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The legacy of cultural landscapes in the Brazilian Amazon: implications for biodiversity

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For centuries Amazonia has held the Western scientific and popular imagination as a primordial forest, only minimally impacted by small, simple and dispersed groups that inhabit the region. Studies in historical ecology refute this view. Rather than pristine tropical forest, some areas are better viewed as constructed or 'domesticated' landscapes, dramatically altered by indigenous groups in the past. This paper reviews recent archaeological research in several areas along the Amazon River with evidence of large pre-European (*ca* 400–500 calendar years before the present) occupations and large-scale transformations of forest and wetland environments. Research from the southern margins of closed tropical forest, in the headwaters of the Xingu River, are highlighted as an example of constructed nature in the Amazon. In all cases, human influences dramatically altered the distribution, frequency and configurations of biological communities and ecological settings. Findings of historical change and cultural variability, including diverse small to medium-sized complex societies, have clear implications for questions of conservation and sustainability and, specifically, what constitutes 'hotspots' of bio-historical diversity in the Amazon region.

Keywords: Amazonia; indigenous peoples; archaeology; historical ecology; bio-cultural diversity

1. INTRODUCTION

The preservation of tropical forests in the Amazon is central to current debates about environmental and climate change across the globe. Greater Amazonia, which refers to the largely forested Orinoco and Amazon river basins, preserves nearly one half of the world's remaining tropical forests. It contains nearly a quarter of the world's fresh water and produces roughly one-third of the world's oxygen, over an area larger than Europe (nearly one-third of South America). According to The Nature Conservancy (TNC website: www.nature.org; consulted 2 December 2006), Amazonia is also home to over one-third of the Earth's known species, and as such is one of the most critical reservoirs of biodiversity on the planet. Not surprisingly, concerns over biological conservation and the future of the region as a critical 'tipping point' in the Earth's climate and ecology are widespread.

The discovery of remarkable variability within Amazonia over the past few decades has overturned popular characterizations of the region as a fairly uniform, impenetrable lowland jungle strangled with plants and teeming with exotic fauna of all kinds. Recent research coupled with the immense power and widespread availability of satellite imagery reveals that, although generally flat and green, there is astonishing biological and ecological variability. Today, in fact, the region has become an icon of biodiversity and widely recognized as one of the most biologically diverse macro-regions on Earth. It is also widely recognized as one of the areas most threatened in terms of ecological balance (Laurance *et al*. 2001).

The documentation of immense biological variation has done little to change stereotypes of the indigenous occupants of the region—as traditionally small-scale and dispersed villages of 'stone-age primitives' hidden away in forest clearings. The majority opinion still holds that natural forces and processes, little impacted by human actions until recently, are responsible for the current composition of the region. However, appearances are deceiving and, in this case, the present composition of the region as closed forest often masks an environmental history much more complex. In-depth studies in ethnohistory and archaeology, i.e. studies with sufficient time-depth to evaluate long-term patterns, clearly document that some areas were home to fairly densely settled, highly productive and powerful regional polities in the past. These small to medium-sized complex societies converted many forests into patchy, managed landscapes, which included fairly large-scale transformations of soils, forest plants and animals, and wetlands.

Regional specialists agree that indigenous populations were decimated by colonialism, making it impossible to sustain the popular viewpoint that indigenous populations have changed little over the past few millennia. Post-contact (1492) population collapse resulted in a wholesale 'fallowing' of managed forest landscapes across large portions of Amazonia. Thus, the image of small, ephemeral indigenous groups and only minimal impacts upon the lands they occupied, still widely maintained by many natural

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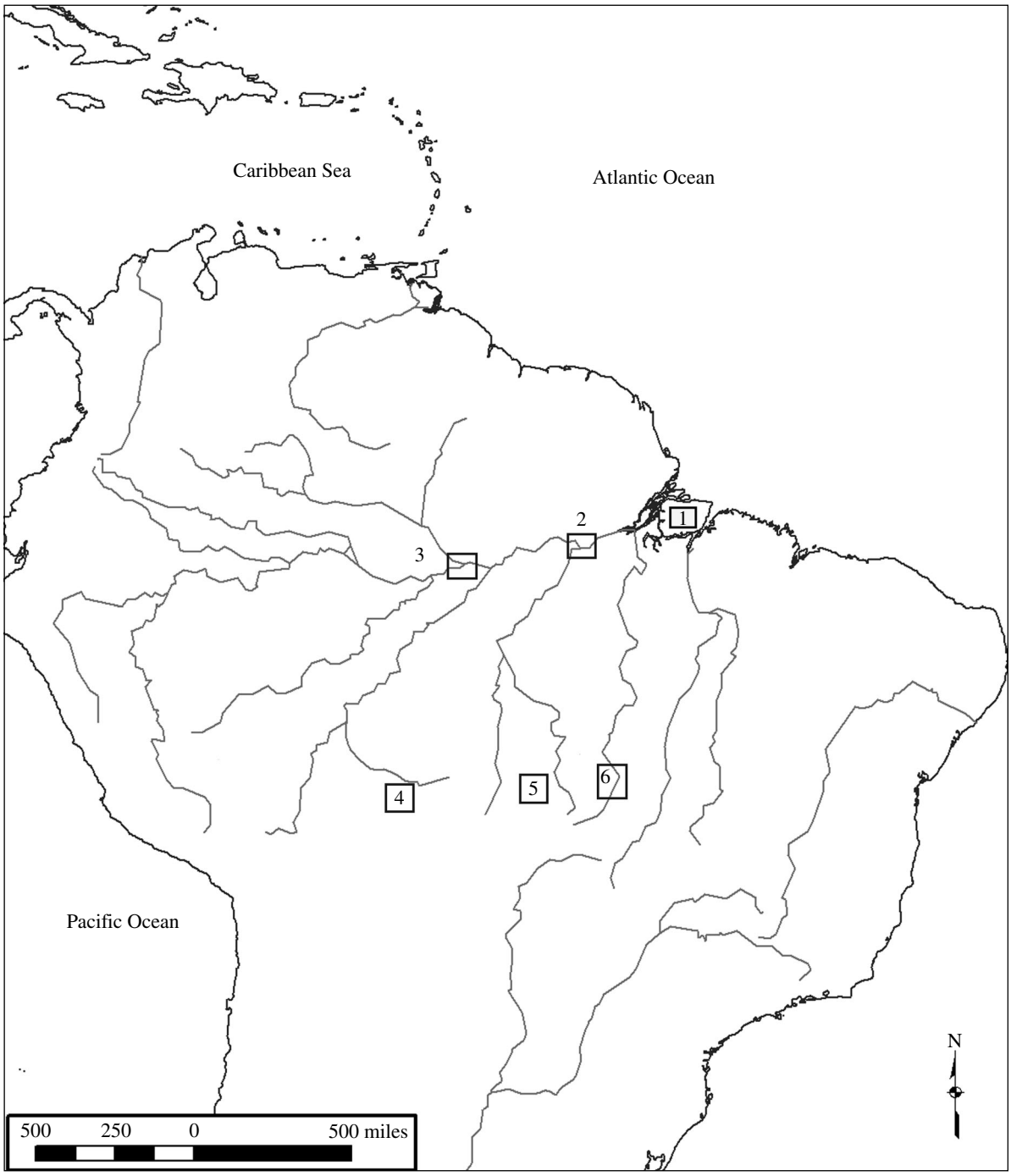

