

Article

Biocultural Diversity in the Southern Amazon

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Abstract: Recent studies in Amazonia historical ecology have revealed substantial diversity and dynamic change in coupled natural human systems. In the southern Amazon, several headwater basins show evidence of substantial pre-Columbian landscape modification, particularly in areas historically dominated by speakers of the Arawak language family. The headwater basin of the Xingu River, the easternmost of these areas occupied by Arawak-speaking peoples, has revealed such a complex built environment. This discussion examines settlement pattern and land-use, which have implications for understanding the dynamics of natural-human systems in the Upper Xingu basin and other areas across the transitional forests of the southern Amazon.

Keywords: anthropogenic landscapes; pre-Columbian complex societies; cultural diversity

1. Introduction

What is Amazonia? Is it one of the few places on earth where Nature still exists in a relatively pristine state, little influenced by human actions until recently? Or, instead, is it a palimpsest of past cultural activities—a human footprint, which reflects substantially modified natural conditions? Recent work on Amazonian historical ecology has led many specialists to believe that major parts of the region reflect extensive anthropogenic influences [1-3]. In a variety of settings, traditional views of the Amazon forest as essentially virgin tropical forest and those that posit cultural uniformity across the region, have given way to perspectives that emphasize cultural diversity, change through time, and, notably, the appearance of large, settled population aggregates by late prehistoric times [4-6]. The realization that aspects of the Amazon forest are cultural in origin, part of a growing recognition that pre-industrial peoples in many parts of the world were capable of having a major impact on plant and

animal communities, hydrology, and even climate [7-11], demands fundamental changes in how natural scientists view the world's largest tropical forest.

Recent studies in several areas of Amazonia suggest dynamic change and great diversity of pre-Columbian social formations. Much of Amazonia is poorly known archaeologically and early eyewitness accounts are rare from most areas. In particular, large-scale archaeological projects that provide robust data on late prehistoric cultural development and, particularly, how Amerindians "domesticated" pre-Columbian landscapes are lacking from most areas. Nonetheless, available evidence from several areas shows evidence of large, settled populations who significantly transformed tropical forest ecologies. The floodplains or v árzea of the Amazon River have long been known as a hearth of complex societies [e.g., 12-16]. Recent research in the transitional forests of southern Amazonia also documents large, settled social formations in late prehistoric times. Contemporary forests in this region represent complex mosaics of anthropogenic ("secondary") forests, the result of fairly intensive prehistoric human use [5,17-20]. In the southern Amazon, the headwater basins of major southern tributaries, in particular, were home to large, densely settled population aggregates, commonly associated with speakers of languages associated with the Arawak language family and other peoples culturally related to them.

Past cultural diversity thus constitutes a critical aspect of contemporary biodiversity, including recent histories of severe depopulation and cultural decimation, geographic compression, and miscegenation [21]. Colonization of the region by Europeans was more gradual than many areas, such as eastern coastal areas, the Caribbean, and the Andes, where populations were decimated in the 16th century. However, the Amazon's dense tropical forests did not insulate indigenous peoples from the catastrophic effects of European colonialism, notably disease related depopulation. Consequently, many areas that currently support seemingly untouched tropical forest are in fact secondary or "fallow" forests, associated with broad regional depopulation.

The present paper focuses on the Upper Xingu region, the easternmost of Arawak-speaking populations and known complex societies across the southern Amazon peripheries. Early Xinguano ancestors were agriculturalists that settled the basin over 1,500 years ago, and triggered profound changes to the natural environment as they molded forests and wetlands to their design. Between ca. AD 1250–1650, local populations were organized in small territorial polities within a regional peer polity that extended across much of the Upper Xingu basin. The Xinguanos have maintained a system of semi-intensive land-use for over a millennium, which, although greatly diminished in size over the past few centuries, continues today. The paper examines the uniquely human and cultural factors in the long-term dynamics of natural-human systems, *i.e.*, the unique ways Xinguano peoples have domesticated nature or, in other words, how they humanized the landscape.

