amazon region, although determining whether the midden morphology at Macurany echoes ringed or linear patterns requires further

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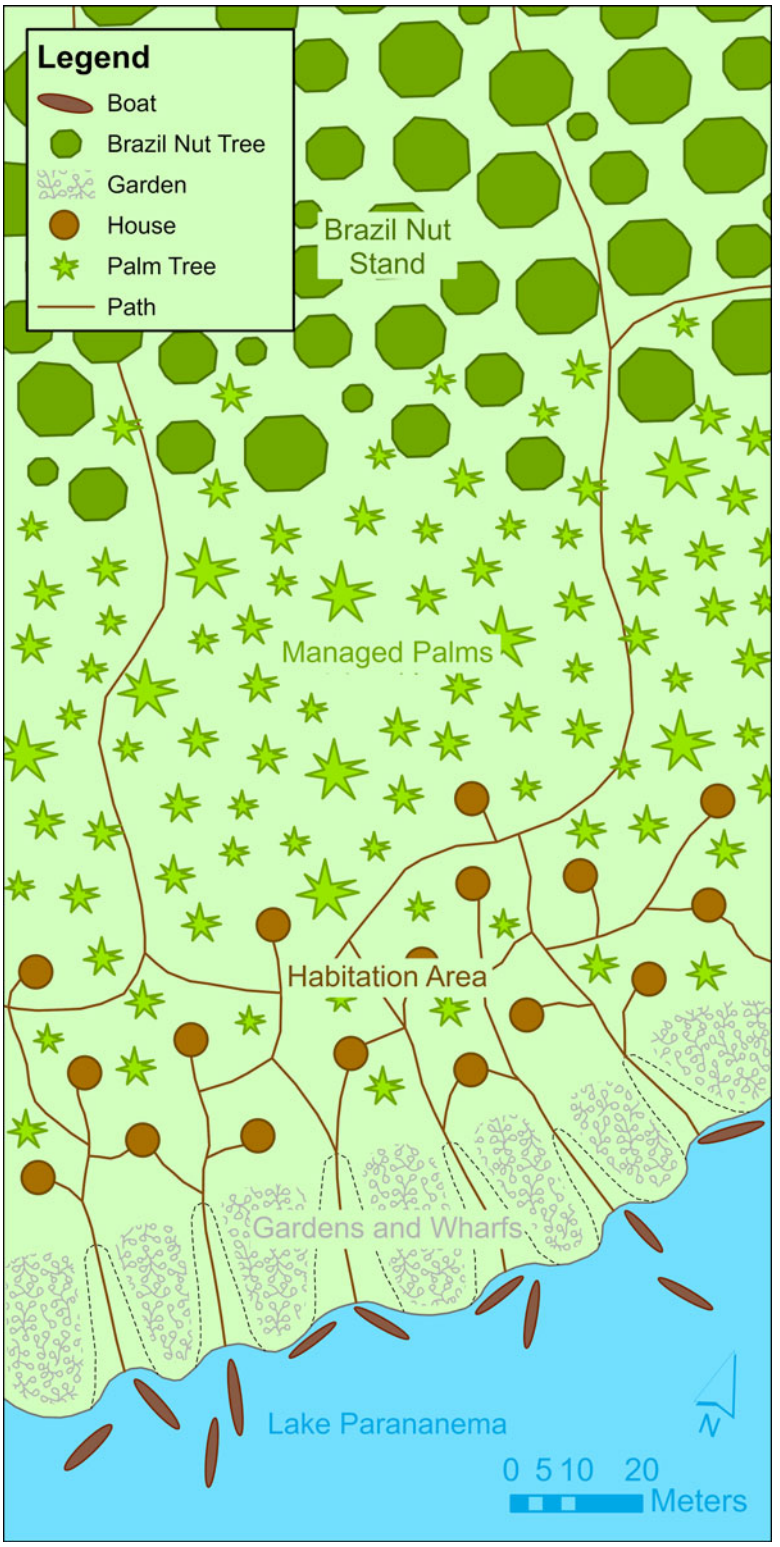

Figure 8. Possible reconstruction of the ancient port of Macurany. (Illustration by M. Grace Ellis.)

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investigation. Nevertheless, this evidence suggests inhabitants of Macurany may have practiced landscape management in similar ways to central Amazonians.