Figure 1. Map of South America showing major rivers and numbered boxes positioned over the areas discussed in text: (1) Marajó Island; (2) Santarém; (3) the central Amazon; (4) Bauré; (5) Pareci; and (6) Xinguano.

scientists, conservationists, policy-makers and the public at large, is no longer tenable as a general characterization of native peoples and must be demonstrated rather than assumed. The time has come to abandon assumptions of uniformity in cultural terms, and recognize that biological *and* cultural variations are the result of the complex and dynamic histories of coupled human–environmental systems.

In this paper, we focus on questions of long-term change in human–environmental relations in several distinctive parts of the Amazon River floodplains, including Marajó Island in the Amazon estuary, Santarém, about 500 km upstream, and the central Amazon region near Manaus, about 1500 km upstream from the mouth of the Amazon (figure 1). This is followed by a more detailed discussion of the lesser known complex societies of the southern Amazon region, specifically in the headwaters of the Xingu River (Mato Grosso, Brazil). In each of these areas, large populations, highly productive political economies and large-scale landscape transformations, if not urban settlement dynamics, were in play, but the productive modification of the land without destroying the tropical forest biomes is notable.

2. HOTSPOTS THROUGH TIME

The world is facing imminent global ecological disaster according to many recent commentaries. Many believe that the demands of the contemporary world will soon

lead to the large-scale destruction of biodiversity and ecological integrity, or even the overall global climate. Indeed, some argue that technology and irresponsible land use have pushed climate 'over the edge,' as seen by increased warming of ocean temperatures, melting glacial and polar ice, and natural disaster. The headline of a recent *Time Magazine* (4 March 2006) cover story on global warming sums it up: 'Be Worried. Be Very Worried.'

In the milieu of heightened concern, the entire Amazon is sometimes seen as one massive 'hotspot,' one of twelve global 'tipping points,' including two forests, which are seen as massive regulators of the Earth's environment (Schellnhuber *et al.* 2006). If these critical regions were subjected to excessive stress, they could trigger large-scale, rapid changes across the entire planet, which in turn could further exacerbate the collapse of modern bio-physical systems.

Hotspot is a term that has diverse meanings, but recent discussions of biodiversity are dominated by the definition of conservation biologists and, particularly, Conservation International (CI), one of the 'Big-Three' biological conservation NGOs operating across the globe (Chapin 2004). For CI, biodiversity hotspots are defined by their endemic species richness, proportional to regional and global distributions, and their degree of degradation (over 70%; from CI website: www.biodiversityhotspots.org; consulted 4 January 2006). Recognizing the great urgency of species loss, CI proposes a triage strategy that looks to protect these areas. There are obvious problems with such a view, such as the focus on certain highly visible species (Irish & Norse 1996; Crawford *et al.* 2005), or how human factors are incorporated in debates. The focus on present conditions of nature and human society tends to portray virgin forest, which is then seen as negatively impacted by human use, in particular the dramatic and rapid expansion of Western technology. In a strategically placed advertisement at Boston's Logan airport (3 October 2003), TNC appears to share this view of a changeless tropical forest in their promotion of efforts to preserve the natural places of the Amazon, 'as they were, as they are, and as they always will be'.

All parties may well agree that the blame lies with modern Western societies: 'Unsustainable consumption in many northern countries and crushing poverty in the tropics are destroying wild nature' (CI website; consulted 4 January 2006). Great variation exists in the definition of terms like endemic, biodiversity, hotspot, or what exactly characterizes a biogeographic unit like Amazonia, what holds it together as a meaningful entity. The difficulty of defining such things outside of specific situations is compounded by questions of anthropogenesis: being partially created by humans through secondary succession and 'intermediate disturbance' (Balée 2006).

The litmus test or definition of biodiversity by conservation biologists is obviously biological. The thermostat for global warming, for climate specialists, is overall impacts on one or another environmental 'threshold' factor in large regional or worldwide systems. Both positions promote local biodiversity (genetic and species richness) and regional or ecosystem biodiversity through conservation, preserving the status quo, and attempt to reorient governance to include if not defer to natural scientists. In most world areas, humans—how they occupy and interact with the land—are an obvious parameter of biodiversity. It seems reasonable to suggest that perspectives outside of the natural sciences, i.e. from the social and historical sciences, at least, are required. Contemporary biodiversity is easily measured in terms of the contemporary distributions of plants and animals, as well as the soils, hydrology and other physical features of the land, but cultural landscapes can only be understood historically.

Anthropologists, in particular, due to their 'grounded' or participatory approaches, tend to see local socio-historical contexts as critical. From an anthropological viewpoint, several important questions emerge: (i) the incorporation (or lack thereof) of indigenous voices in debates about Amazonian environment, (ii) tensions between local and global considerations, and (iii) the degree to which the actual histories of indigenous peoples are considered. This paper focuses on the latter question of indigenous histories and how they are incorporated (or not) into debate about biodiversity, conservation and development.

