Supporting Online Material for

Pre-Columbian Urbanism, Anthropogenic Landscapes, and the Future of the Amazon


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MATERIALS AND METHODS

The Upper Xingu ethnoarchaeology project was initiated in 1992, with the institutional sponsorship of the Museu Nacional, Universidade Federal do Rio de Janeiro (UFRJ). Since 2001, the interdisciplinary project, under the direction of Drs. Franchetto, Fausto, and Heckenberger, combines archaeology, in-depth ethnography, linguistics, and indigenous education, within an overall program of collaboration aimed at documentation of cultural heritage by the Associação Indígena Kuikuro do Alto Xingu (AIKAX) (S1-S4). Ethnoarchaeological research has aimed to understand indigenous history and historical ecology of the region (S5). Primary research findings reported here are focused on the archaeological component of research conducted from 2003-2007.

Indigenous research assistants participated in diverse aspects of archaeological investigations, including hands-on training and educational modules in ethnohistory, cultural and physical geography, ecology, archaeology, and archaeological mapping, including GPS. Indigenous research assistants were critical to identify historical villages (etepes) and ancient settlements (ingiholó-itupes), locating earthworks, anthropogenic dark earth (egepes) and related distinctive vegetation, and ceramics (egehos), which are all closely correlated. Once located, all ADE or egepe sites were positioned with GPS or on satellite images (in those few cases where GPS was not available).

Overall more than 40 km of linear earthworks have been mapped using the Trimble XRS with satellite real-time (OmniStar SA) (S6, Fig. S1, S2). In general, vertex points along earthworks were taken (~5-50 m interval), but in some cases longer distances or continuous reading was employed. Basic mapping of major earthworks was conducted in and around select sites (n=14), including ditch/berm systems and linear berms (.5 to 2 m high), situated at the margins of major roads (>10 m wide) and circular public plaza areas, and gate areas where the two major structural features articulate. Detailed mapping of earthworks was conducted at eight sites (X6, X13, X11, X17-20, X22).

Surface collection was conducted at X6 (2,059 units), X11 (1,996 units), and X13 (330). Surface collection was conducted in 2 m² units, divided into sub-units (1m²), which correspond to excavation units. Units were placed along linear transects (at an interval of 10 m) positioned at 50 m intervals across X6 and X11, and in 100 m² collection/testing areas (10 m grid) at X11 (9 areas with 770 units) and X13 (3 areas with 330 units). Composite distributions are shown in Fig. S3. Opportunistic surface samples with GPS point-provenience were collected at these and other sites.

More detailed investigations were conducted at X6 and X13, due to the proximity to the Kuikuro village and their unique qualities. Subsurface investigations included soil coring, test pit (0.5 m²), excavation trenches (10 m² or more), excavation units (1.0 m²), and larger block excavations (Fig. S1). Test-pit excavation in all collection/testing areas were positioned along two linear transects (10 m interval grid) which intersected at collection area centers. These findings generally confirm the large size of late prehistoric communities, including accretional deposits across most areas of the site (Fig. S4). Recent work in other parts of the region, supports the estimations of large village size (20-50 ha), documents major public architecture (plazas, causeway/road, and ditches) (S7-S9), and provides the basis for regional estimation of cluster distribution.

At X6, 60 test pits, 22 trenches, and 80 excavation units, including one major block excavation (60 units) over house 1 were conducted. Basic excavations used
standard archaeological methods. Trench excavations 1 x 10 m (occasionally longer or wider) included seven bisecting ditch/gate/parapet earthworks and six bisecting road and plaza curbs (Fig. S5, S6). Ten 0.5 x 1.0 m excavation “strips” and the excavation block (Fig. S7) employed fine-grained excavation techniques, including excavation in 5 or 10 cm levels, on-site screening through 10 and 5 mm mesh on-site and 1-2 mm mesh sieves used to sift feature fill (100% collected and fine-processed). At X13, one trench (1 x 10 m) and eight 1.0 m² units were excavated. At X11, three 1.0 m² units were excavated in ditch and road/plaza berm areas. An additional eight 1.0 m² units were excavated at X14 (5) and X15 (3).