Macurany is distinguished from the central and lower Amazon by the presence and distribution of wharfs. This novel set of infrastructural landscape features represents advanced, likely planned, landscape engineering that may indicate a type of low-density urbanization. The area where Macurany is situated, an understudied region of Amazonia, is ecologically different from other regions and may thus represent a completely different approach to settlement than seen elsewhere. Macurany may represent a distinct regional polity not previously detected. Alternatively, it may have served as a settlement node in a larger regional polity, perhaps centered on the central or lower Amazon. In that case, divergences from a central node would be expected because inhabitants would adapt landscape modification practices, given differences in resources and environmental context and the distinct role of Macurany within the regional network.

Finally, Macurany may have been an independent hub for trade and export and may have functioned similarly to many port towns in the contemporary and historic world. Its central location between two major regional polities would make Macurany an ideal location for a trading post. It is also strategically positioned on a lake near but not on a major river, providing an attractive, safe harbor for trade. Schaan (2011) documented anthropogenic canals between lakes and main rivers used for trapping fish, but they could have also provided access routes for lake settlements and ports like Macurany. The seasonal yields of extensive Brazil nut stands at Macurany, which can produce approximately 7,500 seeds during peak season (Neves 2016), would have exceeded what villagers could consume. They may hence have been managed for export, especially considering that concentrating on a single resource like the Brazil nut eliminates valuable space required to produce other essential and economically useful resources. Inhabitants would have had to source vital necessities elsewhere, further suggesting Macurany was oriented toward trade.

Overall, the port of Macurany represents a permanently and densely settled community that intensively engineered the landscape in ancient Amazonia. The density and extent of Brazil nut stands suggest dense populations producing food far beyond their needs, countering traditional claims of food scarcity in Amazonia and further indicating an orientation toward trade. The presence and sheer frequency of wharfs corroborate this hypothesis. Studying other sites on Tupinambarana Island would further illuminate the local and regional role of Macurany. This evidence challenges western perceptions of urbanization and complexity in ancient Amazonia and expands our knowledge of landscape modification, infrastructure and planning, and early forms of urbanism in tropical contexts.

Conclusion

Macurany represents an understudied context in a low-lying floodplain region situated between two known major centers along the main course of the Amazon River. The identified features indicate complex subsistence, settlement, and infrastructural activities by inhabitants prior to European contact. The morphology and construction of wharfs point to an ancient origin and suggest Macurany was a port.

The present geospatial analysis indicates that Macurany was occupied by an ancient society that managed fluvial and terrestrial resources to support dense settlement and facilitate regional interaction. The intensively modified landscape, permanent dense settlement, and infrastructural landscape indicate incipient urbanization (Heckenberger et al. 2008) at Macurany. Enlarging the topographic sample area and adding excavations, soil probes, and radiometric dating would provide more information about settlement organization at Macurany, middenscape morphology and formation, and the chronology and distribution of wharfs.

Methodologically, this research demonstrates the potential of landscape features as units of archaeological investigation in Amazonia. Anthropogenic landscape features are the product of daily practices and activities that become materialized in the landscape, which preserves and reflects past human–environment interaction; this process makes them significant archaeological data sources that should be recognized and treated as units of analysis, like lithics, ceramics, or masonry architecture (Basso 1996; Bender 2002; Ingold 1993; Tilley 1994).

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By explicitly recognizing infrastructural landscapes in ancient Amazonia, we show that Amazonians unambiguously managed landscapes beyond subsistence and settlement purposes. Saunaluoma and colleagues (2021) demonstrated how extensive interregional road networks connecting neighboring territories along the southern rim of Amazonia facilitated movement and identity formation among dispersed settlements. Similarly, Watling and colleagues (2018) illuminated the past and present symbolic and ritualistic function of the geoglyphs in Acre. Amazonians thus actively managed the environment to facilitate infrastructural and ritual functions. Ritual is more commonly discussed alongside Amazonian landscapes (Saunaluoma and Schaan 2012; Schaan 2011; Watling et al. 2018) than infrastructure, likely because archaeologists have not been trained to seek or expect it in tropical contexts like the Amazon. Conversely, and for similar reasons, conversations regarding infrastructural landscapes rarely mention Amazonia, likely because Amazonian cultures have not been traditionally associated with social complexity and urbanization. The wharfs evidenced at the port of Macurany thus add to a growing body of evidence for ancient infrastructures in Amazonia, providing a foundational dataset for understanding settlement organization as planned and early urbanism in the tropics.