Historically minded researchers, at least those who wish to see things across long time spans, beyond a generation or two, might see 'hotspots' as areas that are dynamic and have witnessed significant change. The issue in question is not whether contemporary distributions are real or important, but the degree to which they can be projected into the past without critical evaluation or empirical justification. This perspective focuses upon what happened in history, based on engagements with deposits from other eras (archaeological, palaeontological or geological), i.e. the study of ancient life and its dynamic relation to the non-living environment, rather than what should happen based on assumptions that contemporary patterns prevailed in the past.

The destruction of native lifeways and population collapse is widely accepted throughout the Americas, including Amazonia (Denevan 1976), and archaeology and early ethnohistory show the massive diversity was lost in the wake of colonialism, nation-building and globalization. Indeed, conventional views that small, ephemeral occupations and very few people (0.01–0.3 persons per km^2) were fairly ubiquitous in the region—societies that leave only a very minimal footprint on the natural tropical forest (small, short-term clearings)—are generally unsubstantiated historically or archaeologically, beyond a few generations, at the end of a long arduous history of indigenous struggles against hostile invasion. The idea that any sustained human presence, even indigenous peoples with simple tools, is destructive or even invasive of biodiversity, is not only questionable in many cases but also backwards, since it was cultural forces, in significant part, that were responsible for patterns of biodiversity in the first place. Worse yet, by characterizing groups as migratory or transhumant, or even fugitive, who have made no major 'improvements' to the land, enables adversaries of indigenous land or cultural rights to deny their claims.

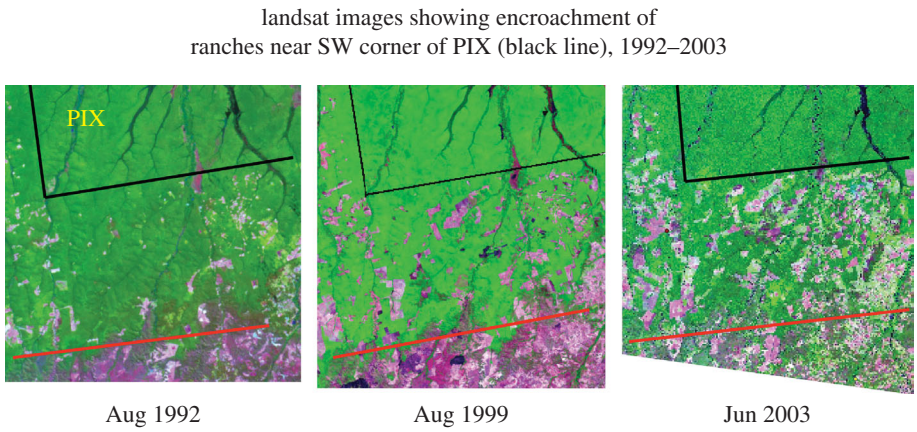

Figure 2. Landsat 5 TM and 7 TM+ scenes (5-4-3) showing encroachment of cattle and agricultural ranches on the PIX (red line denotes approximate original transition from closed forest to high-scrub forest). For animated comparison from Landsat 7, May 2000 and May 2004 visit http://eosweb.larc.nasa.gov/HPDOCS/misr/misr_images/brazil_xingu_fire_ani.gif.

At present, many scenarios of change are proposed based on the measurement and projection of present patterns into the future, with little attention to past patterns prior to about 30 years ago. Without in-depth archaeological and historical research it is difficult to be certain what is being measured or how one or another environment has or will respond to human intervention. The discovery of large, settled communities and dense regional populations suggests a much longer and complex history of human use and, by definition, sustainable resource use. It also provides ways to look back in time to see differential use of Amazonian landscapes and the long-term outcomes of land use. Minimally, it can no longer be assumed that an apparent lack of human influences today is an indication that it was always this way.

The bad news, however, is that very little is known about long-term history in most parts of this vast region. The good news is that there is a direct correlation between indigenous lands and standing forests, as even a cursory look at satellite scenes from the region shows time and again (figure 2). Nepstad *et al.*'s (2005) quantitative analysis of patterns revealed in satellite-based maps strongly shows that 'indigenous lands occupy one-fifth of the Brazilian Amazon…and are currently the most important barrier to Amazon deforestation.' In other words, indigenous resource management strategies are doing something right and it is worth understanding them, in the present and the past, and preserving them in the future.

3. BIO-HISTORICAL HOTSPOTS ALONG THE AMAZON RIVER

Archaeology is a critical component in recent discussions as often the only way to understand long-term dynamic change in coupled human–environment systems in tropical forest settings. In Amazonia, it has revealed a very deep and complicated history, extending from the late Pleistocene to today, and showing remarkable change and variability in cultural patterns through time and from region to region. In late prehistoric times, it is widely believed that large pre-Columbian populations managed resources effectively and on a fairly large scale, particularly in major river settings. Several areas along the Amazon River, in particular, have substantial evidence that large, productive economies were common in some parts of pre-Columbian Amazonia, notably river areas where forest farming and wetland management could be intensified.

Marajó is the massive fluvial island in the delta estuary of the Amazon River and has long been recognized as an area dominated by pre-Columbian complex societies—meaning regionally integrated and internally ranked social formations—generally referred to as Marajoara (see Meggers & Evans 1957). Early theories suggested that Marajoara polities were immigrants from Andean civilization who could not sustain their high level of economic productivity and large populations in this tropical forest setting. They devolved into the generalized Amazonian 'tropical forest culture'. Later researchers favoured *in situ* development and expansion of a generalized riverine tropical forest pattern to explain Marajó and other densely populated areas along the Amazon River (Carneiro 1970; Lathrap 1970).