2. The Arawak Diaspora

In Amazonia, as true in many world regions, differences between the bottomlands of major rivers and uplands were particularly important for distinctive regimes of cultural adaptation [14]. Riverine groups were generally larger, more settled, and practiced more intensive resource management strategies than upland areas. Traditional views posited that the bottomlands of the Amazon River or $v \acute{a}rzea$, in particular, provided unique conditions for cultural development, notably rich alluvial soils

of Andean-derived tributaries [12-14,16]. These conditions were seen as lacking from the broadly defined uplands or *terra firme*, including the major northern and southern tributaries of the Amazon that emanate from the Brazilian and Guiana highlands. In Amazonia, this simple dichotomy between *várzea*, which makes up less than 5% of the region, and *terra firme* settings is complicated by the great diversity of Amazonian rivers. Recent studies from the southern Amazon, including seasonally wet savanna areas of lowland Bolivia and the forested Upper Xingu basin, have revealed the diversity of semi-intensive agricultural systems in riverine settings in Amazonia that supported large regional population aggregates.

Patterns of settled riverine and more mobile upland strategies have a deep antiquity in the region, which relates to both ecological variation and the specific histories of discrete cultural groups and regions. Cultural changes occurred in Amazonia by the third millennium before present (BP) that were critical for bio-cultural diversity in the region, notably the expansion of peoples associated with the most widespread language families in Amazon: Arawak, Tupi-Guarani, and Carib. In Amazonia, early agriculturalists along major rivers are commonly affiliated with speakers of the Arawak language family [13,22,23]. The macro-Tupi linguistic stock and, particularly, Tupi-Guarani language family expanded in upland areas of southern Amazon, in the Paraguai basin, and in coastal areas of eastern South America. Speakers of languages associated with the Carib family likewise spread across upland areas of the Guiana shield and, ultimately, into river and coastal areas of northern Amazonia.

Arawak is the most widely distributed language family in the Americas, extending across the lowlands from Argentina to the northern Caribbean [24]. While the routes and mechanisms of the cultural dispersal were diverse [25], a tendency for Arawak speaking peoples to expand along river corridors and in northern coastal areas of South America and the Caribbean is suggested by historical distributions. The primary period of the Arawak diaspora, between 500 BC to AD 500, can be suggested based on the appearance of distinctive material traits, such as circular plaza settlement orientations and modeled-incised and decoratively slipped ceramics, broadly associated with the so-called Saladoid-Barrancoid traditions, often viewed as typical of early Arawakan-speakers [23].

Max Schmidt [26] was the first to emphasize cultural relations between related Arawak speaking peoples across Amazonia. His work focused on the transitional southern Amazon periphery, situated between the wooded savannas and scrub forests of the central Brazilian plateau and the high evergreen forests of Amazonia. He worked among several of the diverse Arawak speaking and related groups and noted cultural similarities that distinguished them from their neighbors. First, he noted the settled agricultural economies, particularly focused on manioc cultivation and fishing in riverine settings. Secondly, he noted the complex social organization, composed of elite and commoner ranks and regionally organized societies, which later authors generally glossed as chiefdoms [27,28].

As in other major world areas, settled, agricultural populations had a more dramatic impact on their environment than earlier pre-ceramic peoples and established a radically new trajectory of dynamic human-environment interaction and cultural change [29]. In the transitional forest region of the southern Amazon, Arawak speakers were often distributed in forested riverine areas, which enabled them to carry out their forest agriculture and fishing economies. The expansion of Arawak speaking peoples into the transitional tropical forests of the southern headwater basins, initiated a trajectory of change in bio-cultural systems associated with the colonization and development of settled agricultural populations. In several areas of the southern Amazon periphery, specifically, Arawak peoples

developed into large, populous regional polities, although most regions also were characterized by substantial cultural pluralism. Environmental influences intensified with time, ultimately leading to highly anthropogenic and even engineered pre-Columbian landscapes.

Across the broad southern Amazon, settled Arawak agriculturalists and culturally related populations dominated forested headwater basins, surrounded by other upland cultural groups. Arawak speaking groups were engaged in complex relations with other groups in regional societies, but were distinctive from upland groups, which practiced more mobile settlement strategies. In the Llanos de Mojos, the broad seasonally inundated area between the Brazilian shield and the Andes was a particularly complex region in terms of cultural pluralism, but two clusters of Arawakan speakers can be noted which correlate with areas of complex domesticated landscapes in the central llanos (Mojos) and eastern llanos (Bauré) [17,18]. Farther west, within the Brazilian state of Acre, another broad cluster of earthworks or "geoglyphs" have recently been investigated, which correspond to areas historically occupied by Arawak speakers [20]. The economic basis of these societies is not well known, but the density and scale of earthwork sites suggests settled, agricultural land-use and supra-local integration of settlements [19].