This research contributes toward understandings of human–environment interactions, landscape formation processes, settlement organization, and urbanization in ancient Amazonia. It sheds light on an intensively modified landscape that unsettles traditional assumptions about food scarcity and the nature of economies in Amazonia. Macurany adds another layer of complexity to notions of settlement, subsistence, infrastructure, production, and landscape management in Amazonia prior to European contact: it suggests that lowland Amazonian polities may have been more multifaceted than hitherto hypothesized and calls for deeper scrutiny of this intermediate region. It also challenges assumptions about infrastructure, urbanization, and their possible forms, demonstrating that Amazonia, yet again, has much to contribute to fundamental anthropological questions.

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Data Availability Statement. Data available on request.

Competing Interests. The authors declare none.

Note

1. http://www.novomilenio.inf.br/santos/calixt36.htm; https://commons.wikimedia.org/wiki/File:Benedito_Calixto_-_Porto_de_Santos,_1914.jpg; https://masp.org.br/acervo/obra/porto-de-santos-sp-visto-a-direita.

References Cited

Andrews, Anthony. 1990. The Role of Trading Ports in Maya Civilization. In *Vision and Revision of Maya Studies*, edited by Flora S. Clancy and Peter D. Harrison, pp. 159–167. University of New Mexico Press, Albuquerque.

Arroyo-Kalin, Manuel. 2010. The Amazonian Formative: Crop Domestication and Anthropogenic Soils. *Diversity* 2:473–504.

Arroyo-Kalin, Manuel. 2014. The Variability of Amazonian Dark Earths: Comparing Anthropogenic Soils from Three Regions of the Amazonian Biome. In *Antes de Orellana*, edited by Stéphen Rostain, pp. 323–327. Actas del 3er Encuentro Internacional de Arqueología Amazónica. IFEA/FLACSO/USA Embassy, Quito.

Balée, William. 1989. The Culture of Amazonian Forests. In *Resource Management in Amazonia: Indigenous and Folk Strategies*, edited by Darrell A. Posey and William Balée, pp. 1–21. New York Botanical Gardens, New York.

Balée, William. 2013. *Cultural Forests of the Amazon: A Historical Ecology of People and their Landscapes*. University of Alabama Press, Tuscaloosa.

Basso, Keith. 1996. *Wisdom Sits in Places: Landscape and Language among the Western Apache*. University of New Mexico Press, Albuquerque.

https://doi.org/10.1017/laq.2023.6 Published online by Cambridge University Press

Becker, Bertha Koiffmann, and Amanda Cavaliere Lima. 2013. Surtos e ciclos econômicos de Parintins (AM): Condicionantes à sua organização sócio-espacial e estruturação urbana. *Espaço Aberto, PPGG-UFRJ* 3(1):77–100.

Beckerman, Stephen. 1979. The Abundance of Protein in Amazonia: A Reply to Gross. *American Anthropologist* 81:533–560.

Bender, Barbara. 2002. Time and Landscape. *Current Anthropology* 43(S4):S103–S112.

Blatrix, Rumsaïs, Bruno Roux, Philippe Béarez, Gabriela Prestes-Carneiro, Marcelo Amaya, Jose Luis Aramayo, Leonor Rodrigues, et al. 2018. The Unique Functioning of a Precolumbian Amazonian Floodplain Fishery. *Scientific Reports* 8:5998.

Browne Ribeiro, Anna T. 2014. Houses, Hearths, and Gardens: Space and Temporality in a Precolumbian Village in the Central Amazon. In *Antes de Orellana*, edited by Stéphen Rostain, pp. 183–189. Actas del 3er Encuentro Internacional de Arqueología Amazónica. IFEA/FLACSO/USA Embassy, Quito.

Browne Ribeiro, Anna T. 2017. A Fine-Grained Analysis of Terra Preta Formation: Understanding Causality through Microartifactual and Chemical Indices in the Central Amazon. In *The Archaeology of Human-Environment Interactions: Strategies for Investigating Anthropogenic Landscapes, Dynamic Environments, and Climate Change in the Human Past*, edited by Daniel A. Contreras, pp. 165–194. Routledge, New York.

Browne Ribeiro, Anna, Helena Lima, Fernando Marques, Morgan Schmidt, and Kevin McDaniel. 2016. Results from Pilot Archaeological Fieldwork at the Carrazedo Site, Lower Xingu River, Amazonia. *Latin American Antiquity* 27:318–339.