Samples submitted for C14 analysis were collected from discrete stratigraphic contexts, with precise point-provenience (Table S1). In the case of most dates related to the late prehistoric clusters, samples were hand-collected at the interface of intact (pre-earthwork), stratified deposits and overburden from earthwork construction, including dates from X6 (Beta-78979, 176136, 194840, 194841, 194843), X11 (Beta-72263), and X13 (Beta-88362, 88363, 197515, 197516). Deposits well below the interface are dated in the same excavation units by samples from X6 (Beta-72261, 176141) and X13 (Beta-88363, 197517). Samples associated with late or post-abandonment periods from X6 include Beta 81301, 176137, and, possibly, 72260. AMS dating on surface ceramic sherd has produced consistently unexpected results, yielded modern age in areas known not to have been occupied by historically known groups, at least back to the mid-19th century.

Extremely low frequencies of surface and sub-surface artifacts (from 12 excavation units at X6 and X13) and anthropogenic dark earth (ADE) are noted in plaza and road areas, except on plaza and road marginal mounds. Plaza and road marginal earthworks (curbs) are a result of construction and maintenance activities of public works, but form substantial and regular boundary markers.

All artifacts (5,000+) and soil samples (4,000+) from 2002-2005 fieldwork have been fully catalogued, and diagnostic sherds have been given more detailed analysis, including visual characterization of manufacture, paste, decoration, and use-wear patterns, with rim, body and base profiles recorded. Ceramic analysis is coupled with catalog information from >8,500 archaeological ceramics (1,035 receiving detailed analysis) from 1993 investigations.

Ethnographic observations by the interdisciplinary team, as well as previous researchers enable a detailed characterization of contemporary lifeways (S1-5, S9, S10). Of particular importance, continuity in settlement location, domestic activities, and ceramic technology (see Fig. S6B) documents that basic subsistence was similar in the the past. Contemporary agricultural countryside is a mosaic of managed fields of monocrop manioc (Manihot esculenta spp.), converted to orchards of pequi trees (Caryocar sp.) and large areas of sapé grass (Imperata sp.), which is mixed with secondary forest in various stages of regrowth. Fire and fire-adapted landscapes are critical components of annual agricultural activities both burning cut trees and scrub in gardens (slash-and-burn) and burning of anthropogenic and natural grassy areas. Secondary crops are grown in dark earth deposits (ADE) in old habitation sites, and in backyard house gardens.

In prehistoric sites, compost areas, which appear as middens of ceramics and ADE in archaeological sites, are apparent and were likely used as areas for agricultural production. Collective ADE gardening areas are also by frequency of cultivated or
exploited plants in these areas, such as palms (tucuma, *Astrocaryum* sp., and related palms), which dominate areas around plaza areas, many of which have hundreds of whorls (up to 330). Areas lacking ADE and domestic ceramics are interpreted as open gardening areas in prehistoric sites. Today ancient occupation sites (*egepe*) are used for agriculture due to ADE, but prehistorically these were occupied. Several additional aspects of past economies should be noted. There is ADE along roadways, which were likely agricultural hamlets centered on high fertility soils. Assuming tree trunks were used in association with ditch-berm structures, and several thousand trunks were likely needed to create one of the larger palisade walls (up to 2.0 km of ditch). Trunks were likely highly variable size, but likely averaged 10-30 cm, as used today in houses, bridges, weirs and other constructions.

Among contemporary industrial crops, *buriti* or *moriche* palm (*Mauritia flexuosa*), a wetland palm, is the major industrial crop, virtually all parts can be used, fruit, leaf, leaf stalk, and wood. Water turtle, duck, and diverse fish are managed in small ponds, and can be collected from virtually all of the varied water areas. Weirs are positioned across small to large streams, including artificially modified reservoirs, particularly important during the dry season. Storage includes the dam-pond (fish-farming) system, as noted in other areas of the southern Amazon (*S12*), which extends across much of the landscape. Small turtle pens, manioc silos, and basketry tubes for storage of processed *pequi* pulp are storage facilities used by contemporary groups in the region.

Among prehistoric sites, *buriti* palm is densely distributed in wetland areas. Earthen dams (likely associated with weirs), causeways, and artificially modified ponds have been identified. Bridge abutments also have been identified at the intersections of roads and major wetlands, including potential large-scale constructions, such as the spit extending into the lake from the center of X11. Canoe canals were used in low lying areas, which in some cases were artificially constructed or expanded.