In eastern areas, the Arawak groups dominated the headwater basins of southern Amazon, including the Tapaj & (Pareci) and Xingu (Xinguano) rivers, close enough in cultural practices for Schmidt [26] to consider these sub-groups of the same general cultural pattern. In addition to many shared elements of material culture, Arawak speaking peoples were notable for their manioc agriculture, fishing and canoe navigation, networked plaza settlements, and plaza ritual complex. Surrounding these areas, upland areas of the Brazilian shield are dominated by Tupi-Guarani and Gê speaking peoples who practice distinctive settlement, economic, and socio-political strategies. Ethnohistoric accounts from the eighteenth century in the upper Tapaj & headwaters report large settlements (30–40 large houses) in densely settled regions, integrated by wide, straight roads [30]. The region is poorly known historically prior to the expedition, but catastrophic depopulation had likely decimated regional populations by this time. Archaeological and ethnographic (1880s to present) research in the tropical forest areas of the headwater basin of the Xingu River, the easternmost extent of Arawak speakers, provides a clearer picture of settlement patterns in pre-Columbian times, which reveals the degree of landscape modification similar to that noted in other areas.

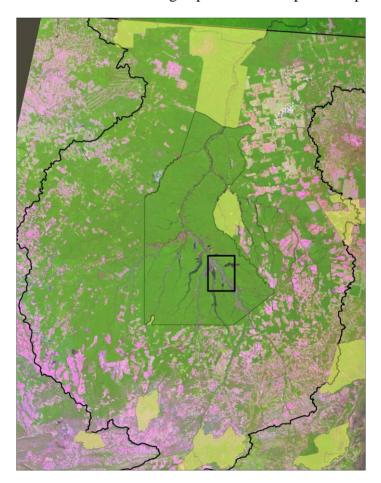
3. Pre-Columbian Xinguano Settlement Patterns

Since it was first described in the 1880s, Upper Xingu or Xinguano society has been composed of diverse sub-groups, including Arawak, Carib, and Tupian speaking groups [31]. As recounted in indigenous oral history, groups speaking Tupi-Guarani and closely related macro-Tupi languages immigrated into the Upper Xingu basin over the past few centuries, supporting the precedence of Arawak and Carib speaking peoples in the region [32]. Regional ethnology strongly suggests that the basic cultural pattern, including the manioc and fishing economy and central plaza and road settlement pattern, is similar to that of Arawak groups across the southern Amazon [23]. Thus, the Xinguano cultural pattern was established by ancestral Arawak speaking groups, who colonized to the region from the west, although it is possible that Carib groups were already present in the basin. Minimally, archaeology and oral history indicate that Arawak and Carib groups co-existed in the basin in late

prehistoric times, as suggested by several small non-plaza sites in eastern margins of the basin, dating to the 15th to 16th century, which oral history associates with Carib speakers.

Archaeological research was conducted in a study area (~1,200 km 3 that corresponds roughly with the territory of the Kuikuro sub-group (Upper Xingu Carib), who today live in three primary plaza villages (Figure 1). It provides a particularly detailed picture of the settlement patterns of late prehistoric cultural groups in the southern Amazon. Settlements throughout the cultural sequence are characterized by circular central plazas and straight, radial roads, as documented in other areas dominated by Arawak speakers in the southern Amazon. Continuity in the manioc agricultural economy, well known ethnographically [33], is documented by persistence throughout the cultural sequence in basic ceramic industries tied to manioc processing and cooking. Four radiocarbon dates from near basal deposits of intact (stratified) dark earth sediments, which range ca, 900–1000 CE, and earlier dates from mixed earthwork sediments, suggest colonization ca. 500–800 CE, or before.

Figure 1. Study area (box) in the Upper Xingu basin (black line). Note: the Parque Ind gena do Xingu is marked by a thin black line, other indigenous areas in light green, and upland open woodlands and areas of agro-pastoral development in pink.



A major transformation of local and regional settlement patterns is indicated by large-scale reworking of settlement earthworks, ca. 1250 CE. At this time, settlements became integrated in hierarchical clusters, which represent small territorial polities [34]. Earlier settlements may have been socio-politically integrated, as well, but significant expansion of local communities and integration is