Carneiro, Robert. 1970. A Theory on the Origin of the State: Traditional Theories of State Origins Are Considered and Rejected in Favor of a New Ecological Hypothesis. *Science* 169:733–738.

Carson, John, Jennifer Watling, Francis Mayle, Bronwen Whitney, José Iriarte, Heiko Prümers, and Daniel Soto. 2015. Precolumbian Land Use in the Ring-Ditch Region of the Bolivian Amazon. *Holocene* 25:1285–1300.

Cavalcanti, Maria Laura Viveiros de Castro. 2000. O Boi-Bumbá de Parintins, Amazonas: Breve história e ethnografia da festa. *História, Ciências, Saúde-Manguinhos* 6:1019–1046.

Chase, Diane, Arlen Chase, and Adrian Chase. 2019. Caracol's Impact on the Landscape of the Classic Period Maya: Urbanism and Complex Interaction in a Tropical Environment. In *Approaches to Monumental Landscapes of the Ancient Maya*, edited by Brett A. Houk, Barbara Arroyo, and Terry G. Powis, pp. 109–130. University Press of Florida, Gainesville.

Chirinos, Ricardo Andres. 2007. A variabilidade espacial no sítio Osvaldo: Estudo de um assentamento da Tradição Barrancóide na Amazônia central. Master's thesis, Museu de Arqueologia e Etnologia, Universidade de São Paulo, São Paulo.

Clement, Charles R., William M. Denevan, Michael J. Heckenberger, André B. Junqueira, Eduardo G. Neves, Wenceslau G. Teixeira, and William I. Woods. 2015. The Domestication of Amazonia before European Conquest. *Proceedings of Royal Society B* 282:20150813.

Clement, Charles, and André Junqueira. 2010. Between a Pristine Myth and an Impoverished Future. *Biotropica* 42:534–536.

Denevan, William. 1998. Comments on Prehistoric Agriculture in Amazonia. *Culture & Agriculture* 20(2–3):54–59.

Denevan, William. 2001. *Cultivated Landscapes of Native Amazonia and the Andes: Triumph over the Soil*. Oxford University Press, New York.

De Oliveira, Edmar Almeida, Ben Hur Marimon Jr., Beatriz Schwantes Marimon, José Iriarte, Paulo S. Morandi, S. Yoshi Maezumi, Denis S. Nogueira, Luiz E. O. C. Aragão, Izaias Brasil da Silva, and Ted R. Feldpausch. 2020. Legacy of Amazonian Dark Earth Soils on Forest Structure and Species Composition. *Global Ecology and Biogeography* 29:1458–1473.

De Souza, Jonas Gregorio, Denise Pahl Schaan, Mark Robinson, Antonia Damasceno Barbosa, Luiz E. O. C. Aragão, Ben Hur Marimon Jr., Beatriz Schwantes Marimon, et al. 2018. Precolumbian Earth-Builders Settled along the Entire Southern Rim of the Amazon. *Nature Communications* 9:1125.

Erickson, Clark. 2003. Historical Ecology and Future Explorations. In *Amazonian Dark Earths: Origin, Properties, Management*, edited by Johannes Lehmann, Dirse C. Kern, Bruno Glaser, and William I. Woods, pp. 455–500. Kluwer Academic, Amsterdam.

Erickson, Clark, and William Balée. 2006. The Historical Ecology of a Complex Landscape in Bolivia. In *Time and Complexity in Historical Ecology: Studies in the Neotropical Lowlands*, edited by William Balée and Clark Erickson, pp. 187–233. Columbia University Press, New York.

ESRI. 2021. ArcPro 2.9. Environmental Systems Research Institute, Redlands, California.

Evans, Damian, Roland Fletcher, Christopher Pottier, Jean-Baptiste Chevance, Dominique Soutif, Bon Suy Tan, Sokrithy Im, et al. 2013. Uncovering Archaeological Landscapes at Angkor Using Lidar. *PNAS* 110:12595–12600.

Fletcher, Roland. 2012. Low-Density, Agrarian-Based Urbanism. In *The Comparative Archaeology of Complex Societies*, edited by Michael E. Smith, pp. 285–320. Cambridge University Press, Cambridge.