Major archaeological research was conducted by Roosevelt (1991, 1999) from the mid-1980s to 1990s. Her studies, building on earlier work in the middle Orinoco River (Roosevelt 1980), suggested that population growth and cultural development and associated landscape transformations were due to intensification of agriculture of floodplain crops (e.g. maize or some local seed crop). Importantly, she contends that small fishes and other aquatic resources were primary to diet, supplemented by diverse agriculture and wild plants (Roosevelt 1991). By the 1980s, it was widely believed that chiefdoms throughout the Amazon bottomlands, or várzea, associated with the 'Amazonian polychrome tradition' that includes Marajoara, depended on fairly intensive exploitation of aquatic resources and diversified cultivation (Lathrap *et al.* 1985; R. L. Carneiro, 1986, unpublished work). The Amazon and its tributaries make up more than half of the world's 10 largest rivers and, as common to major river and maritime human adaptations across the globe, it makes sense that the complex societies along rivers were often more focused on fishing than hunting, despite the common anthropological and ecological focus on hunting strategies among indigenous peoples.

Recent field research by Schaan (2004) reveals aspects of the system of wetland management, as well as the configuration and the size of regional polities. Her research takes a regional perspective and focuses on the large Camutins group of 37 mounds and other sites along upper Anajás River. She argues that the big mounds went up fast, between *ca* 1400 and 1600 calendar years before the present (yr BP), and that mound-building was in decline before European contact, by *ca* 700 yr BP. The largest mounds of the group, the Camutins and Belem mounds, stand nearly 10 m in height and the former is over 100×250 m (2.5 ha) in upper extent. There was significant variation between domestic (low and small) and ritual/elite (large and high) mounds.

Schaan (2004) argues that mounds were constructed concomitant with or even as a result of wetland management, specifically the creation of barrow-pits in river sources that constituted ponds to manage aquatic resources. She feels that small to medium occupation mounds may well have been designed not only to create a level high ground for residential activities, but also ponds in the Camutins stream course. The larger mounds, which also had substantial non-domestic functions, stood far above highest seasonal water levels, and would have created large ponds for surplus production. Wetland landscape management among Marajoara also appears to include river palms fruits, such as Açai palm (*Euterpe oleracea* and related Juçara, *Euterpe edulis*, used today primarily for heart-of-palm; family Arecaceae) and other agricultural crops, including possible indigenous seed crops (Roosevelt 1991; Schaan 2004).

Santarém is a related but distinctive culture concentrated in the region at the confluence of the Amazon and the Tapajós rivers (about 500 km upstream from Marajó), centred on the Brazilian city of the same name. Santarém is an archaeological culture known primarily by its ornate ceramics (see Gomes 2002). It roughly corresponds with the historically known Tapajós polity, which dominated the area during the sixteenth and early seventeenth centuries but was already in rapid decline by *ca* 1650–1700.

Roosevelt's (1999) fieldwork in and around the city of Santarém leads her to believe that the polity was an even more populous and complex chiefdom than Marajó, characterized by intensive floodplain and upland agriculture, and significant impacts in forest and wetland ecologies. Whereas Marajoara peoples may have been more 'heterarchical', i.e. with less rigid social stratification and a more diffuse political economy, Santarém was the capital of a highly stratified and rather large tributary polity. At Santarem, Roosevelt (1999, p. 337) found 'a complex series of deposits including low mounds, pits, caches of fine pottery vessels and statues, and large black-earth middens [and]…floors of longhouses with bell-shaped pits', leading her to conclude that the site is 'of urban scale and complexity'.

Based on largely unpublished fieldwork, she estimates that at its peak, in terminal pre-Columbian times, the site extended over an area of nearly 16 km^2, although as is typical in other parts of the Amazon, the distribution of occupation areas is likely patchy and spread out over this area. Nonetheless, if correct, her estimate of this late prehistoric capital town rivals the size of Cahokia, the largest site in North America, or many of the stone and adobe temple centres of the central Andes and Mesoamerica. Its size and power are corroborated by diverse references to large settlements, populous regions and large-scale canoe flotillas of warriors in early chronicles of the river (Porro 1996).

Recent research on archaeological dark earth (ADE) soils from a variety of sites in the lower Tapajos River appears to have found the agronomic signature of these large populations (Lehmann *et al.* 2003; Glaser & Woods 2004; Glaser 2006). ADE research suggests that the area was densely occupied and that agricultural populations had a complex and sophisticated system of ADE creation and management, including both the occupational soils (*terra preta*) and the non-ceramic bearing agricultural soils (*terra mulata*; Woods & McCann 1999). Areas of altered (anthropogenic) soils vary from quite small (less than 1 ha) to quite large (more than 100 ha) and occur in a wide range of contexts, and in the Lower Tapajós ADE cover an area of well over a thousand hectares (Denevan 2001; Kern *et al.* 2003). Diverse techniques of management, including burning, mulching and other techniques are suggested and supported by ethnographic studies, such as Hecht's (2003) discussion of Kayapó land and soil management and Posey's (2004) general discussion of 'forest islands' (possible archaeological sites as well as integral parts of contemporary resource management) and eco-tone management in the neighbouring middle Xingu River region.

The central Amazon region near Manaus, about 1000 km up the Amazon River from Santarém, is defined by the confluence of the Amazon (Solimões) and the Negro Rivers in Brazil. It is a particularly well-known archaeological sequence leading up to late prehistoric complex societies similar in scale to those from downriver. For the past decade, archaeological research has been ongoing in the central Amazon (e.g. see summary in Neves 2005; Lima *et al.* 2006). The Projeto Arqueológico de Amazônia Central (PAC) has made major contributions to our understanding of the várzea chiefdoms of the Amazon, revealing over 100 sites (Petersen *et al.* 2005; Neves & Petersen 2006).

In late prehistoric times, fairly large-scale regional populations lived in dispersed small settlements (less than 10 ha) tied socio-politically to large residential and ceremonial centres. These major centres, such as the Açutuba site, a large (30–50 ha) plaza centre located about 50 km up the Negro from the confluence, were different from other settlements both in qualitative and in quantitative terms. However, they may have held a fairly small resident (year-round) population. Nonetheless, at times at least the site was used intensively, as suggested by the coffee-ground black soils, low occupation mounds and massive quantities of broken ceramics found in core areas of the settlement around the central plaza (Heckenberger *et al.* 1999).

