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The Call of the Wild: Rethinking Food Production in Ancient Amazonia

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Abstract

The Amazon basin is accepted as an independent center of plant domestication in the world. A variety of important plants were domesticated in the Amazon and its surroundings; however, the majority of plants cultivated today in the Amazon are not domesticated, if this descriptor is understood to convey substantial genetic and phenotypic divergence from wild varieties or species. Rather, many domesticates are trees and tubers that occupy an intermediate stage between wild and domesticated, which seems to be a prevailing pattern since at least the middle Holocene, 6,000 years ago. Likewise, basin-wide inventories of trees show a remarkable pattern where a few species, called hyperdominant, are overrepresented in the record, including many varieties that are economically and symbolically important to traditional societies. Cultivation practices among indigenous groups in the Amazon are embedded in other dimensions of meaning that go beyond subsistence, and such entanglement between nature and culture has long been noticed at the conceptual level by anthropologists. This principle manifests itself in ancient and dynamic practices of landscape construction and transformation, which are seriously threatened today by the risks posed by economic development and climate change to Amazonian traditional societies and biomes.

INTRODUCTION

In a recent article in *The New York Times Magazine*, entitled "The Superfood Gold Rush" (Keiles 2017), the Amazonian palm açaí is touted as a new superfood in health food restaurants in the United States. Açaí juice, or "wine," is extracted from the small, seedy fruits of *Euterpe oleracea*, a species known to thrive in the wetlands at the estuary of the Amazon river where it grows in large stands. In the Brazilian state of Pará alone, located at the mouth of the Amazon, açaí pulp production jumped from 5,418 tons to 11,350 tons between 2004 and 2009, corresponding with an increase from US$6,420,000 to US$27,970,000. The other variety, *Euterpe precatoria*, is the most common tree species across the broad Amazon region, while *Euterpe oleracea* is the seventh most common species (ter Steege et al. 2013).

The current açaí production chain is reminiscent of the "salvage economy" described by Tsing (2015) for matsutake mushrooms: plants that are extracted from nature and achieve economic importance but that, although seeming natural, are found in biomes previously disturbed by human action. Açaí consumption may extend well prior to European colonization of the New World (Morcote-Ríos & Bernal 2001, Roosevelt 1991) and continues to be a traditional staple across the region. However, despite its importance as a cash crop, açaí is a nondomesticated plant, if one adopts the concept of domestication that includes the need for genetic transformation and the generation of a new species in order for a plant or animal to be considered a new species (Meyer et al. 2012).

Açaí is not the only widely dispersed Amazonian tree species extensively used by indigenous populations; other species, such as Brazil nut and rubber trees, have also been highly managed among past and present indigenous people and other local traditional societies. The major difference, however, is that whereas matsutake mushrooms are dispersed in imprecise locations and have to be searched for in forests, rubber trees and Brazil nut trees grow in plots already known and managed by humans, in some instances for hundreds of years, as with Brazil nut stands (Scoles & Gribel 2011). Like açaí, Brazil nuts and rubber are nondomesticated species, and because it is impossible to grow rubber tree on plantations in the Amazon, rubber exports sharply declined there from the 1910s onward; they were unable to compete with the cheaper varieties produced in plantations in Malaysia.

Together the emerging evidence suggests that the development of plant management, extraction, and cultivation strategies in Amazonian tropical forests differs significantly from those in other world areas, notably the classic Neolithic Revolution model (Neves 2016, Fausto & Neves 2018). Investigators have long suggested that tropical agriculture focusing on tuber crops differed from cereal agriculture in temperate climates (Lathrap 1970, Sauer 1952), but the emerging view of Amazonian cultivation of both food and industrial crops supports heterogeneous land use and dispersed production systems, including a broad array of plants and animals. This shift is part of changing views on tropical forests as loci of cultural development and suggests that different processes of human–plant interactions, including the remarkable diversity and scale of Amazonian indigenous societies and economies of abundance, dramatically differ from trajectories elsewhere.

BIOCULTURAL HYPERDIVERSITY

The greater Amazonian tropical forest has approximately 3.9×10^{11} trees grouped in ~16,000 species. Of those, just 227 species (1.4%) account for half, which are referred to as hyperdominant (ter Steege et al. 2013). Of the 10 most hyperdominant tree species, 6 have strong economic importance as foodstuffs, raw materials, or technical plants, and this pattern most likely results from human management in the past (ter Steege et al. 2013). Among the 227 hyperdominant species, one also finds domesticates such as cacao. So important is tree cultivation, or arboriculture, in

Figure 1

Kuikuro house (*üne*) under construction with structural elements composed almost entirely of Pindaíba trees and saplings (*Xylopia brasiliensis*, spp.), a hyperdominant species that was managed semi-intensively in pre-Columbian towns in the Upper Xingu. Sapé grass (*Imperata* sp.) used for house thatch is likewise a critical industrial crop, managed extensively in former cultivated manioc gardens. Photo provided by Joshua Toney, 2005.