In addition to clear evidence of continuity in basic techno-economy and land-use, basic feature of socio-political organization and ideology also show tremendous resiliency over the past five centuries. Of particular note is the form and orientations of settlement spatial organization, notably circular plazas and radial roads. The regional pattern of political and ritual integration is more fully described elsewhere (*S2, S5*).

**SOM TEXT**

Civil and urban society and, particularly, the city itself, have been defined in diverse ways. Without a clear universal definition of what constitutes urbanism, settlement patterns are commonly interpreted based on their correlation to the state, often ignoring complex settlement patterns associated with non-state social formations (*S13-S17*). Tropical forest civilizations, in particular, are underrepresented in discussions of early (pre-AD 1500) urbanism (*S18*). Specifically, Amazonia is seen as generally lacking any form of urbanism and, in fact, is generally considered as a paradigmatic case of non-urban, non-civil societies, characterized by small-scale, autonomous and dispersed settlements, and simple socio-political organization (*S19, S20*).

Most contemporary definitions of prehistoric or early urbanism include a wide range of settlements, in terms of centrality, size, political power, as well as economic or administrative function (*S21-S23*). Many early examples are quite small, little more than
aristocratic compounds or sacred temple centers, where elite rule through divine
ancestors, or comprised of towns and villages, rather than cities, although earliest city-
states are often quite small (S21). A careful consideration of many “classic” urban
societies shows the substantial variation in what constitutes cities or urbanism.

As a case in point, in Early Medieval or “feudal” Europe, small- to medium-sized
fortified towns (“tons” or “burgs”) numbering in the low thousands or less across
temperate Europe were common, compared to a handful of actual cities (5,000 to 7,000
or more habitants) (S24). Parenthetically, the distinction between city and town is not
found in Romance languages or Latin, which generally distinguishes only between city
and village (S25). Preceding Late Iron Age (Celtic) occupations, which precede Medieval
urbanism, also show great variation of settlement patterns, related to walled settlements
or *oppida*, many of which are similar in key features with later settlement patterns (S13,
S14).

The Greek *polis* is another classic example of early urban societies. Typically
seen as city-states, variability was common in ancient Greek *poleis*, ranging in size and
power from average small- to medium-sized regional polities to massive regional powers,
such as Athens, although most are well out of the range of full-blown cities (< 5,000,
with some numbering in the hundreds) (S26). Southwestern Asian city-states were
likewise highly varied and often quite small (S21), as is true of mid-range polities in
Africa, SE Asia, and China (S16, S23).

Urbanism in the Americas is generally seen as restricted to the central Andes and
Mesoamerica, but in these areas a wide range of settlement patterns have been
characterized as urban or proto-urban (S27, S28). In these areas, significant temporal and
spatial variations in regional settlement patterns, which form a continuum from small to
large urban societies, although cities, where present, are generally smaller than Old
World examples (S29). In fact, when discussing Andean urbanism “the label
administrative-religious center or, in some cases, palace complex … is therefore more
appropriate than city when describing the function performed by the architectural groups
that have been excavated” (S28).

In the Americas, cosmological-*cum*-ritual orientations are pervasive in the
organization and dynamics of urban societies (S16, S30-S33). Many Native American
civilizations, including Amazonian complex societies, are notable for the orientation of
major settlements around central public plazas. The largest Amazonian polities, such as
in the Central and Lower Amazon (S34, S35), generally fit the model of small- to
medium-sized plaza civilizations, which also include Andean and Mesoamerican, as well
as other minor polities of North and Central America and the Caribbean. Upper Xingu
examples are another permutation of this plaza orientation, underscoring the critical
importance of public ritual as a basis for socio-political integration.