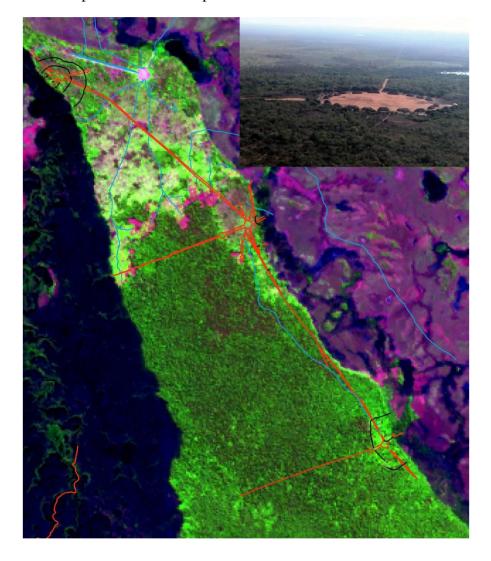
documented by major earthwork reconstruction, including plaza and road marginal linear mounds (roughly 0.5 to 1 meter high) and large peripheral and intra-settlement ditches, which range up to over 2.0 km in length, 10–15 meters wide, and 3–5 meters deep [35]. Two such clusters have been identified in the study area.

The northernmost of the two clusters has been the primary focus of archaeological investigations. It is composed of a center, four major residential satellites regularly positioned in relation to the center, and smaller satellites linked to the major residential centers. The primary cluster center (X13) is interpreted as the political ritual hub of the cluster, but limited domestic occupations have been identified in comparison to the large residential occupations of primary satellites. The two larger residential sites, or towns, are over 40 ha in size and situated roughly equidistant (5 km) to the north/northwest and south/southeast of X13 (Figure 2). Two slightly smaller towns are likewise nearly equidistant (8 km) to the northeast and southwest from X13. Smaller non-ditched plaza villages were also linked to major centers by the extensive road system and represent a peripheral zone of the regional, territorial polities. In the southern cluster, the primary ritual hub (X11) also represents that largest residential site (~50 ha), which was linked to two primary satellites to the west and southeast (Figure 3). Other primary satellites known in indigenous knowledge systems based on the presence of characteristic soils and vegetation patterns, called *egepe* by the Kuikuro, and earthwork constructions.

The primary defining feature of both prehistoric and recent settlements is the large, circular central plaza with radial roads, which exit plazas at regular angles. Central plazas generally range between 120 and 175 meters in diameter and form the core of all major residential centers. Plazas in contemporary villages are defined by a ring of houses and backyard trash middens, which also form a near continuous ring surrounding the village. In pre-Columbian villages, a low marginal mound formed a continuous ring around plazas, broken only by road entryways where the plaza marginal mounds articulate with low linear mounds or "curbs" along roadsides. In the northern cluster, several sites have secondary plazas, notably the political ritual center of X13 and its primary northern satellite (X6). At X6, one smaller central plaza appears to represent an earlier (pre-1250) settlement configuration, with the larger central plaza of the walled late prehistoric settlement relating to the expansion of the community ca. 1250 CE.

Major residential centers were also defined by a large peripheral wall, archaeologically preserved as a linear, semi-lunar ditch surrounding settlements, although open along the wetland margins of settlements. Ditches were likely associated with a palisade wall as suggested by indigenous oral history and the funnel-shape of the ditches, which appear to be the footing of standing tree-trunk structure. In the large walled prehistoric settlements, residential areas extended over the entire area enclosed by the peripheral ditches, based on the distribution of domestic ceramics at X6 and X11. Some settlements had concentric ditches, which along with roads and plazas partitioned settlement into neighborhoods.

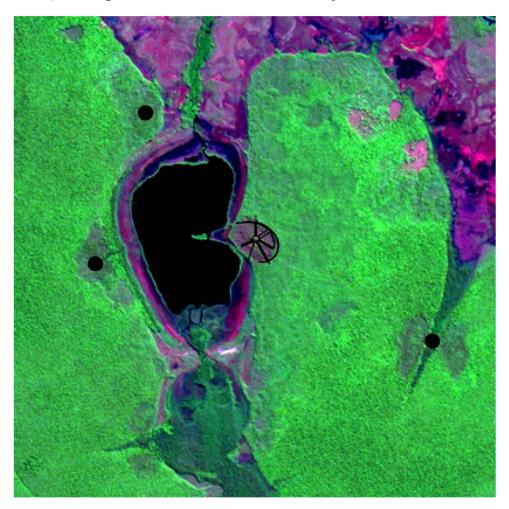
Figure 2. Core area of the northern cluster showing ritual political hub site (X13) and two major residential centers, located to the north (X6) and south (X18) of X13 (roads are denoted by red lines and peripheral ditches by black lines). Note: the Ipatse stream course appears as a meandering blue-black line along the eastern edge of the forested upland area (green), which is bounded to the west by the marshy lowlands of the braided Angahuku River (solid dark blue/black). Inset: Kuikuro village in 2003, which corresponds to pink dot with blue radial paths to the left of photo.