Fletcher, Roland J., Damian Evans, Mike Barbetti, Dan Penny, Heng Than, Im Sokrithy, Khieu Chan, Toush Somaneath, and Christopher Pottier. 2003. Redefining Angkor: Structure and Environment in the Largest, Low-Density Urban Complex of the Pre-Industrial World. *UDAYA* 4:107–121.

Graham, Steve, and Simon Marvin. 2001. *Splintering Urbanism: Networked Infrastructures, Technological Mobilities, and the Urban Condition*. Routledge, New York.

Green, James, Victoria Langland, and Lilia Moritz Schwarcz. 2019. Conquest and Colonial Rule, 1500–1579. In *The Brazil Reader: History, Culture, Politics*, edited by James Green, Victoria Langland, and Lilia Moritz Schwarcz, pp. 7–11. Duke University Press, Durham, North Carolina.

Gross, Daniel R. 1975. Protein Capture and Cultural Development in the Amazon Basin. *American Anthropologist* 77:526–549.

Harvey, Penelope, Atsuro Morita, and Casper Jensen. 2016. *Infrastructures and Social Complexity: A Companion*. Routledge, New York.

https://doi.org/10.1017/laq.2023.6 Published online by Cambridge University Press

Hecht, Susanna. 2003. Indigenous Soil Management and the Creation of Amazonian Dark Earths: Implications of Kayapó Practice. In *Amazonian Dark Earths: Origin, Properties, Management*, edited by Johannes Lehmann, Dirse C. Kern, Bruno Glaser, and William I. Woods, pp. 355–372. Kluwer Academic, Amsterdam.

Heckenberger, Michael. 2005. *The Ecology of Power: Culture, Place, and Personhood in the Southern Amazon, AD 1000–2000*. Routledge, New York.

Heckenberger, Michael. 2008. Amazonian Mosaics: Identity, Interaction, and Integration in the Tropical Forest. In *Handbook of South American Archaeology*, edited by Helaine Silverman and William H. Isbell, pp. 941–961. Springer, New York.

Heckenberger, Michael J., Afukaka Kuikuro, Urissapá Tabata Kuikuro, J. Christian Russell, Morgan Schmidt, Carlos Fausto, and Bruna Franchetto. 2003. Amazonia 1492: Pristine Forest or Cultural Parkland? *Science* 301:1710–1714.

Heckenberger, Michael, J. Christian Russell, Carlos Fausto, Joshua Toney, Morgan J. Schmidt, Edithe Pereira, Bruna Franchetto, and Afukaka Kuikuro. 2008. Precolumbian Urbanism, Anthropogenic Landscapes, and the Future of the Amazon. *Science* 321:1214–1217.

Heckenberger, Michael, J. Christian Russell, Joshua Toney, and Morgan J. Schmidt. 2007. The Legacy of Cultural Landscapes in the Brazilian Amazon: Implications for Biodiversity. *Philosophical Transactions: Biological Sciences* 362:197–208.

Hoorn, Carina, Frank P. Wesselingh, Hans ter Steege, Mauricio A. Bermudez, Andres Mora, Jan Sevink, Isabel Sanmartín, et al. 2010. Amazonia through Time: Andean Uplift, Climate Change, Landscape Evolution, and Biodiversity. *Science* 330: 927–931.

Huggett, Richard John. 2011. *Fundamentals of Geomorphology*. 3rd ed. Routledge, New York.

Ingold, Tim. 1993. The Temporality of the Landscape. *World Archaeology* 25:152–174.

Iriarte, José, Paulo DeBlasis, Jonas Gregorio de Souza, and Rafael Corteletti. 2017. Emergent Complexity, Changing Landscapes, and Spheres of Interaction in Southeastern South America during the Middle and Late Holocene. *Journal of Archaeological Research* 25:251–313.

Iriarte, Jose, Sarah Elliott, S. Yoshi Maezumi, Daiana Alves, Regina Gonda, Mark Robinson, Jonas Gregorio de Souza, Jennifer Watling, and Josephine Handley. 2020. The Origins of Amazonian Landscapes: Plant Cultivation, Domestication, and the Spread of Food Production in Tropical South America. *Quaternary Science Reviews* 248:106582.

Isendahl, Christian, and Michael E. Smith. 2013. Sustainable Agrarian Urbanism: The Low-Density Cities of the Mayas and Aztecs. *Cities* 31:132–143.

