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Contingent Diversity on Anthropic Landscapes

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Abstract: Behaviorally modern human beings have lived in Amazonia for thousands of years. Significant dynamics in species turnovers due to human-mediated disturbance were associated with the ultimate emergence and expansion of agrarian technologies in prehistory. Such disturbances initiated primary and secondary landscape transformations in various locales of the Amazon region. Diversity in these locales can be understood by accepting the initial premise of contingency, expressed as unprecedented human agency and human history. These effects can be accessed through the archaeological record and in the study of living languages. In addition, landscape transformation can be demonstrated in the study of traditional knowledge (TK). One way of elucidating TK distinctions between anthropic and nonanthropic landscapes concerns elicitation of differential labeling of these landscapes and more significantly, elicitation of the specific contents, such as trees, occurring in these landscapes. Freelisting is a method which can be used to distinguish the differential species compositions of landscapes resulting from human-mediated disturbance *vs.* those which do not evince records of human agency and history. The TK of the Ka'apor Indians of Amazonian Brazil as revealed in freelisting exercises shows differentiation of anthropogenic from high forests as well as a recognition of diversity in the anthropogenic forests. This suggests that the agents of human-mediated disturbance and landscape transformation in traditional Amazonia encode diversity and contingency into their TK, which encoding reflects past cultural influence on landscape and society over time.

1. Introduction

This article concerns how systems of traditional knowledge (TK) encode and classify the accumulated impacts of the human species on the formation and transformation of Amazonian landscapes over time. The most significant of these impacts resulted from agrarian technologies. Humans have lived in the Amazon region for thousands of years. Although debate proceeds apace as to the peopling of South America, with the focus on exactitude of dating, especially fossil *vs.* molecular evidence and radiocarbon confidence intervals for a host of selected ancient sites, few archaeologists today dispute the findings of the last quarter-century that there were pre-Clovis traditions in South America some time before 11,400 B.P., if not probably for at least a thousand years before that [1-3]. Regardless of the antiquity of the original peopling of South America, none of the credible proponents for pre-Clovis cultures in South America, and hence, Amazonia, have questioned the premise that the first sapient inhabitants of the region were not only anatomically, but also behaviorally modern, human beings. Behavioral modernity brings with it not only certain technologies and cultural repertoires, such as probably both art and religion, but also vast social and political potential, such as the structuring of economies based on reciprocity and essentially corporate means for maintaining egalitarianism in spite of tendencies of our species to social hierarchies [4]. These social abilities have been transposed to the landscape, in archaeological sites and assemblages, their conventional identifying features. On another point of agreement among archaeologists with otherwise diverse viewpoints, the first inhabitants of Amazonia would have arrived without domestication, either of plants or, with the dubious exception of the dog, of animals [5]. In addition, it is now clear that agrarian technology arose independently in Amazonia, especially in peripheral corridors [6]. The long-term human presence in Amazonia has had impacts on floristic and faunal diversity in locales and regions, and these impacts are reflected in TK. Amazonian TK is reflected in lexical richness of vocabulary referencing biota intrinsic to anthropic landscapes.

1.1. The Human Impact on Amazonian Diversity

Hunter-gatherers have arguably altered Amazonian landscapes, though clearly not as profoundly as trekking societies [7-9] and sedentary horticultural societies [10-13], with the exception of the sambaqui and shell-mound builders of the Brazilian Atlantic Coast, lower Amazon, and Guianas, all of whom had disappeared long before the arrival of the Europeans [14-16], and the moundbuilders of Marajó Island, the earthworks of which are surrounded by inundated lowlands, on which significant populations both of people (needed for moundbuilding) and extensive areas of domesticated food plants with an intolerance for flooding, would not have been likely to coexist [17].

My focus on understanding diversity is at the level of species, and especially the extent to which species have been subjected to anthropic influences on the spatially limited but conceptually useful scales of alpha and beta diversity. The concern is not with the process of domestication around the Amazon Basin (e.g., [6]), but rather with reallocation of species distributions and turnovers in species numbers in situ and across related sites. Any emphasis on diversity, of course, could be on genetic diversity, implicating *de rigueur* employment of new technologies such as DNA barcoding or other

molecular tools and phylogeographic methodologies [6], but that level of metamorphosis of biological material is less likely to have been observable to people involved in effecting species turnovers and domestication events in the first place. Changes on that level would not have been encoded initially in TK, because they were not directly observable, and these modifications would be perhaps ultimately immaterial when trying to discern human effects on limited yet observable spatial scales, such as those of alpha and beta.