Ongoing PAC research has also made important strides forward in ADE research, including recognition of differential and patchy distributions within and between sites, the diversity and scale of constructions, refuse activities and surrounding transformations of

agricultural landscapes, including terra mulata formation (largely a ceramic ADE deposits surrounding Açutuba), defensive structures and wetland modifications (Petersen *et al.* 2001; Neves *et al.* 2003, 2004). The infrastructural elaboration of Açutuba, including mounds, ramps and ditches, sculpted plazas and agricultural areas, attest to the necessarily great alteration of the tropical forest in this riverine setting. Use of the broad area was highly patchy and variable as people move from place to place, or not, through time. This brings to mind Balée's (1989, 2006) notion of broad anthropogenic landscapes built up through time, as well as Denevan's (1992, 1996, 2001) suggestion of intensively used zones around bluff settlements, which he feels was more typical in the past before metal axes. These findings corroborate early ethnohistoric accounts from the middle Amazon River (Porro 1996).

The PAC provides the strongest archaeological evidence to date that the Amazon River bottomlands and adjacent areas were densely populated and some settlements had heavily constructed core areas, including architectural earthworks, massive soil alteration in and around settlements, large agricultural areas and possible wetland management systems. It suggests a great deal of local variation in the size and duration of settlements, or their impacts on the environment. It supports the idea of environmental complementarity between densely and sparsely settled stretches of the main rivers, including 'buffer-zones', and between river and hinterland zones, which created a highly patchy regional landscape. But areas where environmental impacts were low were a reflection of cultural and political factors as well as ecology, and served as 'preserves' for diverse animals.

4. THE UPPER XINGU: A HOTSPOT THROUGH TIME

The headwater region of the Xingu River, or Upper Xingu, in northeastern Mato Grosso state, Brazil, provides another clear case of anthropogenic modification of Amazonian landscapes over the long term (see Heckenberger *et al.* 2003; Heckenberger 2005). The Upper Xingu is one of several areas in the southern Amazon region where densely settled complex societies flourished during the late prehistory. The broad region which extends from the Tocantins River headwaters in the east to the Guaporé River (the easternmost headwater of the Madeira River) is dominated by semi-deciduous forests transitional between the high forests of central Amazonia and the low and scrub forests of the highland central Brazilian plateau (see figure 1). The overall topography can be characterized by pockets of flat, low-lying and forested areas corresponding to the headwater basins of the major rivers that eroded out along the northern flanks of the Brazilian highlands (300–500 m.a.s.l.). These basins are interspersed by rolling topography and more open forests in highland interfluves between the headwater basins.

Steward & Faron (1959) called these complex societies 'theocratic chiefdoms,' which dominated the densely forested areas of the basins. They were largely of the Arawakan language family and related peoples. Sixteenth and seventeenth century accounts describe the Bauré peoples of the middle Guaporé, the Pareci peoples of the Juruena and Arinos rivers (headwaters of the Tapajós River headwaters), and the Terena/Guana peoples (upper Paraguay River) as large, densely settled populations, with complicated settlement and agricultural works, and regional socio-political organization.

Archaeological complexes associated with these groups, including sophisticated agricultural, settlement and road earthworks, have long been known from the eastern lowlands of Bolivia (Denevan 2001). Aerial photography in the mid-twentieth century made it more feasible to visualize the scale and configuration of agricultural earthworks, raised causeways and other features in open savanna. Erickson's (e.g. 2000, 2001, 2006) recent archaeological work has revealed a complex system of earthworks, including causeways, fish weirs and ponds, and forest islands (ancient settlements), raised fields and diverse other archaeological landscape features. Erickson (2000, p. 193) notes that: 'Rather than domesticate the species that they exploited, the people of Bauré domesticated the landscape'. Recent research suggests that not only is much of the area anthropogenic, but that biodiversity is equal if not higher in anthropogenic than in non-anthropogenic areas (see Balée 2006).

To the east, in the adjacent upper Tapajós River headwaters, Antonio Pires de Campos, an early frontiersman, made reference to the settlement pattern of the Arawak-speaking Pareci nation: 'These people exist in such vast quantity, that it is not possible to count their settlements or villages, [and] many times in one day's march one passes ten or twelve villages, and in each one there are from ten to thirty houses…even their roads they make very straight and wide, and they keep them so clean that one will find not even a fallen leaf' (Pires de Campos 1862[1720], pp. 443–444, authors' translation).

In the Upper Xingu basin, the easternmost of the southern Arawakan groups, recent archaeological work shows a settlement pattern very similar but even more developed and elaborated than the one described by Pires de Campos. The southern Arawakan and related groups are a fascinating example of how related groups expand into areas with select ecological conditions (forested bottomlands) and diverge over time as they orient themselves to distinctive social, ecological and historical conditions (Heckenberger 2002). The Upper Xingu is distinctive from its distant socio-political cousins, the Arawakan polities to the west, in the degree to which ancient lifeways are carried forward by their living descendants. Demonstrable cultural continuity expressed in material culture and built environment links contemporary indigenous peoples and their pre-Columbian ancestors, including important aspects of economics, settlement patterns and technology (Franchetto & Heckenberger 2001).