Keay, Simon. 2012. The Port System of Imperial Rome. In *Rome, Portus and the Mediterranean*, edited by Simon Keay, pp. 33–67. Archaeological Monographs of the British School at Rome, London.

Kern, Denise Clara, Helena Pinto Lima, Jucilene Amorim da Costa, Herjania Veras de Lima, Anna Browne Ribeiro, Bruno Marcos Moraes, and Nestor Kämpf. 2017. Terras Pretas: Approaches to Formation Processes in a New Paradigm. *Geoarchaeology* 32:694–706.

Larkin, Brian. 2013. The Politics and Poetics of Infrastructure. *Annual Review of Anthropology* 42:327–343.

Lathrap, Donald. 1970. *The Upper Amazon: Ancient Peoples and Places*. Thames and Hudson, London.

Levis, Carolina, Marcio de Souza Silva, Mauro Almeida e Silva, Claide P. Moraes, Eduardo K. Tamanaha, Bernardo M. Flores, Eduardo Goés Neves, and Charles R. Clement. 2014. What Do We Know about the Distribution of Amazonian Dark Earth along Tributary Rivers in Central Amazonia? In *Antes de Orellana*, edited by Stéphen Rostain, pp. 305–311. Actas del 3er Encuentro Internacional de Arqueología Amazónica. IFEA/FLACSO/USA Embassy, Quito.

Lima, Hedinaldo, Carlos Schaefer, Jaime Mello, Robert Gilkes, and João Ker. 2002. Pedogenesis and Pre-Colombian Land Use of "Terra Preta Anthrosols" ("Indian Black Earth") of Western Amazonia. *Geoderma* 110(1):1–17.

Lins, Juliana, Helena Lima, Fabricio Baccaro, Valdely Kinupp, Glenn Shepard Jr., and Charles Clement. 2015. Precolumbian Floristic Legacies in Modern Homegardens of Central Amazonia. *PLoS ONE* 10(6):e0127067.

Lipkind, William. 1948. The Caraja. In *The Tropical Forest Tribes*, edited by Julian H. Steward, pp. 179–191. Handbook of South American Indians, Vol. 3. US Government Printing Office, Washington, DC.

Lombardo, Umberto, José Iriarte, Lautaro Hilbert, Javier Ruiz-Pérez, José M. Capriles, and Heinz Veit. 2020. Early Holocene Crop Cultivation and Landscape Modification in SW Amazonia. *Nature* 581:190–193.

Lombardo, Umberto, and Heiko Prümers. 2010. Precolumbian Human Occupation Patterns in the Eastern Plains of the Llanos de Moxos, Bolivian Amazonia. *Journal of Archaeological Science* 37:1875–1885.

Lucero, Lisa, Roland Fletcher, and Robin Coningham. 2015. From "Collapse" to Urban Diaspora: The Transformation of Low-Density, Dispersed Agrarian Urbanism. *Antiquity* 89:1139–1154.

Meggers, Betty. 1954. Environmental Limitation on the Development of Culture. *American Anthropologist* 56:801–824.

Meggers, Betty. 1971. *Amazonia Man and Culture in a Counterfeit Paradise*. Aldine, London.

Miller, Arthur G. 1982. *On the Edge of the Sea: Mural Painting at Tancah-Tulum*. Dumbarton Oaks, Washington, DC.

Moraes, Claide de Paula. 2010. Aldeias circulares na Amazônia central: Um contraste entre fase Paredão e fase Guarita. *Arqueologia Amazônica* 2:581–604.

Moraes, Claide de Paula, and Eduardo Góes Neves. 2012. O ano 1000: Adensamento populacional, interação e conflito na Amazônia central. *Amazônica-Revista de Antropologia* 4(1):122–148.

Moraes, Claide de Paula, and Eduardo Góes Neves. 2020. Earthworks of the Amazon. In *Encyclopedia of Global Archaeology*, edited by Claire Smith, pp. 3491–3503. Springer, New York.

Moran, Emilio. 1993. *Through Amazonian Eyes: The Human Ecology of Amazonian Populations*. University of Iowa Press, Iowa City.