Amazonia that out of the ~140 local Amazonian cultivars, 70% are tree or wood perennials (Clement et al. 2010, p. 73) (**Figure 1**).

The role of extinct Pleistocene megafauna in selecting for traits such as fruit size also needs to be considered. "Megafaunal fruits" are fleshy individuals with a size ranging from 4 to 10 cm in diameter with up to 5 large seeds or to fleshy fruits more than 10 cm in diameter and more than 100 small seeds (Guimarães et al. 2008). Among these fruits are the Calabash tree (*Crescentia cujete*), cacao (*Theobroma cacao*), biribá (*Rollinia mucosa*), and other Annonaceae such as soursop (*Annona muricata*) and pequi (*Caryocar brasiliense*). Megafauna action was not restricted only to fruit trees though. The wide distribution of squashes across the Americas, the presence of seeds of Cucurbitaceae in megafauna dung, and the fact that it was domesticated independently in more than one place across the continent strongly suggest that it was previously dispersed and selected by megafauna as well (Kistler et al. 2015). Many of these large fruits have no other animal dispersers than humans today, and indigenous peoples have likely taken up and further selected such traits already favored by the extinct megafauna (Neves 2016).

The Amazon is accepted by scholars today as one of the independent centers of plant domestication in the world (Clement et al. 2015, Roosevelt 2013, Watling et al. 2018), a place where important crops, some of them consumed worldwide, such as manioc, peanuts, chili peppers, sweet potato, pineapple, and peach palm, were initially cultivated. However, the Amazon Basin is almost the size of the continental United States, and one can even devise distinct local centers of domestication within the Basin (Clement et al. 2015). Southwestern Amazonia was both a major primary and a secondary center of plant domestication. Genetic data show that, as a primary center, Southwestern Amazonia initially cultivated the Peach Palm (*Bactris gasipaes*) and manioc (*Manihot esculenta*) as well as some varieties of peanuts (*Arachis hypogea*), chili peppers (*Capsicum baccatum)*, cocoyam (*Xanthosoma* spp.), and annatto (*Bixa orellana*) (Clement et al. 2016). Direct archaeological evidence shows the cultivation of rice (*Oryza glumaepatula*) around 2200 BCE (Hilbert et al. 2017), as well as of ariá or lerén (*Calathea allouia*), Brazil nuts (*Bertholletia excelsa*), and guava (*Psidium guajava*) by the early Holocene (Watling et al. 2018). Southwestern Amazonia's role as a secondary center is supported by genetic data showing that varieties of maize were developed there after being introduced from Mesoamerica and later spread through lowland South America 6,000 years ago (Clement et al. 2016, Kistler et al. 2018, Levis et al. 2017, Watling et al. 2018) (**Figure 2**).

Southwestern Amazonia is also a major center of cultural diversity as inferred by languages and language families. Language diversity in greater Amazonia is among the highest recorded in the modern world; ∼300 languages are grouped into 50 distinct genealogical units, which could be either relict language families or isolated languages (Epps & Salanova 2013). In Southwest Amazonia alone, one finds more than 50 languages, 11 of them isolated and the remainder grouped into 8 families (Crevels & Van der Voort 2008).

CULTIVATION, AGRICULTURE, DOMESTICATION, AND FAMILIARIZATION

The long-term history of plant management, cultivation, and domestication in the Amazon must be understood against this backdrop of great biocultural diversity. Elsewhere we argue that the use of concepts such as "Neolithic" or "Formative"—its New World relative—to describe Amazonia and the Neotropics does not explain the unique trajectories of human–plant interactions (Fausto & Neves 2018, Neves 2016), including widespread practices, documented archaeologically and ethnographically, to involve cultivation without agriculture or cultivation without domestication (Piperno 2011). Before moving forward, however, a few definitions are needed. Agriculture is understood as representing economies with near or total reliance on domesticated plants or animals (Winterhalder & Kennett 2006, p. 3). Cultivation is an inclusive category that encompasses the intentional propagation or tending of plants not recognizably altered from their wild relatives (Harlan 1975). Hence, the concept of cultivation is more useful than that of agriculture to explain the patterns discussed here (Acosta Ochoa 2017, Smith 2001).