The Upper Xingu is a sedimentary basin (peneplain) with a diverse range of lakes, ponds, rivers and streams, deep forest, managed forest (at least at one time) and scrublands (restricted to a small area of seasonally wet but not flooded bottoms). In the basin, the primary landforms appear to have been

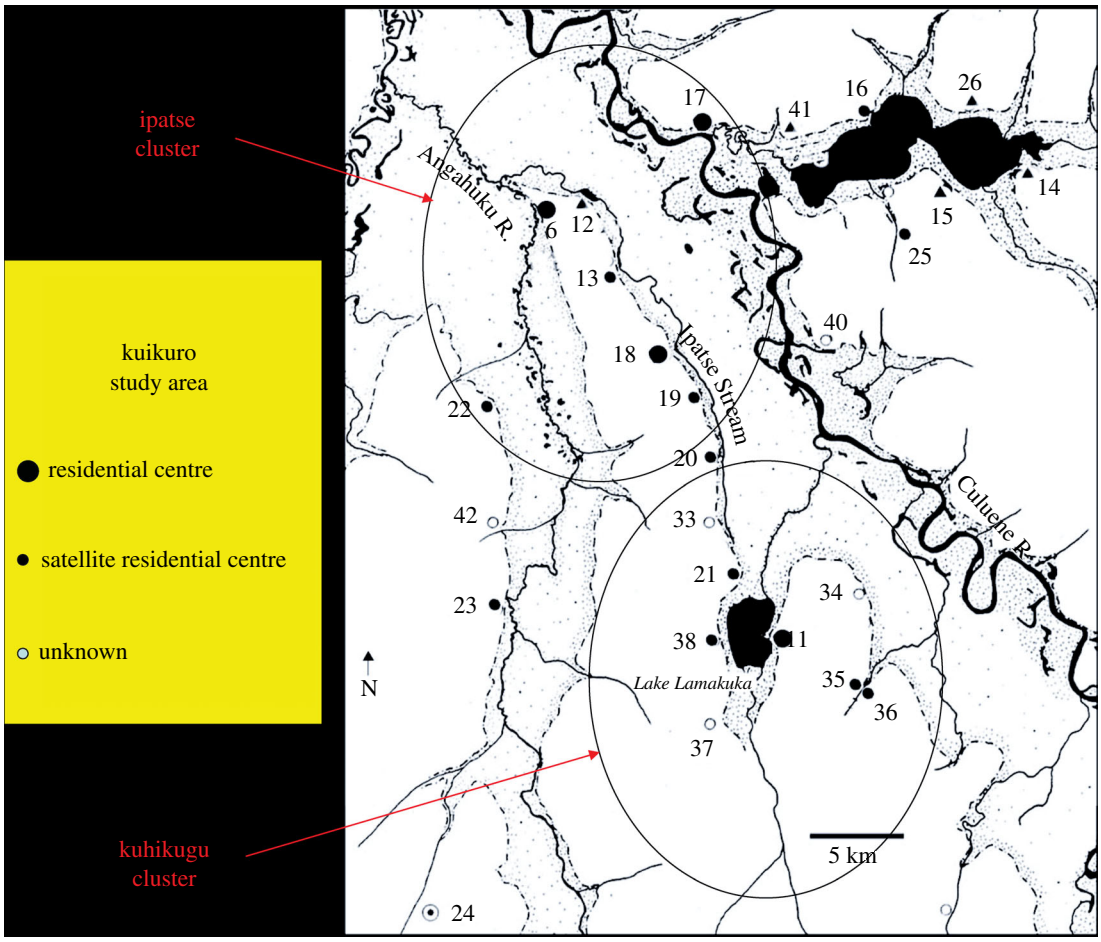

Figure 3. Map of Ipatse and Kuhikugu cluster sites in Kuikuro study area (PIX).

stable over the past 1200–1500 years or so of human occupation, due to the continuity of settlement locations from this time to the present (a conclusion supported by recent sediment coring in several pond and lake settings (Jason Curtis & Mark Bush 2006, personal communication)). The Upper Xingu is critical today as the last remaining large stand of indigenous controlled tropical forest in the transitional forests of the southern Amazon, although areas all around it on the south, east and west are heavily deforested. The Parque Indígena do Xingu (PIX), the first indigenous area established in Brazil (1961), protects Xinguano lands and literally forms an island of forest (see figure 2).

The ecology of the area shares with the areas mentioned above a wide diversity of forested areas and wetlands, but lacks the fertile floodplain soils or agricultural ADE (*terra mulata*) soils of the Amazon River polities. Likewise, it lacks raised fields or other agricultural improvements in seasonally saturated areas (small areas of possible but very slight ridging have been noted, but artificial origin is unconfirmed). Earthen causeways are present where roads pass over maintained wetlands, and are an important component of the wetland management system. Like other areas described above, many areas of wetlands and forests were modified over generations of near continuous occupation, and over time well-defined land-use 'zones' evolved, consisting of the areas of continual management (roads, settlements, bridges), the areas of active but occasional management (manioc gardens, fish weirs, orchards and grass fields for thatch) and the areas that are utilized but not actively managed (forest 'preserves').

Archaeological studies (1992–2005) have been concentrated in the traditional territory of the Kuikuro Amerindian community, whose three villages form part of the larger Xinguano society (composed of nine subgroups, living in 14 villages, and almost 2500 people, confined today to the PIX). The Kuikuro territory expands over an area of approximately 1200–1500 km^2 (the regional society was minimally spread over an area 10 times this size or more in late prehistory based on known archaeological distributions). Over 30 residential sites have been identified in the Kuikuro territory. Most or all of these were occupied and interconnected in late prehistoric times (1250–1650) and were organized into two or three integrated and ranked clusters of 8–12 villages (figure 3).

The cultural sequence can be broken into four distinctive periods: (i) early occupations by Arawak and, perhaps, Carib-speaking peoples, *ca* 1500 yr BP or before, until 750 yr BP, (ii) a galactic period, from *ca* 750 to 350 yr BP or soon thereafter, marked by the integrated clusters of small to large villages, (iii) a historical period, dominated by adaptation to the indirect and direct effects of Western expansion, from *ca* 350 to 50 yr BP, and (iv) the modern period, from 1950 till now. The first known occupations were agriculturalists (proto-Xinguano tradition), historically related to other Arawak-speaking groups to the west. After 750 yr BP, there was a major reconstitution of the