Neves, Eduardo. 2013. Was Agriculture a Key Productive Activity in Pre-Colonial Amazonia? The Stable Productive Basis for Social Equality in the Central Amazon. In *Human-Environment Interactions: Current and Future Directions*, edited by Eduardo Brondízio and Emilio Moran, pp. 371–388. Springer, Dordrecht, Netherlands.

https://doi.org/10.1017/laq.2023.6 Published online by Cambridge University Press

Neves, Eduardo. 2016. A Tale of Three Species or the Ancient Soul of Tropical Forests. In *Tropical Forest Conservation: Long-Term Processes of Human Evolution, Cultural Adaptations and Consumption Patterns*, edited by Nuria Sanz, Rachel C. Lewis, José Pulido Mata, and Chantal Connaughton, pp. 229–244. UNESCO, Paris.

Neves, Eduardo, and Michael Heckenberger. 2019. The Call of the Wild: Rethinking Food Production in Ancient Amazonia. *Annual Review of Anthropology* 48:371–388.

Neves, Eduardo, and James B. Petersen. 2006. Political Economy and Precolumbian Landscape Transformations in Central Amazonia. In *Time and Complexity in Historical Ecology Studies in the Neotropical Lowlands*, edited by William Balée and Clarke Erickson, pp. 279–309. Columbia University Press, New York.

Ossenbach, Carlos. 2018. Orchids in the Era of Grigory von Langsdorff: Two Golden Decades in the History of the Botanical Exploration of Brazil (1813–1830). *Lankesteriana* 18:111–149.

Petersen, James, Eduardo Góes Neves, and Michael Heckenberger. 2001. Gift from the Past: Terra Preta and Amerindian Occupation in Amazonia. In *Unknown Amazon: Culture in Nature in Ancient Brazil*, edited by Colin McEwan, Christiana Barreto, and Eduardo Góes Neves, pp. 86–107. British Museum Press, London.

Polanyi, Karl. 1963. Ports of Trade in Early Societies. *Journal of Economic History* 23:30–45.

Prestes-Carneiro, Gabriela, Philippe Béarez, Salvador Bailon, Anne Rapp Py-Daniel, and Eduardo Goés Neves. 2016. Subsistence Fishery at Hatahara (750–1230 CE), a Precolumbian Central Amazonian Village. *Journal of Archaeological Science: Reports* 8:454–462.

Prümers, Heiko, Carla Jaimes Betancourt, José Iriarte, Mark Robinson, and Martin Shaich. 2022. Lidar Reveals Pre-Hispanic Low-Density Urbanism in the Bolivian Amazon. *Nature* 606:325–328.

Rathje, William, and Jeremy Sabloff. 1973. Ancient Maya Commercial Systems: A Research Design for the Island of Cozumel, Mexico. *World Archaeology* 5:221–231.

Roosevelt, Anna. 1991. *Moundbuilders of the Amazon: Geophysical Archaeology on Marajo Island, Brazil*. Academic Press, San Diego.

Roosevelt, Anna. 1999. The Development of Prehistoric Complex Societies: Amazonia, a Tropical Forest. In *Complex Polities in the Ancient Tropical World*, Archaeological Papers 9, edited by Elisabeth A. Bacus and Lisa J. Lucero, pp. 13–33. American Anthropological Association, Arlington, Virginia.

Rostain, Stéphen. 2012. *Islands in the Rainforest: Landscape Management in Precolumbian Amazonia*. New Frontiers in Historical Ecology Vol. 4. Left Coast Press, Walnut Creek, California.

Saunaluoma, Sanna, Justin Moat, Francisco Pugliese, and Eduardo Neves. 2021. Patterned Villagescapes and Road Networks in Ancient Southwestern Amazonia. *Latin American Antiquity* 32:173–187.

Saunaluoma, Sanna, and Denise Schaan. 2012. Monumentality in Western Amazonian Formative Societies: Geometric Ditched Enclosures in the Brazilian State of Acre. *Antiqua* 2(1):e1.

Scarborough, Vernon, and Christian Isendahl. 2020. Distributed Urban Network Systems in the Tropical Archaeological Record: Toward a Model for Urban Sustainability in the Era of Climate Change. *Anthropocene Review* 7:208–230.

Schaan, Denise P. 2011. *Sacred Geographies of Ancient Amazonia: Historical Ecology of Social Complexity*. New Frontiers in Historical Ecology Vol. 3. Left Coast Press, Walnut Creek, California.

Schaan, Denise Pahl, and Elaina Teles Rodrigues. 2018. Managing Water and Land at the Amazon River Estuary from Pre-Columbian Times to the Present. In *Water and Society from Ancient Times to the Present*, edited by Federica Sulas and Innocent Pikirayi. Routledge, New York.