Domestication is a more ambiguous concept that could be defined either narrowly as a process that leads to "morphological and genetic distinction from wild ancestor as a result of artificial selection, or no longer occurring outside cultivation" (Meyer et al. 2012, p. 31) or broadly as the "phenotypic changes in cultivars that make them different from unmanaged wild populations" (Fuller et al. 2014, p. 6147). The first definition based on both genetic and morphological criteria does not work well to explain Amazonian contexts. The second definition is more flexible but risks being too general, flattening immense biocultural variation, and overlooks the specific historical and cultural choices that marked the coevolutionary histories of plants and peoples over the

Figure 2

Wild flowering variety of wild manioc (*Manihot* spp.) growing on the edge of a dirt road, Teotonio village, Upper Madeira River, Brazilian Southwestern Amazon. These tuber varieties thrive in disturbed environments and have been cultivated in the area since at least the Middle Holocene. Photo provided by Eduardo Neves, 2019.

millennia. Ethnographic data for contemporary Amazonian Indians (Carneiro da Cunha 2017, Fausto & Neves 2018) show that cultivation in gardens and in orchards often entails engagements with human and nonhuman agents, with an emphasis on the production of cultivar diversity, similar to how kinship ties are constructed to incorporate outsiders into the social realm (Fausto & Neves 2018; cf. Hastorf 2006 for the Andes).

SCALE AND PERSPECTIVE

The general processes of plant and animal domestication developed independently in a few primary centers across the world beginning at the Terminal Pleistocene, and they are still unfolding (Smith 2016). That these processes occurred globally at the outset, with independent origin centers, demands some sort of general explanation and one that is probably related to the patterns of gradual climatic change and population growth at the transition of the Pleistocene to the Holocene. Despite such basic common background to explain plant and animal domestication as global processes, however, we must seek to understand the particular historical trajectories built through human, plant, and other animal engagement around the world, or we risk masking deeply different histories under general explanatory categories.

Figure 3

Fish weir (*ataca*) damming the Angahuku River near the Kuikuro village of Ipatse, which extended >300 meters. More than 20 conical traps (also *ataca*) were positioned in this communal structure in 2004, with smaller family-owned weirs also in use, creating an integrated system of managed pools and seasonal ponds. Photo provided by Morgan Schmidt, 2004.

Animal domestication, for instance, was never as important in the New World as it has been elsewhere. This process can be accounted for in part by the fact that Late Pleistocene megafauna extinctions in South America were more intense than those in other world areas (Baronsky & Lindsey 2010), which reduces the number of species that could be potentially domesticated, notably ungulates, but does not tell the whole story. Indigenous Amazonians eagerly keep pets but are not interested in controlling their reproduction and rarely eat them. Once brought to the villages, such animals often receive names and have reciprocal ties with their owners, being incorporated into social life and rendering their slaughter and consumption inconceivable (Descola 1994, Fausto 2012, Stahl 2014). Like plants, the few animals that were managed in large numbers, notably including aquatic fauna, such as turtles, manatee, and ducks, did not undergo obvious genetic or morphological changes (Prestes-Carneiro et al. 2016) (**Figure 3**). Likewise, understanding plant domestication and cultivation through the Holocene in the Amazon needs to incorporate such distinct ontologies as well (Carneiro da Cunha 2017, Fausto & Neves 2018).

Together with this ontological shift, foregrounding indigenous perspectives, it is also critical to consider scale. Amazonia, as defined here, includes not only the Amazon River Basin but also areas of contiguous tropical evergreen forests in the Orinoco Basin and the Guianas, which cover more than seven million square kilometers. It also lacks major geographical barriers—such as deserts or high mountain chains—within it. For instance, the city of Pucallpa, next to the Central Andes in Peru is located more than 4,000 km from the mouth of the Amazon and is less than 150 m high. The Amazon River alone is more than 6,000 km long, with a water discharge 10 times bigger than that of the Mississippi River, and roughly five-sixths of its extent is on the lowlands east of the Andean cordillera where its sources are. Such an extensive aquatic network includes countless lakes, islands, and secondary channels, providing thousands of linear kilometers for settlement along bluffs and floodplains as well (Denevan 1996, Neves 2013). Some of these places—such as, for instance, those located along rapids where fishing productivity is higher—have records of continuous occupation spanning centuries or millennia; these persistent places are full of symbolic and historical meaning (Almeida & Kater 2017).