Dispersed urban (or proto-urban) settlement patterns had dramatic impacts on
local and regional landscapes (S20, S36, S37). Regions occupied by these small- to
medium-scale polities have very different dimensions of biodiversity and ecological
resiliency than areas of less human direct impact in the tropical forests of Amazonia (S38,
S39). Areas of secondary or altered – anthropogenic – forest landscapes constitute >10% of
the region (S40) and have greater potential for human use, as reflected in past land-use
practices.
Archaeological sites along the floodplain regions of the Amazon River, related to late prehistoric complex societies, by 1000-750 BP (S19, S35), are notable for large concentrations anthropogenic soils, or “Amazonian dark earths” (ADE). ADE form thick continuous deposits of habitation refuse and non-habitation management activities and contain significant biodiversity (S41-S44). Estimates of human-modified soils range up to 10%, including areas significantly altered by intentional burning (S41). In the Upper Xingu, substantial archaeological remains, including ADE, are present in areas currently covered in forest, and, by implication, once partially deforested, and attest to major landscape transformations in the past, as documented in other areas of the southern Amazon (S39, S45). The composition of succession forest, including high forest, is an artifact or “eco-fact” of past human land-use, like “crop-marks” in modern agricultural landscapes.
Figure S1. Field methods, including: (A) GPS-mapping (Trimble XRS, Omnistar SA satellite service); (B) soil-augering (8 cm); (C) test-pit excavation (.5 m²), with basal soil-auger; (D) surface collection sub-unit (1 m²); (E) excavation unit (1 m²) positioned adjacent excavation trench (1 x 10 m); (F) excavation block (house 1) at X6.
Figure S2. GPS mapped earthworks over Landsat 7 ETM+ (5-4-3) of (A) X6, (B) X19, (C) X18, and (D) X13 (See Fig. 2 in main text for an overview of these sites and their position within the Ipatse cluster). X6 and X18 are first-order residential centers, X13 is the ceremonial center (hub) of the cluster, and X19 is a third-order residential satellite center. Note the road connecting X6 (A) and X13 (D).
Figure S3. (A) X6 surface collection densities, from 2,059 collection units (2 m²); (B) X11 ceramic densities (1,996 units); (C) X13 ceramic densities (330 units); (D) collection area 1 ceramic densities, test-pit cruciform transects were positioned to intersect in center of collection area. (North arrow = grid north)
Figure S4. Select test-pit excavation profiles from across X6 and X13 (Transect 1 = collection area 1, T2=A=2, etc.; basal dimension = .5 m²).

1. 1 = ADE (Anthropogenic dark brown strata)
2. 2 = Light ADE (anthropogenic/mechanical mixed light brown strata)
3. 3 = Red Latossol (natural red strata)
4. 4 = Other (disturbance/other strata)
5. 5 = Unexcavated
Figure S5. Select excavation trench profiles bisecting X6 ditch 2 (A, B, D) and ditch 1 (C).
Figure S6. Select excavation trench (ET) profiles of X6 (A-B) and X13 (C) and excavation units at X11 (D) and X13 (E) positioned over road/plaza berms/curbs.
Figure S7. (A) contemporary house (post-house fire); (B) central kitchen area, showing primary ceramic cooking utensils; (C) feature 2A, hearth with manioc (tapioca) cooking pot support (see B) in X6 house 1; (D) feature 2B and 2C, central house post-molds in X6 house 1; (E) X6 house 1 during excavation; (F) plan view map of X6 house 1; and (G) backyard (ADE) trash midden behind X6 house 1.
Table S1. Radiocarbon dates from the Kuikuro Study Area.

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**Surface Pottery**

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<td>890 ± 40 BP</td>
<td>Cal AD 1040-1260</td>
</tr>
<tr>
<td>MT-FX-13</td>
<td>ET1 EU1</td>
<td>60-70</td>
<td>Charcoal</td>
<td>Beta 197516</td>
<td>930 ± 50 BP</td>
<td>Cal AD 1020-1250</td>
</tr>
<tr>
<td>MT-FX-13</td>
<td>ET1 EU1</td>
<td>90-100</td>
<td>Charcoal</td>
<td>Beta 197517</td>
<td>1160 ± 80 BP</td>
<td>Cal AD 690-1030</td>
</tr>
</tbody>
</table>
S36. Proto-urbanism may be preferred by some readers to refer to the dispersed, multi-centric settlement patterns of small- to medium-sized regional polities, but we eschew the term since in Amazonia, at least, the patterns described here organized large populations, and were notable in the degree of local and regional planning, self-organization, and regional integration. Furthermore, they did not give rise to cities in any known case (i.e., they are an endpoint not a form prior to a full-blown, city-based urbanism).