Schmidt, Morgan, Anne Rapp Py-Daniel, Claide Moraes, Raoni Valle, Caroline Caromano, Wenceslau Texeira, Carlos Barbosa, et al. 2014. Dark Earths and the Human Built Landscape in Amazonia: A Widespread Pattern of Anthrosol Formation. *Journal of Archaeological Science* 42:152–165.

Shepard, Glenn, and Henri Ramirez. 2011. "Made in Brazil": Human Dispersal of the Brazil Nut (*Bertholletia excelsa*, Lecythidaceae) in Ancient Amazonia. *Economic Botany* 65(1):44–65.

Smith, Nigel. 1980. Anthrosols and Human Carrying Capacity in Amazonia. *Annals of the Association of American Geographers* 70:553–566.

Smith, Monica. 2016. Urban Infrastructure as Materialized Consensus. *World Archaeology* 48:164–178.

Sombroek, Wim. 1966. *Amazon Soils: A Reconnaissance of the Soils of the Brazilian Amazon Region*. Center for Agricultural Publications and Documentation, Wageningen, Netherlands.

Stahl, Peter. 2015. Interpreting Interfluvial Landscape Transformations in the Precolumbian Amazon. *Holocene* 25:1598–1603.

Stenborg, Per. 2016. Towards a Regional History of Pre-Columbian Settlements in the Santarém and Belterra Regions, Pará, Brazil. In *Beyond Waters: Archaeology and Environmental History of the Amazonian Inland*, edited by Per Stenborg, pp. 9–22. University of Gothenburg, Gothenburg, Sweden.

Stenborg, Per, Denise Schaan, and Camila Figueiredo. 2018. Contours of the Past: LiDAR Data Expands the Limits of Late Precolumbian Human Settlement in the Santarém Region, Lower Amazon. *Journal of Field Archaeology* 43:44–57.

Steward, Julian (editor). 1948. *The Tropical Forest Tribes*. Handbook of South American Indians Vol. 3. US Government Printing Office, Washington, DC.

ter Steege, Hans, Nigel Pitman, Daniel Sabatier, Christpoher Baraloto, Rafael Salomao, Juan Ernesto Guevara, Oliver Phillips et al. 2013. Hyperdominance in the Amazonian Tree Flora. *Science* 342:1243092.

Tilley, Christopher. 1994. *A Phenomenology of Landscape: Places, Paths, and Monuments*. Berg, Oxford.

Walker, John. 2008. Precolumbian Ring Ditches along the Yacuma and Rapulo Rivers, Beni, Bolivia: A Preliminary Review. *Journal of Field Archaeology* 33:413–427.

https://doi.org/10.1017/laq.2023.6 Published online by Cambridge University Press

Walker, John. 2011. Social Implications from Agricultural Taskscapes in the Southwestern Amazon. *Latin American Antiquity* 22:275–295.

Walker, John. 2012. Recent Landscape Archaeology in South America. *Journal of Archaeological Research* 20:309–355.

Watling, Jennifer, José Iriarte, Francis Mayle, Denise Schaan, Luiz Pessenda, Neil Loader, Alayne Street-Perrott, Ruth Dickau, Antonia Damasceno, and Alceu Ranzi. 2017. Impact of Precolumbian "Geoglyph" Builders on Amazonian Forests. *PNAS* 114:1868–1873.

Watling, Jennifer, Francis Mayle, and Denise Schaan. 2018. Historical Ecology, Human Niche Construction and Landscape in Precolumbian Amazonia: A Case Study of the Geoglyph Builders of Acre, Brazil. *Journal of Anthropological Archaeology* 50:128–139.

Wiener, Charles, Jules Crevaux, Désiré Charnay, and Edouard François André. 1884. *América pintoresca: Descripcion de viajes al nuevo continente por los mas modernos exploradores*. Montaner y Simon, Barcelona.

Wohl, Ellen. 2014. *Rivers in the Landscape: Science and Management*. John Wiley and Sons, Hoboken, New Jersey.

Woolley, Leonard. 1938. The Excavations at Al Mina, Sueidia. II. *Journal of Hellenic Studies* 58:133–170.

Wüst, Irmhild, and Cristiana Barreto. 1999. The Ring Villages of Central Brazil: A Challenge for Amazonian Archaeology. *Latin American Antiquity* 10:2–23.

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