Owing to logistical constraints, archaeological research in the Amazon has traditionally been done mostly on sites or areas located along the major rivers, and this bias has led to the assumption that riverine settings would have been preferentially settled in the past. Although true to some extent, such an assumption has been challenged in the last 20 years by work done either away from the large nutrient-rich rivers that drain from the Andes or along the headwaters of comparatively nutrient-poor rivers draining from geologically much older areas. Research in these places has documented the presence of large sites connected by roads composing low-density urban arrangements, or "garden cities," such as in the Upper Xingu Basin of southern Amazonia (Heckenberger et al. 2008); ditched sites placed hundreds of kilometers south of the main channel (de Souza et al. 2018) or on the hills north of the main channel near the estuary; and hundreds of earthen geometric structures and mounded sites connected by roads in a large area that includes Bolivia and Brazil (Heckenberger et al. 2008, Prümers & Jaimes Betancourt 2014). These are just a few examples showing that, together with the large floodplains, at least part of the Amazonian hinterlands were densely occupied in the past as well. Given that many large areas have never been thoroughly studied by archaeologists, the extent of these nonriverine occupations, a point of intense debate in the last ten years or so, remains to be understood (Bush et al. 2015, McMichael et al. 2012, Piperno et al. 2015, Roosevelt 2013, Stahl 2015).

In this context, demographic processes, such as population pressure, were likely weak in the Amazonian past, even considering that the region may have harbored ~8,000,000 indigenous peoples by 1492 (Clement et al. 2015). This concept of relative low population pressure sharply contrasts, for instance, the context of the narrow valleys that cross the desert running west from the Andes to the Pacific Ocean, where some of the early evidence for monumentality is found in the Americas and where resource concentration, labor mobilization, geographic circumscription, and population pressure may have acted dialectically as important historical forces (Carneiro 1970). In the Amazon, on the other hand, size, weak demographic pressures, biological diversity, and resource abundance created a vastly different scenario, in which there were few pressures for political centralization and a strong reliance on agriculture to emerge and reproduce itself over the long term (Neves 2014, Neves & Petersen 2006).

ECONOMIES OF ABUNDANCE

Another important premise about the Amazonian tropical forest is abundance. For many years, environmental determinism provided the major framework to explain the lack of evidence for the emergence of the state or other forms of hierarchical or politically centralized structures in the

Figure 4

Excavation plan of anthropogenic dark earth (*terra preta*) stratum associated with a hearth structure dated to ∼3500 years BCE, Teotonio site, Upper Madeira River, Brazilian Southwest Amazon. Photo provided by Eduardo Neves, 2018.

Amazonian past. According to this reasoning, environmental factors including poor soils or lack of available animal protein away from the floodplains would have prevented sedentism and population growth there. Interdisciplinary research done with archaeological soils in the Amazon has contributed to the falsification of these hypotheses. The fertile, organic-rich, and deep dark soils known as *terras pretas* in Portuguese, or anthropogenic dark soils (ADE) in English (Glaser & Birk 2012, Kern et al. 2017), are accepted today as the result of past human management mostly related to trash pits or organic garbage composting along settlements (Schmidt et al. 2014). *Terras pretas* keep high nutrient levels for years or centuries even under the action of the intensive lixiviation that is characteristic of tropical soils. Although the early evidence for their formation dates to about 4000 years BCE, such soils became much more widespread and visible across the Amazon from about 500 years BCE and, as the result of the establishment of sedentary settlements, across the whole region (Neves et al. 2003, 2014) (**Figure 4**).

Together with the data on tree hyperdominance, *terras pretas* provide strong evidence for niche construction and landscape domestication in ancient Amazonia (Arroyo-Kalin 2015, McMichael et al. 2015, Palace et al. 2017). Niche construction is understood here as the actions whereby organisms, including humans, transform the settings where they live instead of only reacting to external environmental forces (Laland et al. 2016; Smith 2016, p. 312). However, as much as they are an important piece of evidence demonstrating the permanent modification of nature, *terras* *pretas* were not, in most cases, formed intentionally, at least not initially, but rather as the result of widespread changes in settlement patterns mentioned above. In the Central Amazon, most of the studied ADE sites are residential and formed by stratified deposits with different ceramic complexes (Neves 2011). In these places, the deeper strata with dark soils are found in middens surrounding residential areas (Schmidt et al. 2014, Stampanoni 2016) or in contexts associated with trash pits (Neves 2011). Ethnoarchaeological work with the Kuikuro Indians of the Upper Xingu Basin in southern Amazonia confirms such a pattern, showing higher nutrient values, compatible with the development of *terras pretas*, on the areas of trash middens located at the back of the houses of these ring-shaped villages (Schmidt et al. 2014). Such inferences are further supported by the documentation of ADE sites along the already naturally fertile floodplain soils of the Amazon River in settings where further soil improvements are not needed.