The biomass in any one given area, as altered by human activity, clearly represents a different measure from the diversity in the species variability therein, or of the molecular differentiation within it. The global proportion of the biomass of domesticated animals and humans, for example, is probably today on the order of two-fifths [18], which implies a massive reallocation of species concentrations on earth since the various Formatives from diverse continents and regions, including Amazonia [19], had taken place. Many "Holocene" environments are essentially artificial to the extent these were, in fact, transformed by cultural activity [20,21]. The ultimate emergence and expansion of agrarian technologies, domesticated organisms, and associated invasive species across the globe alone, however, do not elucidate species diversity in situ, or even across locales linked by environmental or temporal gradients [22], which remain subordinated to the purview of still comparatively rudimentary methods of macrobiological and systematic inventories. Yet the complex local and regional phenomena documented by these inventories have been the realities acted upon and accessible to human consciousness and classification, in both folk and indigenous contexts, since the origins of agrarian technologies. Hence, standardized measurements of these possess validity when attempting to understand diversity that is associated with human-mediated disturbance. What people in indigenous contexts perceived during Amazonian prehistory, in their mundane activities on the landscape, were phenotypes and locales, and it is their variegated effects on and perceptions of these that constitute the central focus of this article.

1.2. Primary vs. Secondary Landscape Transformation

Prehistoric societies of Amazonia engaged in human-mediated disturbance of natural biota (whether wholly, partially, or not-at-all domesticated) occurring on a multitude of landforms. That human-mediated disturbance before historical documentation became available is of considerable importance in decoding the underlying patterns of diversity on many landscapes today. Two principal types of human-mediated disturbance and the resulting change in species composition effected by humans in Amazonian indigenous contexts can be identified: primary and secondary landscape transformation [23]. Transformation in this sense is directly derived from the notion of human-mediated disturbance engendering a "fundamental change in appearance or nature" on given landscapes, with the principal methods originating in agrarian, industrial, and advanced industrial technologies ([24], p. 5). The changes I am examining in the context of Amazonia are, for the most part, simply agrarian [19]. In some cases, indigenous societies using TK created well-drained forests above seasonally inundated savanna in the form of mounds, raised fields, and causeways in eastern Bolivia [11,25]. Without following any "uniform formula" ([26], p. 153), certain forest islands in *cerrado* environments of central Brazil are also the result of anthropogenesis [27]. In both cases, the forest vegetation is more diverse (at least in species of trees if not other organisms, especially soil

organisms, because the soils of these sites are altered and qualify as Amazonian Dark Earths (e.g., [11,28]) than the original, presumably primeval, landscapes that surrounded them. These cases illustrate what I mean by *contingent diversity*. Specifically, diversity in these locales is, or was, contingent on human-mediated disturbance, which is another way of saying human history and agency.

This contingent diversity of forest islands, both of seasonally inundated savannas and cerrados, is the result of *primary landscape transformation*, which denotes a complete turnover of species due to human intervention and metamorphosis of earlier environments. That turnover in species, which can involve more or less invasive species, is often documented as resulting in a net loss of diversity, often on a large scale because of the dissemination of invasive species and their superior competitive attributes (e.g., [29]), but what we have learned from historical ecology is that primary landscape transformation can sometimes result in net increases in diversity [23]. In either case, regardless of the upward or downward trend in species abundance values, the anthropogenesis of Amazonian landscapes is increasingly documented not only in the living vegetation, but archaeologically in the form of extensive patterns of earthworks [15,16,19,30-35]. In contrast, *secondary landscape transformation*, as mediated by human disturbance, results in a partial turnover in species. This does not involve significant alterations of the substrate, as in deliberate construction of earthworks seen in mounds, forest islands, causeways, raised fields, ridged fields, artificial levees, and like phenomena, but rather extensive but intermediate disturbance of the environment usually for the purpose of short-term food production or medium-term human habitation, as with swidden fields and medium-term settlements of semisedentary horticultural societies. Forests that arise in the association and aftermath of these contexts are distinct in terms of the number of species they share with adjacent nondisturbed forests on the same kinds of substrates yet quantitatively comparable in species diversity to those forests [36].