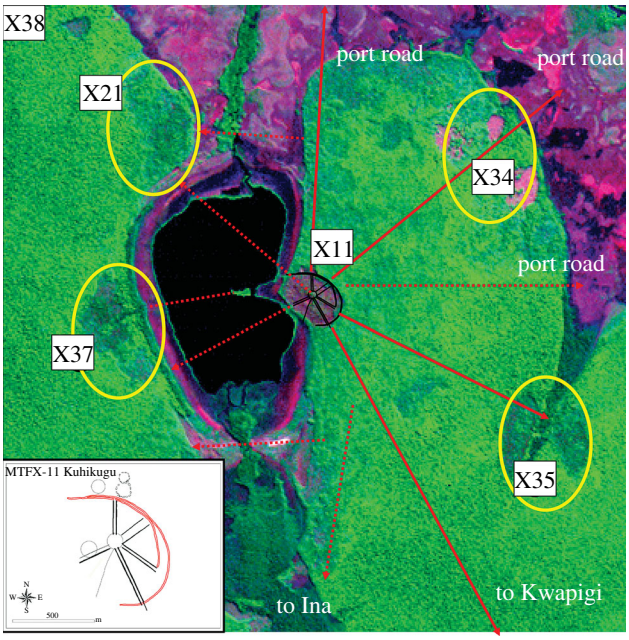

Figure 4. Distribution of archaeological sites associated with Kuhikugu cluster, showing X11 roads (red) and secondary settlements. Note associated anthropogenic forest scarring in the areas of archaeological sites (yellow ovals).

overall regional settlement system, whereby settlements were reconstructed and formally linked into galactic patterns of nodes and roads across the area through the construction and/or elaboration of linear village earthworks (figure 4).

Regional ethnohistory shows diverse migrations and episodes of ethnogenesis, in response to Western frontier expansion over five centuries (Franchetto 1992, 2001; Franchetto & Heckenberger 2001; Heckenberger 2005; Fausto *et al.* in press). This has helped fill the gap of declining population, but by 1950 the regional population was only 500, perhaps less than 5% of its pre-Columbian size (Agostinho 1972; Heckenberger 2005). Population collapse resulted in a process of landscape 'fallowing', as settlement after settlement was merged and whole areas abandoned (figure 5). It is an exemplary case example of what a large, settled pre-Columbian polity looks like after five centuries of decline. Remarkably many basic cultural patterns have been resilient through the time, such as circular plaza village form and general landscape orientations. Xinguano agricultural patterns can also be reconstructed over the long run, as well through analysis of functionally specific utilitarian ceramics through time, which also show continuity in forms used to cook manioc and fishes. Indeed, Xinguanos still eat more than 99% traditional foods, fishes and manioc, primarily supplemented by turtle, monkey and some bird meat, insects, pequí fruit and several palm fruits (Carneiro 1957, 1983; Basso 1973; Dole 1978; Heckenberger 2005).

Agricultural areas form a patchy mosaic created by long-term (20–50 years) rotational succession, marked by planted gardens and heritable orchards of pequí fruit trees (*Caryocar brasiliense*, family Caryocaraceae). These orchards contain a few to a dozen or so trees. Pequí is planted in manioc fields along with other useful specialty crops, which begin to die off as the pequí trees mature. The areas with ADE soils (i.e. archaeological sites) are sometimes used to plant corn, watermelon and other plants today, but this was

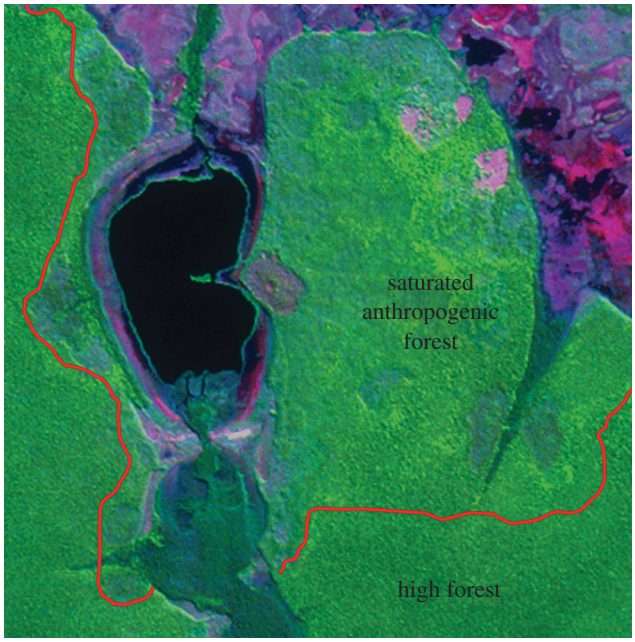

Figure 5. Saturated anthropogenic landscape in area of Kuhikugu (X11) and related settlements, separated with red line from the areas of less altered high forest.

apparently restricted to trash middens (also ADE) within occupied settlements and small hamlets with ADE along some pre-Columbian roads.

ADE is an important part of the landscape as part of ancient occupation sites. It is distributed in overlapping and sometimes mixed refuse disposal middens (composts), domestic, and work area deposits, although generally not in public plaza areas and major roads leading away from them (Schmidt & Heckenberger 2006). In pre-Columbian villages, ADE soils are concentrated in core residential areas and form macro-strata that cover areas of about 6–8 ha (within larger residential sites, 20–50 ha). In other areas, trash middens and domestic areas show restricted soil darkening and alterations, like in contemporary

villages. This distribution of ADE deposits, like vegetation and wetland habitats, is the historical outcome of Xinguano settled agricultural lifeways, including village permanence, as well as sustained demographic decline during the past five centuries. Many technologies, such as subterranean manioc-storage, water-storage features in seasonal ponds (modifications of existing stream channels) and turtle pens have largely been abandoned, although fish weirs are still widely in use (see Clement 1999, 2006 for an important discussion of crop diversity and post-1492 loss of it in Amazonia).

The moriche or buriti palm, *Mauritia flexuosa* (family Aceraceae), the most important non-architectural industrial plant among Xinguanos, is closely associated with ancient settlement areas and flourishes in managed wetlands, although not exclusively. Sapé grass (*Imperata brasiliensis*, family Poaceae), the preferred house thatch, is another disturbance crop that, like its more common relative cogon grass (*I. cylindrica*) in other parts of the world, invades and overtakes disturbed areas, establishes well after a burn and helps control erosion over large open areas. Xinguano fields of sapé are annually burned at the end of the dry season, in August or September. This practice does not apparently create overly darkened soils. Nonetheless, a clear anthropogenic effect on chemical composition and soil texture is expected. Over time, grassy areas are choked out by scrub, and near abandoned Xinguano settlements, pequí trees and other fruit trees are common (at least for a few generations). Several exploited palms are also common, with some large mucujá (*Acrocomia aculeata*; family Arecaceae) perhaps dating to the time of ancient communities (based on extremely tall size and number of whorls, over 300 in some cases).