Whether the new niches initiated by the formation of such soils opened for cultivation were used from about CE 500 to 1600, when European colonialism in the Amazon became more constant, remains to be better understood. By that time, such plots were likely already used as orchards or places for annual cultivation, as they are today (Maezumi et al. 2018). A survey done along farming communities in the Madeira River in the Central Amazon showed that areas with *terras pretas* host a much larger concentration of useful tree species than do the surrounding forested areas (Fraser et al. 2011). However, the archaeological evidence briefly presented here shows it would be wrong to conceive that such soils were deliberately created to overcome severe adaptive limitations (Kern et al. 2017). Doing so reinforces an anachronistic perspective that views the tropics as places that need to be developed, always lacking in something that needs to be brought from the outside. Such notions of development have guided external and internal colonialism from the nineteenth century onward and still inform public policies today, with tragic consequences for traditional societies settled there (Hecht 2013).

The same kind of scarcity-based argument was also advanced to explain the supposed impossibility of nonagricultural societies' occupation in areas of tropical rainforest in Equatorial Africa and Asia as well (Headland & Bailey 1991). However, as has been discussed above, evidence demonstrates that the Amazon was densely settled in the past, as it can be inferred by the presence of large sites, some of them with urban scale, associated with earthen structures such as mounds, ditches, roads, wells, causeways, and other kinds of earthworks (Stenborg 2016). Such structures became more common and widespread after ~500 BCE, but some of them, in western Amazonia, close to the Andes, date to ~2200 BCE. Moreover, it is also clear that some of the earliest ceramics of the New World were also produced in the Amazon, with dates referring back to ~5000 years BCE (Roosevelt 1995, Roosevelt et al. 1991, Pugliese et al. 2018), and that it was an independent center of plant domestication (Clement et al. 2010, 2015; Levis et al. 2017; Watling et al. 2018).

Based on these data, it is no longer possible to sustain the idea that environmental factors prevented the establishment of large and sedentary settlements in ancient Amazonia or, conversely, that the humid tropical lands were backward peripheries in the deep cultural history of the Americas. However, it remains to be explained why, with the lack of evidence for environmental limiting factors, the state or other forms of permanent hierarchical structures emerged elsewhere in the Americas but not in the Amazon. Part of the answer may be that there is some deep antagonism between abundance and the state (Neves 2014). French anthropologist Pierre Clastres understood that the negotiations of power among nonstate societies of the tropical lowlands were worthy of a political science approach, and he conceived the idea of understanding politics without the state (Clastres 1989). Although trained in the francophone intellectual tradition, he established a dialogue with the anglophone cultural evolutionist literature of the mid-twentieth century, which established a four-tiered division of ancient South American societies that followed geographical but also evolutionist division criteria. Such a perspective, proposed almost 70 years ago, still provides, albeit sometimes silently, the working paradigm for South American archaeology. One of its problems, for instance, is that it labels under general denominations—such as "chiefdoms," "intermediate," or "formative"—a vast array of social formations that defy the rigid classification into single evolutionist categories. Indeed, it looks like the state—exemplified in South America by the Inka Empire—was much more the exception and that the rule was made of those loose, undefinable, cycling, and transient political arrangements.

For Clastres, contrary to being the outcome of an inexorable historical process, the state should have been understood as a sort of anomaly against which politics of lowland societies would be constantly mobilized. In this perspective, factionalism is a positive force, and collapse, a productive process. Such change in focus may help to understand the long-term history of places such as the Llanos de Mojos (Prümers & Jaimes Betancourt 2014), Marajó Island (Schaan 2012), and the Upper Xingu (Heckenberger 2005), where, prior to the onset of European colonialism, one sees smaller settlements replace monumental mound buildings and large urban-like structures. Instead of explaining these as the results of environmental collapse, researchers should investigate the extent to which deliberate movements against political centralization may have operated in the long term. Such an argument makes sense if backed by data on contemporary and ancient plant management in the Amazon.