In extreme eastern Amazonia, habitat of the Ka'apor Indians, Jaccard coefficients of alpha similarity between fallow pairs of forest ranged between 13.5% and 20.2% with an average of 17.2% and coefficients of alpha similarity between high forest pairs ranged between 19.9% and 25.1% with an average of 22.8%. In contrast, when mixed pairs of anthropogenic fallow forest and high forest were compared, the coefficients of alpha similarity ranged between 8.7% and 13.0% with an average of only 10.9%, meaning that the forests produced by secondary landscape transformation are different from the native forests ([36], p. 134), though both exhibit similarity in terms of absolute diversity. Because there is still significant sharing of species between anthropogenic fallow forests (that is, cultural forests) and nondisturbed high forests (that is, forests on well-drained soils without evidence of human-mediated disturbance), this being an average of 10.9%, anthropogenesis in the turnover is partial, not total, and hence, the overall sequence is one not of primary, but of secondary landscape transformation. If the thesis that indigenous societies along the Amazon River and its tributaries first practiced intensive or semi-intensive agriculture [37-39], as suggested by the presence of *terra mulata* (dark earths without significant deposits of potsherds and other household refuse, which are evidence of human occupation in situ per se and always found with *terra preta*) withstands continued scrutiny, the referenced sites with attendant biotic diversity would have been the product of primary, not secondary landscape transformation. The diversity of Amazonia, which on alpha and beta scales is to some extent anthropogenic, though certainly less so if seen from a gamma perspective (e.g., [40,41]), has been recognized in TK, that is, in local cultural contexts.

2. Psychological Reality of Contingent Diversity

A reasonable question concerns intention of human agents in effecting values that represent contingent diversity, and while this is always difficult to ascertain from the archaeological record, the diversity produced by human activities through primary and secondary landscape transformation may be recognized, more or less in fact, at least phenotypically, by the human agents and their predecessors who were involved in such dynamics. The question cannot be answered fully because of the retrospective character of the archaeological record, its actors having long since exited the stage of landscape anthropogenesis and, as is widely known, having bequeathed precious few symbolic artifacts, perhaps the most key of which being written documents. On the other hand, the living languages of today display landscape histories, both in their vocabularies and grammars. This is seen in ideophones that reference onomatopoeic aspects of animals as in their various vocalizations [42] yet also of plants, such as the crackling sounds of trees bending in strong winds [43-45]. Linguistics as an index of Amazonian historical ecology and hence landscape transformation in that region is noted also in marking reversals, which reference changes in the cultural and psychological familiarity and uses of organisms over time, precisely because of human-mediated disturbances [46,47].

This recognition suggests that alpha and beta increases in diversity due to human agency probably did not go unnoticed in prehistory, because these are extant in vocabularies full of reflexes, that is, symbolic relics, in the linguistic and ethnobiological record. Such relics of landscape history are clearly most obvious inside the lexicon. Several languages explicitly distinguish between anthropogenic forests and primary forests. Such distinctions suggest recognition in TK of human-mediated disturbance and its impact on diversity. Specifically, the Ka'apor language, which is a member of the TupíGuaraní family of languages, denotes old fallow forest as **taper**, which is distinguished from high forest, called **ka'a-te**, on the basis of several biotic and abiotic criteria [36], to be discussed in relation to trees, below.

2.1. Recognition of Diversity in TK

My concern here is with recognition in traditional Amazonian knowledge systems of potential nuomenal diversity, which, of course, is nothing less than staggering when considering Amazonia as a whole. This would be so even if only in light of the biota of its soils [28], or perhaps especially so in terms of that kind of diversity, let alone its better known, elevated world proportions of marine and above-ground terrestrial organisms. In terms of global diversity, for instance, the Amazonian proportions of all species represent about one-third each for plants and fish, 30% for birds, and 20% for mammals [48]. Indigenous societies tend to recognize local segments of this total diversity, and in many cases the species in certain clades, both of flora and fauna, are overdifferentiated in traditional classification systems [27,36,49-52].