All settlements in the study area are linked by major roads extending from each settlement according to specific angles, notably the principal formal entryway and bathing/port road, oriented roughly east to west according to sun position during the primary ritual season, June to August. Perpendicular north and south roads are present in many settlements, and are sometimes positioned at inter-cardinal and other regular angles (see Figure 2). Within settlements, major roads are defined by low marginal mounds, like those around plazas. In fact, these low mounds form a nearly continuous landscape-scale feature in settlements and linking settlements across the area. Like plaza mounds, the low marginal mounds were likely the result of construction and maintenance activities, which in most cases involved "scraping" anthropogenic dark earth (ADE) soils from the open public areas, which also served as primary areas for refuse disposal. Major roads are commonly associated with raised

causeways and bridge abutments over wetland areas, associated with large tree-trunk bridges as known ethnographically. Although continuous roads, defined by marginal curbs, are not always identifiable in many areas, causeways and upland roads certainly link with thoroughfares extending across the floodplain areas, as known among contemporary Kuikuro, linking settlements across the region.

Figure 3. Core area of southern cluster showing principal center (X11), showing peripheral semi-circular ditches and radial roads, and primary satellite settlements, marked as black dots (note: vegetation "scars" associated with major settlements).



Prehistoric territorial polities can be divided into core and periphery areas. In the northern cluster the core area (roughly 50 km 3 is defined by the center and four primary satellites: the ceremonial hub site (X13) with limited domestic refuse, two large walled settlements situated roughly 5 km to the N/NW (X6) and S/SE (X18) of X13, and two medium-sized walled settlements situated roughly 8 km to the NW (X17) and SE (X22) of X13 [36]. Although less well known, a similar configuration is suggested for the southern cluster based on known site locations and indigenous knowledge of additional sites. As discussed below, fairly intensively used agricultural countryside areas likely created a patchy landscape in the core areas defined by the five major settlements nodes. It is surmised that smaller peripheral sites had a less pronounced anthropogenic "footprint," which graded into high forest wilderness covering areas between clusters.

Smaller plaza settlements (<10 ha) are distributed in areas at the margins of core areas and extend into broad peripheries, which overlap from one cluster to another. Indeed, while within the sphere of influence of the galactic core settlements, settlements at the boundaries likely maintained dual identities, linking clusters not only spatially but socially. Overall, overlapping polity territories, with broad high forest wilderness in peripheral areas that acted as natural preserves and buffer zones, were approximately 250 km? conforming to a circle roughly 20 km in diameter. These settlements share the basic plaza and radial road ground plan as major walled settlements, but lack site peripheral ditches and, like the contemporary community, were non-walled. Within core areas, small hamlets (<2 ha) characterized by anthropogenic dark earth (ADE) and domestic ceramics were distributed along roadways. In eastern portions of the study area, several small non-plaza habitation sites have been identified around the large Lake Tafununo.

Across the region, the distribution of major settlements with ditch earthworks extends across an area roughly 200 km north to south by 100 km east to west, suggesting a minimal 20,000 km ² for the Xinguano nation or macro peer polity [34]. The vast majority of the forested Upper Xingu basin is unknown archaeologically, and a far greater number of such prehistoric settlements almost certainly await discovery Based on better known settlement patterns in the study area, large walled settlements are suggested to represent the centers of independent clusters, or territorial polities. In short, the clear pattern in the study area suggests that large walled settlements do not exist alone, but include clusters of integrated settlements, a pattern which likely characterized settlements known elsewhere in the basin.

4. Economy and Landscape

The ecology of Upper Xingu can be divided into two primary areas: low-lying wetland areas and higher ground (non-inundated) forested areas. Wetlands are diverse and in the study area include: (1) the large channelized Culuene River, including oxbow lakes and gallery forest in the active floodplain, and broad relict floodplains with seasonally wet savannas not subject to overbank flooding; (2) the braided Angahuku River, which is marshy across its broad, multi-channeled course with occasional deep pools; (3) the small Ipatse stream that hugs the upland forest line at the western edge of the broad relict floodplain of the Culuene River, which is a seasonally marshy area punctuated with artificially modified pools associated with prehistoric settlements; and (4) several large lakes. Naturally occurring closed tropical forest is restricted to areas that are permanently non-inundated [37].