Research on traditional Amazonian gardens and orchards shows that cultivators, normally women, take a particular pleasure in stimulating the creation of diversity either through the control of plant reproduction or by tending to and experimenting with those varieties that sprout from the ground after clearing (Carneiro da Cunha 2017). Fresh archaeological data has verified that such a combination of controlled and uncontrolled production of diversity goes back at least to the middle Holocene, if not earlier (Watling et al. 2018).

THE PRODUCTION OF HYPERDIVERSITY

A third premise about Amazonian forests and management is the production of hyperdiversity. Since the 1990s, historical ecology has had a fundamental influence on reshaping Amazonian archaeology (Erickson 2008, Heckenberger & Neves 2009). This theoretical shift came about initially on the basis of ethnographic observations on plant management (Balée 1989, 1994), demonstrating practices that created new niches and landscapes. For example, the use of fire over generations by the Ka'apor Indians created secondary forests of nutrient-rich *babaçu* (*Attalea speciosa*) palms, which were in turn exploited by the highly mobile Awá who lived in the same area (Balée 1994). Other examples include how Kayapó management leads to the planting of seedlings of useful species along tracks in the forest and how "resource islands" are created with transplanted or planted useful species (Anderson & Posey 1989). Such ideas provided a powerful argument against environmental determinism and hence were eagerly taken by archaeologists as guiding principles for research.

Until recently, though, virtually no direct archaeobotanical evidence had been extracted from archaeological contexts in the Amazon, which made it difficult to understand the historical depth of these management practices. The few exceptions were Roosevelt's pioneering study of macrobotanical remains from the terminal Pleistocene at Pedra Pintada rock shelter at the lower Amazon (Roosevelt et al. 1996), which documented generalist consumption practices including fruits still eaten today, or Morcote-Rios's similar evidence from Western Amazonia (Morcote-Rios & Bernal 2001).

The lack of direct archaeobotanical evidence led to the assumption that manioc cultivation, which today provides the bulk of starches and carbohydrates for different traditional Amazonian societies, was also prevalent in the past (Arroyo-Kalin 2010, Fausto & Neves 2018, Van den Bel 2015). Recent research shows that although manioc cultivation was indeed important and prevalent in some contexts (Dickau et al. 2012, Heckenberger 1998, Iriarte et al. 2012), in many others, it is surprisingly absent. It is becoming clearer that past and contemporary traditional Amazonian diets are composed of an array of nondomesticated but managed plants, including many tree and root crops, which are kept at different intensities of cultivation (Carneiro da Cunha 2017, Fausto & Neves 2018, Mendes dos Santos 2016). It is likely that European and internal colonialism has greatly reduced the number of plants cultivated in ancient Amazonia (Clement 1999), stimulating an increase in manioc cultivation (Fausto & Neves 2018, Van den Bel 2015). Indeed, so large was the repertoire of past cultivated plants extracted from archaeological contexts that one of the mounting tasks of archaeobotanical research in the Amazon today is the establishment of reference collections for starch grains, phytoliths, and charcoal because most of the recovered specimens are yet to be identified (Shock et al. 2014, Watling et al. 2018).

Different productive strategies based on the cultivation of domesticated and nondomesticated plants under distinct combinations are being identified as new archaeobotanical and isotopic data are produced across the Amazon (Carson et al. 2015; Dickau et al. 2012; Hermenegildo et al. 2017; Maezumi et al. 2018; Watling et al. 2017, 2018). Such strategies have been termed "agroforestry polyculture" (Maezumi et al. 2018) or simply "agroforestry" (Neves 2011), and they comprised the cultivation of plants that have life scales with different temporalities. Over the long term, the cultivation of perennial tree crops, or arboriculture, for either food or raw materials, creates stands that last for decades or even centuries, such as cacao and its other Theobroma genus relatives, distinct palm species (McMichael et al. 2015, Watling et al. 2017), pequi (*Caryocar brasiliense*) (Smith & Fausto 2016), and the peach palm (Rival 2002), or even for several centuries, such as the nutrient-rich Brazil nut (*Bertholletia excelsa*) (Shepard & Ramirez 2011). In most cases, arboriculture is an example of nondomesticated cultivation (Piperno 2011), a widespread and ancient practice employed for cash crops even today, such as with açaí. *Theobroma cacao*, for instance, was cultivated 5,300 years ago at the Santa Ana-La Florida site in the northwest Amazon (Zarrillo et al. 2018).