One might ascribe such recognition to universal patterns of distinction between environments subjected to human-mediated disturbance and those not. Academic discourse on diversity begins with Plato, who prized diversity of organisms for its own sake, which he considered to be among the "brute facts" of the world ([53], p. 46). Fundamentally, to Plato, in what appears to be his last and in many ways most nuanced dialogue, the *Timaeus* [54,55], "it takes all kinds to make a world" ([53], p. 51)

and "the world is the better, the more [living things] it contains" ([53], p. 52; [56], p. 5). The notion has been aptly termed the principle of plenitude [53]. Although it has been often argued that Plato was an essentialist who considered nature and its species diversity to be unchanging, a good in and of itself (e.g., [57]), in fact, to Plato, the diversity of plants was the result of human gardening, not abstract nature in its effervescent variety; Plato indeed lamented what he considered the degradation of Attica, Greece, not because of human intervention on its landscapes, but precisely because human gardening there had ceased ([58], p. 218). A strong circumstantial case has been made by Charles Clement for a decrease in genetic diversity of Amazonian cultivars, if not of species, because of a cessation in the human management of these, due to human population collapse in the aftermath of European diseases and epidemics after 1500 [59,60]. It is clearly true that there are no precedents for the expansion of domesticates and invasive species across the landscapes of the world thanks to human-mediated disturbance, and regardless of global warming and other possible proximate causes of decreases in species diversity, this mega-disturbance of anthropogenic origins alone is likely to have future effects on diversity in the globe at large as well as in tropical forests such as those of Amazonia [18,61].

The focus here is not, therefore, on the potential similarity of all living things in the scope of TK, reduced to the modern *élan vital* of shape-shifting and perspectivism [49]. (My use of the term *élan vital* differs, incidentally, from that of philosopher Henri Bergson, a critic of spatialization, semiotics, and perspectivist viewpoints [62]). Indigenous societies of the past had altered (*i.e.*, transformed) environments without necessarily regarding the spiritual and intellectual contents found in them. Perspectivism, with its notions of shape-shifting and living human energy looming beneath outward appearances, no doubt, exists broadly in indigenous Amazonian thought [63-65]. The concept advanced here, however, is not connected to the realization of forms in a Platonist sense, like the shadows on the wall of the cave in *The Republic*, and how these forms might transcend outward appearances, or rather, how they might exhibit something other than their shadows or "envelopes" [66].

Instead, the focus here specifically concerns the recognition of diversity among those envelopes of living things [63-66], that is, their material and physical manifestations as these are perceived, named, classified, and sometimes nurtured by indigenous and folk societies, even if they do not tell the whole emic story of the forms that underlie and, in the final analysis, project them. I am also not specifically concerned, in trying to understand recognition of biotic diversity, with the fact that indigenous groups of Amazonia sometimes, if not often, exhibit more complex labeling systems of local substantive landscapes than one finds in currently dominant models of biogeography [67-69]. The object is understanding species diversity, not landscape diversity, and this includes species diversity on contingent landscapes.

With these considerations in mind, and knowing that such phenomena are not localized to one locale, region, or linguistic or cultural grouping in Greater Amazonia, but rather found widely across it, the focus on recognition of diversity becomes an instantiation of more general principles of ethnobiology. Perhaps first among these concerns the reality of living things within the framework of spatialization in TK, which tends to be limited to the immediacy of known and historic landscapes that have molded the cultures in question which exhibit such classification [49,50], and these have, in turn, been changed in historic time by cultural behaviors emanating from those very places. To continue with classical analogues, then, my object of inquiry is on the emic perception of *physis* ("what exists

and grows itself") rather than on the presumed *nomos* (what human societies create, infer, and envision to underlie things) ([70], p. 5).

People do tend to reduce diversity of envelopes to underlying intelligible tropes, such as tricksters illustrative of morality—or lack thereof, divinities that control game and fish supplies, and spirits that engage in all sorts of hybrid behaviors for which there is no other explanation except their otherworldliness. Those spiritual dimensions of traditional Amazonian knowledge systems, however limited in number, are always cloaked in the skins, or envelopes, of more or less familiar animals and plants. It is that familiarity with the envelopes which speaks directly to recognition of contingent diversity, as understood from the perspective of systematics, and such correspondences between the otherwise disjunctive systems of science and TK can be thereby delineated.