All settlements are positioned at the interface of these diverse wetlands, including lakes, rivers, and streams, and upland forest. In prehistoric times, settlements were also positioned according to the regional planning described above, particularly the relation between major residential satellites and cluster centers defining core areas of each polity. In non-inundated forest areas, prehistoric settlements were fairly regularly spaced along margins of forest upland and wetlands. These areas are converted to patchy agricultural landscape in areas around settlements. The location of settlements through time shows tremendous continuity, which over time developed into anthropogenic islands composed of a unique soil and vegetation characteristics, which as noted above are locally known as *egepe*.

In several settings, wetland areas adjacent to large plaza settlements were modified by the construction of short causeways and artificial ponds. Settlements locations along Ipatse Stream, for

instance, were situated where the stream course occurs immediately adjacent to non-inundated uplands. This raises the possibility of stream course modification, due to the regular settlement spacing. Particularly suggestive of major wetland modifications are ponds along Ipatse Stream, which in every case are located directly adjacent to residential sites, including larger (ditched) and smaller (non-ditched) plaza settlements. Small, deep lagoons along the larger, braided Angahuku River, may also have been modified. Other than the pond and dam systems, apparently modified canoe canals are recognizable in several areas, which link settlements along Ipatse Stream to the Culuene River. No other significant structural elaboration of floodplains has been confirmed, although untested low ridges may have been artificially modified as raised linear fields, such as widely reported in the Llanos de Mojos.

Fishing, including fisheries management, is a critical component of Xinguano subsistence economies, providing the vast majority of animal protein in the diet. Traditionally, fishing technologies included bow fishing, leisters, several hand held nets and baskets, and traps used in association with small to large-sized weirs, as well as fish poisoning in small bodies of water. Managed wetland areas, including portions of the Angahuku River and Ipatse stream, are densely populated with buriti palm, which in addition to house thatch, is an important industrial crop for cordage, mats, and other crafts. Of particular note, the pond areas adjacent to settlements along Ipatse Stream and perhaps even deep pools of the Angahuku River were modified as part of a fish farming complex by pre-Columbian Xinguano populations.

Detailed ecological studies in the Upper Xingu region are lacking, but archaeological settlement patterns provide clear evidence that local ecology was substantially altered by past human activities. In contrast to other semi-intensive systems, particularly the raised field systems described from eastern lowland Bolivia [17,18], Xinguano agricultural systems were based on conversion of closed forest areas to settlement and agricultural countryside. Archaeological distributions have important implications for questions of biodiversity, including semi-intensive land-use in agricultural countryside and wetland modifications related to core settlement areas and less intense use in peripheral areas, grading into forest wilderness between clusters. Critically important to reconstruction of settlement patterns is the correlation between archaeological patterns documented on the ground and vegetation patterns visible on satellite images. Notably areas of intense anthropogenic impacts associated with long-term settlement nodes have unique soil and vegetation patterns on the ground (egepe), which show up clearly as vegetation "scars" in satellite images, and more heterogeneous forest in core areas that contrasts to surrounding high forest areas (see Figure 2).

As noted above, individual clusters are organized into core and peripheral areas. This pattern is particularly clear in the better known northern cluster, where core areas are defined by the center and four primary satellites with peripheral areas occupied by smaller plaza settlements. Roads have not been detected in satellite images, but GPS mapping and extrapolation of roads between settlements indicates that major settlements were linked by substantial, straight roads (see Figure 2). This created a lattice-like structure to the landscape. Intervening areas between major core settlements, broad agricultural landscapes would have represented what Bal & [38] describes as "intermediate disturbance," indicative of semi-intensive agricultural practices. This does not achieve the level of primary disturbance, but some species are associated only with areas of significant anthropogenic disturbance, notably sap & grass (Imperata sp.) and pequi fruit (Caryocar sp.), which are planted or

invade garden areas, as well as certain palms, which are generally limited in their distribution in or near settlement areas, notably including abandoned settlement areas of galactic clusters. Outside of core areas, a mosaic of managed areas, interspersed with high forest, grades into closed high forest in peripheral areas and forest wilderness between clusters.