At a much shorter time frame, but still beyond annual cycles, root crops of the genera Manihot, Calattea, Xanthosoma, and Ipomea, to name but a few, have vegetative reproduction and can also be cultivated continuously for several years in gardens or tended along paths in the forest (Clement et al. 2010, Mendes dos Santos 2016). That they can be stored in the ground without a fixed harvesting cycle provides a buffer against annual variations and, as argued below, has prevented the emergence of rigid forms of labor control and hence the establishment of deep social inequalities. Similar patterns of cultivation involving the combination of arboriculture and root crops are also common in other tropical forest areas, such as Melanesia (Kennedy 2012), where they have been referred to as "vegeculture" or "forms of plant exploitation that display an awareness of, and a dependence upon, the vegetative reproductive capacity of plants" (Barton & Denham 2018, p. 20). Likewise, in Africa, although data are still scant, evidence indicates that the cultivation of yams, for instance, did not include their domestication (Fuller & Hildebrand 2013, p. 521). Even in Mesoamerica, one of the very cradles of plant domestication in the Americas, Killion (2013) proposed that a mixed, nonagricultural model of plant cultivation was associated with the Early Olmec societies. Hence, some of the patterns described here for the Amazon were likely more widespread, prevailing elsewhere in the world.

However, different from in the Pacific, where vegeculture includes predominantly the cultivation of root crops such as taro and yams and tree crops such as bananas and palms (Barton & Denham 2018), there is growing evidence of the cultivation of short-cycle plants, such as cereals [maize and rice (Hilbert et al. 2017)], legumes [peanuts (Clement et al. 2016)], and cultivars (e.g., tobacco, chili peppers, among many others) in Amazonian ancient agroforestry systems. The presence of maize and rice (Hilbert et al. 2017, Pagán Jimenez et al. 2015, Watling et al. 2018) is noteworthy. Elsewhere in the world, the cultivation of such cereals is loosely associated with population growth and the emergence of political centralization. In Southwestern Amazonia, however, where starch grains of maize and rice phytoliths are found at contexts dating respectively to 4000 BCE and 2200 BCE (Hilbert et al. 2017, Watling et al. 2018), there is no evidence of population growth after their introduction, as in the case of maize, or resulting from their domestication, as in the case of rice. This finding is interesting because the genetics of maize show that Southwestern Amazonia was a major secondary center of domestication, after maize was introduced there from Mesoamerica, where it was initially domesticated (Kistler et al. 2018, Piperno 2011). Likewise, at Hatahra, an ADE mounded site in the Central Amazon, the presence of maize macro and micro remains is not matched by isotopic data indicating high reliance on maize consumption at the end of the first millennium CE (Bozarth et al. 2009, Caromano et al. 2013). Evidence of rice domestication is also intriguing because there are few, if any, historical or ethnographic records of its cultivation in the last few centuries, showing that its cultivation may have been abandoned after it was domesticated (Hilbert et al. 2017).

The relative unimportance of maize or the case of abandonment of rice cultivation seems to fit into a pattern of "agricultural regressions" ethnographically described by populations who abandoned farming for hunting and gathering (Balée 1994, Fausto 2012). Likewise, data from different groups show that, up to the recent past, groups who would be classified as hunters and gatherers kept productive economies that were also based on the cultivation of domesticates and nondomesticated plants as well (Mendes dos Santos 2016). Among those nondomesticates, there is the remarkable *batata mairá* (*Casimirella rupestris*), a tuber that reaches 200 kg, can be processed into flour and bread, and was consumed until recently among different groups of the middle Purus basin of the South-Central Amazon (Mendes dos Santos 2016). On the other hand, archaeobotanical and isotopic data from the mound-building societies that thrived for several centuries at Marajó island, at the mouth of the Amazon, show no reliance on domesticated plants and generalist diets with no evidence of maize (Hermenegildo et al. 2017, Roosevelt 1991).

The above data, albeit preliminary, indicate that ancient and contemporary Amazonian production strategies are fluid and flowed over time and space from stronger to weaker emphases on the cultivation of domesticated plants. Hence, it would be inaccurate to refer to the abandonment of cultivation from hunting and gathering as a reversion; rather, we view these processes as alternations that were common in the past (Fausto 2012, Neves 2008). Likewise, it may be time to reconsider the notion of "gathering" as a passive category and to understand it as an active component of the processes of landscape management and domestication (Acosta Ochoa 2017; Mendes dos Santos 2016, p. 34; Politis 2007).