2.2. Reality of the Envelopes in Forests of Contingent Diversity

It was earlier determined from freelisting exercises that the Ka'apor recognize a large number of tree species spontaneously, and that the concept of tree is essentially wedded to notions of size (dominance) and hardness (density), not frequency per se [71]. Freelisting has been used in studying people's knowledge of plants before [72,73]. In studying Ka'apor knowledge of "trees" in 2008 each subject was interviewed separately and each was asked in his/her language to "tell me all the tree names you know" ("*Eme'u ihẽ pe upa myra rer nde rekwaha nde pe*"). Respondents were not stimulated with clues or with requests to give more names, and respondents were reasonably isolated from others in order to guarantee independence of response and avoid contamination of data [73]. The interviews lasted about 25 minutes each. The data were "cleaned" up in terms of elimination of repetition, synonymy, and effects of free variation, dialect, and idiolect. There is redundancy in most freelists of domains with many items, because terms included as members of superordinate taxa are often listed together with the terms for those superordinate taxa on the same individual lists. This is widely considered to be one of the limitations of the method [74,75]. The method's utility, on the other hand, is in showing the intricacy, or not, of readily accessible vocabulary within a given semantic domain. Trees are diverse in their lexical attributes in everyday Ka'apor speech, as evidenced in freelisting studies.

In many systems of TK, it is well known that names of plants and animals will occupy a substantial portion of the lexicon [50]. In fact, the Ka'apor distinguish 768 species of plants [36] specifically. That knowledge would not be readily available, however, in the spontaneous exercise of freelisting, using a finite sample of Ka'apor subjects who had been given a limited time frame in which to answer a seemingly simple question. Another advantage of freelisting, apart from initially showing the intricacy of shared knowledge of a semantic domain, is it is also capable of revealing the psychological salience of items within an ethnobiological classification [72].

The procedure of freelisting assumes that the most psychologically salient items will be listed first. For that reason, one understands how in classes of undergraduates in the US asked to freelist "animal" terms they know, dog and cat are consistently found at the top of lists that otherwise normally contain hundreds of items [75]. This finding also suggests reliability of the method, incidentally. Zipf's law [76] is relevant to the underlying assumption: the frequency of usage of a word in a natural language tends to be inversely proportional to its length, insofar as the initial terms tend to be folk

generic (simple, non-compound constructions) like dog or cat, rather than folk specific constructions, like sheep dog or Maine coon cat—in other words, commonly used words, presumably of high psychological salience (that is, those readily accessible in common speech), tend to be shorter than infrequently used words. Zipf's law helps explain redundancy on freelists, since folk specific members of a taxon will appear typically later, or further down, on the lists.

Smith's s is a means of controlling for the premise that the most psychologically important items in a domain will tend to be listed first and that if mere frequency of an item is considered as a measure of importance, the results will be blurred with numerous ties of rank order [77]. This statistic weights the order given to an item on a list as well as length of the list as an index of psychological salience for an individual on a specific item. Individual psychological salience of an item, then, is expressed as:

$$S_j = 1 - (r_j / l_i)$$

where S_j is the psychological salience of item j, r_j is the rank of item j on the individual's list, and l_i is the length of the individual's list. In determining the psychological salience of an item across a group of respondents, the s values of the item are simply averaged. In determining the content of a domain shared among a group of respondents, it is a common procedure to eliminate all items with a frequency of only 1, since presumably such items are not shared [75]. If the sample were substantial enough, such items either would not pertain to the domain or would have negligible psychological salience as members of the domain. The 24 Ka'apor informants in the earlier study listed 290 names of "tree" (**myra**), of which 149 had a frequency greater than 1. The psychologically most important "tree" by Smith's s in that study was **tajy** (*Tabebuia impetiginosa*) and it was also the most frequently cited (occurring on 22 of n = 24 lists). Arguably from these data, **tajy** is a prototypical tree [71,78] in Ka'apor culture and Ka'apor ethnobiological classification.

In separate studies of freelists of Ka'apor and Sirionó (a Tupí-Guaraní language in eastern Bolivia), the number of valid terms in both languages for kin terms was much lower than for trees, based on unpublished research I carried out in 2007, 2008, and 2009. In the Ka'apor sample (n = 22) there were 48 kin terms and in the Sirionó sample (n = 20), there were 26 kin terms with frequencies greater than 1. But for tree names with a frequency greater than 1, as we know in the Ka'apor sample (n = 24), there were 149 terms, or about three times the number of kin terms. In the Sirionó sample (n = 18), there were 50 terms with a frequency greater than 1, or about twice the number of kin terms. The Ka'apor habitat is more diverse than the Sirionó habitat, with an average of 120 species of trees per hectare compared to about 55 species of trees per hectare, respectively [11,36], and this may partly explain the lower number of tree terms in Sirionó. Quantitatively speaking, in a general sense, nevertheless, both Ka'apor and Sirionó adults recognize the relatively high arboreal diversity of their respective habitats and this is reflected in tree vocabulary vis-à-vis the lexicon concerned with human kinship.