Basic features of pre-Columbian agricultural economies can be suggested based on ethnographic analogy with contemporary Xinguano subsistence patterns. Continuity in settlement location, ceramic industries functionally related to manioc processing and cooking, and wetland features associated with settlements, including ponds, dams (weir footings), and bridges, suggests that a similar agricultural and fishing economy characterized past occupations. In particular, durable ceramic industry shows remarkable consistency through time in the primary cooking vessels. Unlike many Amazonian industries, which show considerable internal variability, Xinguano ceramic technology is largely composed of two forms associated with manioc cooking and processing and fish cooking. Primary cooking vessels constitute roughly 70% of the contemporary and prehistoric ceramic industries, notably included medium- to large-sized vessels today used for processing manioc flour and cooking tapioca and small- to medium-sized vessels used to cook fish. In addition, use wear documented on large cooking vessels, including notches on the rim, associated with straining manioc pulp, and corrosion on the inside of rims, associated with boiling processing "juice" to remove acid toxins, suggests continuity in basic subsistence regimes, focused on manioc [39,40].

The Upper Xingu provides one of the clearest ethnographic examples of a settled agricultural economy in Amazonia. Manioc (*Manihot esculenta*) cultivation is the most important agricultural staple, with 46 or more varieties constituting roughly 80% of the diet [41]. Carneiro [33] provides a detailed description of Kuikuro manioc production. Manioc matures in the ground and can be harvested at virtually any time. Peccaries are a primary threat and manioc fields are sometimes protected by low fences. Increasing encroachment by weeds rather than soil fertility is the primary reason for garden abandonment. Manioc is cultivated in upland (non-inundated) areas in broad agricultural areas, isolated gardens, remote garden hamlets and house gardens. Some households cultivate manioc in all three settings, particular higher ranking households responsible for sponsoring major ritual events, which require surplus production. Manioc is stored in houses in large baskets and basketry silos, which can contain over 1,000 kg of manioc flour.

The mosaic agricultural countryside can be divided into concentric zones of use extended outward from the settlement. Within a radius of roughly 2.5 km around communities, the landscape is a patchwork of active and abandoned manioc garden areas. Small orchards of *pequi* fruit trees (*Caryocar* sp.) are occasionally planted in manioc gardens prior to abandonment. The small orchards that dot the agricultural countryside are owned by the families that planted them. Much of this area is densely populated by $sap \, \acute{e}$ grass (*Imperata* sp.), which invades recently abandoned manioc garden areas that are typically abandoned after three years of use. $Sap \, \acute{e}$ grass is a critical industrial resource for house thatch. After some time, secondary forest, a primary resource for firewood, develops in grassy areas. Higher stands of secondary forest are the primary areas for establishment of new gardens, which is felled and burned prior to planting. Areas of $sap \, \acute{e}$ grass not being harvested for thatch are commonly burned annually in the dry season in areas away from settlements and fires burn across much of the secondary forest. Annual dry-season burning in the fire-adapted landscape not only provides nutrients to the soil, but makes soils friable and more easily worked into the small mounds.

Between 2.5 and 5.0 kilometers from the village more sparsely distributed manioc gardens and patchy areas of secondary growth grade into closed high forest (*itsuni*). Seasonal hamlets are located farther away from plaza settlements are occupied for a brief time, from days to months, during the dry season. Carneiro [33] noted that Kuikuro production was far below the potential of the area in the 1950s to 1970s (<150 persons). At over twice the village population after 1990 (>300 persons), manioc gardens were still fairly sparsely distributed across the broad agricultural landscape, although areas more distant from the village (>2.5 km) were exploited due to the widespread incorporation of bicycles in local communities. After 2000, the acquisition of a tractor and pick-up truck made access to these areas even easier. In the core areas of prehistoric clusters, areas of semi-intensive land-use overlapped in more developed agricultural countryside.

Carneiro [42] suggested that contemporary manioc agricultural technology could support a substantially larger community population, numbering in the low thousands. Archaeological evidence that documents settlements over ten times the size of current villages suggests that indeed it had. Moreover, the density of major settlements in prehistoric clusters suggests that production was significantly higher in prehistoric times, which would have included more intensive land-use, particularly in core areas. The more densely settled landscapes of pre-Columbian Xinguano peoples were laid out according to a precise plan, as clearly documented in the northern cluster and likely characteristic of the southern cluster, as well: a center with four satellites defining a core area and more distant satellites situated in a peripheral zone, similar in size to 20th century villages, and possible non-plaza settlements or hamlets, similar to seasonal hamlets of contemporary Xinguanos. Indeed, the entire core area was likely patchy agricultural countryside, much like the areas surrounding individual settlements today, characterized by long rotational cycles of manioc gardens, pequi orchards, and open expanses of sap é grass interspersed with secondary scrub forest, before being converted again into gardens. The lattice- or grid-like layout of settlement nodes connected by roads also strongly affected land-use, as well as the return to high forest after abandonment of most settlements in the century or so after 1492. Furthermore, several dark earth areas have been identified along roadways in core areas, which may represent small hamlets or specialized production areas.