Cleared garden spaces, either as individual gardens, clusters or broad agglutinated spaces, create a broad agricultural landscape of areas largely denuded of original forest vegetation, which extend about 3 km out from contemporary villages. In the context of multiple contemporary villages, such as were typical in the past, a lattice-like pattern was created by roads and plaza villages, and adjacent communities would have overlapping orbits of cultivated and managed lands. This raises the question of whether post-European depopulation truncated a pattern of forest conversion that may have been degrading landscapes by late prehistoric times. Certainly in the past there was a greater proportion of non-forested to forested areas, but evidence suggests that sustainable levels of land use were being maintained. In fact, it seems that economic productivity and landscape configuration had co-evolved over many centuries, and intensification was carried out by fine-tuning the diverse and patchy orchard, field and garden agricultural areas, as well as by management of wetland fisheries.

In pre-Columbian villages, we can expect that the landscape was much more densely occupied and used more intensively and according to more rigidly defined divisions and schedules. Where today (2006) there are three villages of about 500 people (with only one of 350 a decade earlier), there were over 20 settlements in at least two clusters, with the larger first-order settlements ranging over 10 times the residential area of the modern Kuikuro village. These multi-centric settlement hierarchies encompass a small territory of about 400 km^2. It is hard to say what the exact scale of communities or regional populations was, but the size and configuration of the settlements themselves is quite clear. Plaza villages, like today, were critical social nodes and tied into elaborate socio-political networks. Primary roads and bridges are oriented to plazas, or more accurately, are ordered by the same spatial principles, which also order domestic and public space, creating a cartography and landscape that was highly partitioned and rigidly organized according to the layouts of settlements and roads, as shown in figure 4.

These areas of heightened alteration and management (saturated anthropogenic landscapes) can be readily seen in altered forest signatures on the landscape, as seen on the ground or in satellite images (shown in figure 5). The anthropogenic footprint of late prehistoric occupations is still clear today, even in the areas little used by contemporary Kuikuro communities. Rather than some delicate balance forged from millennia of almost changeless human use of the landscape, with almost imperceptible impacts on the forest, indigenous groups in the southern Amazon have a remarkable and indelible footprint. The scars of previous occupations, clear on satellite images, provide graphic testimony to what was lost, and underscore the need to consider human factors in the constitution of biodiversity and ecological zones.

5. FINAL COMMENT: REQUIEM FOR A PRIMITIVE WORLD?

The Brazilian Amazon contains roughly 40% of the world's remaining tropical forest. It is also among the most threatened with rapid degradation due to agro-pastoral expansion and other development (see Goulding *et al.* 2003). Optimistic and non-optimistic scenarios have been developed based on predictive modelling of current patterns (post-1950s and particularly post-1990s, when satellite imagery became widely available), but the ability to model accurately would be greatly improved by considering how biodiversity, whether measured in genetic, species or ecosystem diversity, came into being and changed over the long term. Clearly in the Upper Xingu, like the other areas discussed, a new concept, distinct from traditional conceptions of biodiversity, must be developed, which includes biocultural diversity—looking at the way certain cultural and biological patterns are mutually constituted—and bio-historical diversity, for lack of a better term, to describe how this process unfolds over the long term.

The realization that Amazonia is not a land of primitive peoples and pristine nature, untouched until quite recently, does not imply that indigenous societies are similar to contemporary (Western) society. What is interesting is how native peoples developed through time in unique ways, organizing themselves and the natural world through complex cultural relations with nature and sophisticated technologies through which to manipulate or manage the natural environment, rather than 'tame' it. But, while they differ entirely from

contemporary mechanized agriculture, these societies had impacts on the forests of the region, much like that seen in the temperate forests of Medieval Europe (cf. Crumley & Marquardt 1987). It is important to be clear, however, that comparing pre-Columbian population scales or technologies with contemporary agribusiness and frontier development is like comparing a seventeenth century grist mill with a modern hydrodam. That Amazonian landscapes are richly historical and constructed makes them no less natural or interesting, or tainted in terms of biodiversity.

Many aspects of indigenous and folk resource management provide ready-made alternatives to imported and far more destructive development strategies and technologies. As Laurance *et al.* (2001, p. 439) suggest: 'Rather than rampant exploitation, an alternative and far superior model for Amazonian development is one in which agricultural land is used intensively rather than extensively and 'high-value' agroforestry is valued and perennial crops are favoured over fire-maintained cattle pastures and slash-and-burn farming plots…' Indeed, this is precisely what it seems some indigenous groups were doing. Indigenous practices limit deforestation and lasting partnerships between indigenous and rural peoples in the region will maintain standing forests and potentially even restore tropical forest degradation (Lamb *et al.* 2005; Nepstad *et al.* 2005).

Future strategies of land management require approaches that promote interdisciplinary and multivocal cooperation—*genuinely* participatory strategies—and recognize the need for contextual knowledge and knowledge production in cultural and historical realities (Heckenberger 2004). Indigenous knowledge and practices are deeply situated, based on both highly specific knowledge of place and context and highly general and transposable knowledge of life in the Amazon tropical forest. In the Upper Xingu, at least, as one of the last large remnants of standing forest and last refuges of traditional indigenous peoples in the transitional forests of the southern Amazon, a convergence of interests in preserving local (indigenous or endemic) biological and cultural diversity may help to cultivate partnerships between specialists and indigenous peoples. But, as a hotspot in terms of genes, species and the overall ecosystem(s), as well as in terms of local, national and world heritage, issues of human agency, dynamic change in coupled human–environmental systems and human rights loom large in questions of conservation or sustainable development. In this regard, understanding indigenous systems of management, including those that are only or largely apparent archaeologically, may hold critical keys to future approaches to land use and land rights.

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