3. Freelisting of Trees from the Anthropogenic Forest

The inquiry here specifically involves whether Ka'apor TK encodes the anthropogenic forest, called **taper**, as distinctive in terms of biotic contents and diversity, and if so, how? Whether they have Platonist appreciation for the variety of beings—or whether they would subscribe, to borrow Arthur Lovejoy's phrase [53], to the principle of plenitude—including what indicates landscape

transformation, is distinct from asking whether they specifically label that variety in some more or less faithful recognition of its inherent and undeniable complexity. To answer this question in a preliminary way, I will limit analysis to the domain of trees and examine whether freelists of trees from the anthropogenic forest can yield insights into shared (*i.e.*, cultural and ethnobiological) understanding of the origins and diversity of that forest by a sample of Ka'apor adults. Determining the biota that characterize an anthropogenic landscape, such as its distinctive trees, is a related but essentially different endeavor from identifying the members of a class of organisms itself, such as birds, fish, or trees [cf. 71]. The question can be logically approached, nevertheless, also using freelisting procedures.

In August 2009, 22 Ka'apor adult subjects were asked to freelist "trees" (**myra**) of the anthropogenic forest. The question was stated as: "*Ma'e myra ta taper rupi ha ngi nde rekwaha pe*" ("What are the trees of the anthropogenic forest?"). The same sorts of controls were in place as for the earlier study which, in essence, asked "what is a tree?" in Ka'apor [71]. Appendix 1 shows the results of the present exercise, freelisting the trees of the anthropogenic forest, ranked by Smith's s and analyzed using ANTHROPAC 4.983/X software (© 1985−2002 Analytic Technologies). There were a total of 147 separate terms elicited, of which 68 were valid, that is, with a frequency higher than 1. The last column in Appendix 1 shows whether the term references or not species occurring either in the four-hectare inventory of anthropogenic forest or the four-hectare inventory of high forest. If trees were distributed randomly in the two forest types, one would expect each term to reference both forests, or neither, if no difference were recognized in content, but only 38 of the 68 terms do so, and this difference is statistically significant ($p = 0.0365$, Fisher's exact test).

Table 1. Comparison of twenty ecologically most important tree species by Ecological Importance Value (E.I.V.) from four hectare inventories each between high forest (**ka'a-te**) and old fallow (**taper**) in Ka'apor habitat.

Rank	High Forest Species	E.I.V.	Old Fallow Species	E.I.V.
1.	*Eschweilera coriacea*	37.83	*Jacaratia spinosa*	11.40
2	*Sagotia racemosa*	14.53	*Attalea speciosa*	9.37
3.	*Tetragastris altissima*	11.60	*Astrocaryum vulgare*	7.76
4.	*Protium trifoliolatum*	7.76	*Spondias mombim*	6.53
5.	*Protium decandrum*	7.07	*Neea sp. 1*	6.26
6.	*Protium pallidum*	6.78	*Pisonia sp. 2*	6.25
7.	*Carapa guianensis*	5.69	*Pouteria macrophylla*	5.71
8.	*Couepia guianensis*	5.07	*Attalea maripa*	5.40
9.	*Pourouma minor*	4.54	*Platypodium elegans*	5.02
10.	*Taralea oppositifolia*	4.51	*Platonia insignis*	4.32
11.	*Mabea caudata*	4.06	*Simaba cedron*	4.26
12.	*Pourouma guianensis*	3.28	*Hymenaea parvifolia*	4.17
13.	*Dodecastigma integrifolium*	3.10	*Trichilia quadrijuga*	4.06

Table 1. *Cont*.

14.	*Couratari guianensis*	2.77	*Lecythis pisonis*	3.56
15.	*Oenocarpus distichus*	2.72	*Dialium guianense*	3.32
16.	*Sterculia pruriens*	2.65	*Astrocaryum munbaca*	3.31
17.	*Bagassa guianensis*	2.65	*Eschweilera coriacea*	3.19
18.	*Cecropia obtusa*	2.60	*Theobroma speciosum*	3.11
19.	*Newtonia psilostachya*	2.47	*Lindackeria latifolia*	3.05
20.	*Chimarrhis turbinata*	2.40	*Tabebuia impegitinosa*	2.85

There is, as I noted above, a degree of sharing of species between high forests and fallow forests, on an average of about 10.9% (see above). The differences between these forests are most notable not so much in species that are unique (endemic), though there are such species, to one or the other forest type, but rather in quantitative measures, such as density, frequency, and dominance. These measures may be combined for an overall ecological importance value (EIV), in which the sum of the relative density, frequency, and dominance of all species in a forest inventory is 300 [36]. The 20 most ecologically important tree species from four one-hectare inventories each of anthropogenic forest and high forest, with the respective EIVs of each, are shown in Table 1. Only 1 of these 39 species in total is shared.