At the regional level, nuclear portions of the Upper Xingu basin formed a patchwork of areas intermediate disturbance, associated with cluster core areas and immediately surrounding smaller satellite settlements, and forest wilderness in areas between clusters. More peripheral areas of the Upper Xingu basin were dominated by closed forest wilderness conditions, which grade into more open scrub forests and woody savanna of the uplands (*cerrado*) surrounding the Upper Xingu basin. Arguably, this pattern of heavily anthropogenic conditions in core areas of the forested Upper Xingu basin can be suggested for other major headwater basins of major rivers (Tapaj & and eastern Madeira river headwaters) in the southern transitional forests, also dominated by settled Arawak speaking groups. If so, a very large portion of the transitional forests, a major sub-region of the forested Amazon basin, were substantially anthropogenic and reflect the long-term dynamics of coupled natural-human systems.

5. Discussion

In Civilizations [43], Fern and ez-Armesto, notes: "Some societies make do with the environment nature provides," but the "civilizing impulse" is the recrafting of nature into built environment. For centuries, the Western imagination has portrayed native Amazonian communities as small, simple, and relatively unchanging: societies that merely make do. They have complex knowledge about the natural world, highly sophisticated ethno-ecologies, but lack hallmarks of civilization: centralized government, major surplus, stone masonry, or urban settings. The Xingu is one of a growing number of Amazonian cases that show this may not be entirely true. Although quite different in organization that urban societies in many parts of the world, and certainly lacking stone cities, the networks of towns and villages organized in small, regional polities extending across core areas of the Upper Xingu basin, an area roughly the size of Wales, are comparable, in terms of regional planning, integration, and the transformation of nature, to the small- to medium-sized complex societies that dominated the globe in 1492. Notably, nuclear areas of the Upper Xingu basin were a mosaic of areas heavily impacted by human activities, representing areas intermediate disturbance [38], grading into areas of moderate to minimal anthropogenic influence. Such human influences can be expected to indirectly effect the distribution of plant and animal distributions even in areas peripheral to primary anthropogenic alteration. Peripheral areas of the basin were more lightly occupied, representing a buffer zone between core areas of the Upper Xingu basin, dominated by the related polities of the regional peer polity, and areas dominated by other indigenous groups, notably including Tupi-Guarani (north and east) and Gê-speaking peoples (south and west).

Settlement and land-use patterns in other areas dominated by Arawak speaking populations across the southern Amazon, including not only the Upper Xingu basin but the upper Tapajós River and upper Madeira River in Bolivia and adjacent portions of Brazil, suggest that the much of the southern Amazon transitional forests were strongly influenced by human factors. This does not rule out the possibility of large settlement size, denser regional populations, and significant anthropogenic influence in the less forested upland regions neighboring the forested basins, generally to the south. Nor does it suggest that closed evergreen forests located in the middle reaches of the major southern tributaries to the north were not also densely occupied. This remains to be seen based on detailed studies in these areas. What can be suggested, however, is that throughout the southern Amazon transitional forests, the forested headwater basins were dramatically altered by past human occupations. Detailed ecological studies are lacking from most areas, but it can be assumed that such areas have very different characteristics than untouched forest. Therefore, the ecological diversity of these areas cannot be fully understood through recourse to natural factors but must contend with the complex cultural history and historical ecology of the region.

The recognition that large portions of the southern Amazonian transitional forests are anthropogenic has important implications for questions of conservation and development in the broad region. Notably, in the transitional forests of the southern Amazon, which are among the most heavily deforested areas of the Amazon, many of the largest tracts of standing forests are associated with indigenous areas. These areas are critical for regional ecological integrity and will have an important role to play in global initiatives to preserve tropical forests, such as the UN REDD initiative (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries). Protecting these vulnerable

forested areas is vital for ecological integrity and as important carbon stocks in regional systems, but these forests are also actively used by indigenous peoples, including forest conversion in agricultural landscapes. In the face of population growth and technological change among indigenous groups, the stewards of these forested areas, the cultural and land-use rights of these groups must be recognized, alongside global concerns regarding forest conversion. In this regard, past semi-intensive land-use practices, which created mosaic landscapes of settlement, agricultural, and forested lands, including secondary fallow forest and high forest, offer important insights for future sustainable development in these areas, and may even provide clues to ecological restoration in heavily deforested areas outside of indigenous reserves.

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