One way to account for these alternating cycles is that resource abundance was strong enough to place weak pressure on agriculture to emerge. Indigenous practices of the production of diversity would further increase such natural conditions, building niches that increased the productive potential of different settings (Arroyo-Kalin 2015). The conceptual framework provided by historical ecology and niche construction theory should be further explored to avoid more unidirectional perspectives that place managed and cultivated plants along a ladder that climbs from wild to fully domesticated and passes through categories such as "incipient" and "semidomesticated" (Smith 2016).

LANDSCAPES OF PRODUCTION

Finally, it is important to address the question of labor in past production systems, considered against the backdrop of biocultural diversity and abundance. While many Amazonian cultivation systems followed a different trajectory than did many other world areas, lacking the type of focused management of a few staple crops commonly referred to as a Neolithic revolution, some plant management systems did develop into intensive food production systems that focused on a few crops. In the Upper Xingu, for instance, standardization in ceramic systems recognized late in pre-Columbian times relates to a semi-intensive system of crop production, notably manioc agriculture but also concentrating on fruit trees, notably pequi (*Caryocar brasiliense*) (Heckenberger 1998). This transition coincides with the reorganization of the system, including the fixed permanence of settlements in the galactic regional system over centuries. However, this reorganization was practiced within a domestic mode of production rather than within the creation of permanent surplus: manioc stored in the ground and surplus aimed primarily at ritual activities.

In terms of labor, another feature of tropical forest resource management is worth emphasizing: Amazonian material systems lack stone, brick, or wooden plank constructions, and within this world of organic architectural materials, industrial plants and, notably, trees were critical features of production landscapes. In fact, in terms of landscape modification, these industrial tree crops were more critical in forest management systems than were subsistence crops, notably the process of conversion of forest to forest, rather than forest to open agricultural areas, as typical in models of a Neolithic Revolution. Even in areas of semi-intensive food production, diverse plants and animals were managed within long-term cycles of secondary forest management, which differ dramatically from nonmanaged forest areas.

In this regard, it is important to emphasize the distinction between species domestication and landscape or niche construction in Amazonia (Balée & Erickson 2006; Clement 1999; Clement et al. 2010, 2015; Denevan 2001). Data from archaeology and historical ecology should inform and widen biodiversity conservation studies and efforts, from a focus on environmental hotspots—defined by endemic species richness—to regional-level socioenvironmental systems, aligning questions of cultural heritage that include agents such as indigenous people (the living descendants of pre-Columbian Amazonian peoples), local traditional farmers (*caboclos* or *ribeirinhos*), and the descendants of former African slaves (*quilombolas*). Such traditional practices and systems of knowledge that unfolded over millennia hold answers to the dramatic problems of food security threatened by deforestation and climate change, raising a concern that the Amazonian tropical forests are at a tipping point (Lovejoy & Nobre 2018).

CONCLUSIONS

Amazonian ethnology tells us that Amazonian cultivators are concerned with the production of diversity (Carneiro da Cunha 2017, Emperaire 2005), mirroring other dimensions of their social lives, where the production of differences through kinship, age, gender, and language is of fundamental concern. This process of producing diversity was both controlled and uncontrolled, and recent archaeological data show that it may go back to the beginning of human occupation in the Amazon. These mixed and diversified cultivation systems, which were based on domesticated and nondomesticated tree arboriculture and root crops, as well as on domesticated cereals and legumes, were probably inimical to agricultural expansion, mostly because tree crops are long-lived perennials (Harris 2003, pp. 31–32), as well as to the emergence of permanent political centralization. In the long run, the outcome of these activities over millennia was the emergence of the large language and cultural diversity seen in the Amazon, which, unfortunately, is threatened and disappearing quickly.

This proviso is important in places such as the tropics, where public policies of economic development are embedded in notions about progress or development that became naturalized but that ultimately stem from nineteenth-century evolutionist thinking. Contemporary research in those places needs to contradict such notions and show that they have political content. Such policies are rapidly spreading across the tropical world, expelling people from their homelands and sometimes violently transforming into pastures or monoculture forests and fields that result from centuries of polyculture cultivation by traditional societies. Understanding and respecting sophisticated practices of indigenous resource management, including the diverse production systems of pre-Columbian Amazonians, provide important clues to strategies that contribute to efforts to preserve the tropical forests and its peoples in the face of development and climate change. Such understanding may also force one to rethink the meaning of deeply ingrained concepts such as "natural" or "pristine," since taking a critical approach is the most effective intellectual tradition that anthropology can offer to the public debate.

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