It is at this level—ecological importance value—that one notes relevant distinctions between anthropogenic forest, the diversity of which is contingent on human history, and high forest, the diversity of which, in contrast, originates in natural drivers. The ecologically most important trees in high forest exclude palms, with one exception, the bacaba palm (*Oenocarpus distichus*); in contrast, the ecologically most important trees of the anthropogenic forest include four palms (*Attalea speciosa, Astrocaryum vulgare, Attalea maripa,* and *Astrocaryum munbaca*). The *Attalea* species have cryptogeal germination [79], which helps account for their success atop once-burned substrates that hosted erstwhile swiddens and settlements of agrarian societies, which is the case with all documented secondary landscape transformations in the Ka'apor habitat. *Astrocaryum vulgare* is usually predominant in inundated forests but typically found only in old fallow, including archaeological sites [80], when outside that milieu [36]. The prototypical Ka'apor tree, **tajy** (*Tabebuia impetiginosa*, known in Portuguese as *pau d'arco* or *ipê roxo*) [71] is essentially only viewed in the anthropogenic forest. It is an important timber species, used by the Ka'apor in making bows. Another notable contrast between these lists in Table 1 is that more than one-half of the trees of the anthropogenic forest are important fruit trees. These include the well known hog plum (*Spondias mombim*, the Ka'apor name of which, incidentally, **taperiwa'y**, as given in Appendix 1, literally means 'fruit tree of the anthropogenic forest'); lucuma (*Pouteria macrophylla*); bacuri (*Platonia insignis*); monkey pot (*Lecythis pisonis*); and nondomesticated cacao (*Theobroma speciosum*). The only significant fruit tree on the high forest list is the aforementioned bacaba palm (*O. distichus*). The proliferation of fruit trees and other useful trees in the anthropogenic forest is in all likelihood due to initial dispersion of the seeds by human beings, whether intentional or not [49].

Now the question becomes how well recognized is the species composition of the anthropogenic forest? A definitive answer cannot be given from freelisting of a relatively small sample. On the other

hand, it has been determined that the Ka'apor distinguish lexically and psychologically between **ka'a-te** and **taper** forests. It can be also determined from Appendix 1 that nine of the twenty ecologically most important anthropogenic forest species are referenced by these terms, whereas only three of the high forest species are so denoted, although the difference is not statistically significant per se, in part because of small sample size.

Table 2. Twenty most ecologically important tree species named by twenty most psychologically important tree names in Ka'apor (n = 22).

Rank of Ka'apor Name by Smith's s	Species Name	Ecological Importance Rank on Old Fallow	Ecological Importance Rank on High Forest
1.	*Hymenaea parvifolia*	13	--
2.	*Hymenaea courbaril*	*	*
3.	*Tabebuia impetiginosa*	20	--
4.	*Eschweilera coriacea*	18	1
5.	*Senna sylvestris*	--	--
6.	*Tabebuia serratifolia*	*	--
7.	*Attalea maripa*	9	--
8.	*Jacaranda* spp.	*	*
9.	*Bagassa guianensis*	*	18
10.	*Spondias mombim*	5	--
11.	*Duguetia* spp.	*	*
12.	*Jacaratia spinosa*	1	--
13.	*Dipteryx odorata*	--	*
14.	*Astrocaryum vulgare*	4	--
15.	*Rinorea* sp.	*	*
16.	*Helicostylis tomentosa*	--	*
17.	*Pouteria macrophylla*	8	*
18.	*Lecythis idatimon*	*	2
19.	*Theobroma speciosum*	19	*
20.	*Anacardium* sp.	*	*

* The species occurs on the inventory, but it ranks below 20.

In any event, these results are shown in Table 2. In broad terms, seventeen of the twenty psychologically most salient terms for trees of the anthropogenic forest have referents in the four-hectare inventory of anthropogenic forest; twelve have referents in the high forest. With one exception (*Eschweilera coriacea*, which is the most common tree in the habitat, probably), the seventeen terms denoting a species in the top twenty species of ecological importance of anthropogenic forest do not apply to the most important species of the high forest. The most important tree psychologically in the old fallow (*Hymenaea parvifolia*) occurs in the top twenty ecologically most important species for that forest type (at rank thirteen) and the most important tree ecologically in the old fallow (*Jacaratia spinosa*) also appears in the top twenty trees in terms of psychological salience (at rank twelve), and neither is present in inventories of high forest.

4. Conclusions

Plato was concerned with the loss of the garden-like aspects of Attica, for in this degradation he perceived a reduction of diversity in living forms. Diversity was a given of the sensible world Plato inhabited, and as such, in his metaphysical paradigm it was a good in and of itself. Plato did not know of evolution by natural selection, of course, which would only first be truly understood by Darwin two thousand and some years later, but he recognized cause and effect, for he stated that "We must ask the question which, it is agreed, must be asked at the outset of any inquiry concerning anything: Has it always been, without any source of becoming; or has it come to be, starting from some beginning?" ([55], p. 16). Anthropogenic forests, or **taper**, have not always been, and though it may be the case that **ka'a-te** has not always been either, its existence can be explained apart from human contingency. Rather, anthropogenic forests started from a beginning, and this beginning involved the deployment of agrarian technology enlightened and driven by TK. These landscapes are, therefore, deserving of explanation, and an adequate one can only be found in contingency, specifically that intrinsic to human history and agency, which in the initiation of landscape transformation is the same as human-mediated disturbance. The study of a system of TK, such as that of the Ka'apor of Amazonia in reference to the domain of trees, shows recognition of preexisting phenotypic diversity [36,71]. It also shows a clear distinction between anthropic and non-anthropic landscapes, which is in the first instance noted in the distinction of labels for the two forest types. Subsequently, the contents of the forest types are distinguished in Ka'apor TK as landscapes contingent on human history and agency and those not so contingent, as I have endeavored to show with the relatively simple yet powerful tool of freelisting. In conclusion, human societies have engendered species-rich forests, on both alpha and beta scales, and in turn, the systems of TK found in these societies reveal that the anthropic influence on the diversity of Amazonian landscapes over long periods of time has been also recognized and encoded.

Acknowledgements

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Appendix 1. Trees of the Anthropogenic Forest (**taper**) to a Sample of Ka'apor Adults (n = 22), Ranked in Order of Psychological Salience by Smith's.

Rank Ka'apor Name Scientific Name Freq. Smith's s F/H[1].

Rank	Ka'apor Name	Scientific Name	Freq.	Smith's s	F/H
1	**jetai'y**	*Hymenaea parvifolia*	15	0.451	+/-
2	**tarapai'y**	*Hymenaea spp.*	14	0.437	+/+
3	**tajy**	*Tabebuia impetiginosa*	12	0.405	+/-
4	**parawa'y**	*Eschweilera coriacea*	13	0.390	+/+

Appendix 1. *Cont.*

5	**ximoran**	*Senna sylvestris*	11	0.301	-/-
6	**tajypo**	*Tabebuia serratifolia*	10	0.285	+/-
7	**inaja**	*Attalea maripa*	10	0.211	+/-
8	**para'y**	*Jacaranda spp.*	7	0.206	+/+
9	**tareka'y**	*Bagassa guianensis*	7	0.203	+/+
10	**taperiwa'y**	*Spondias mombin*	5	0.183	+/-
11	**pina'y**	*Duguetia spp.;* *Unonopsis rufescens*	6	0.168	+/+
12	**mamawiran**	*Jacaratia spinosa*	5	0.158	+/-
13	**kumaru'y**	*Dipteryx odorata*	4	0.151	-/+
14	**tukumã**	*Astrocaryum vulgare*	7	0.143	+/-
15	**pywa'y**	*Rinorea spp.*	6	0.143	+/+
16	**akaú'y**	*Helicostylis tomentosa*	6	0.143	-/+
17	**akuxityrywa'y**	*Pouteria macrophylla*	7	0.141	+/+
18	**jaxiamyr**	*Lecythis idatimon*	5	0.123	+/+
19	**kakawiran**	*Theobroma speciosum*	4	0.121	+/+
20	**akaju'y**	*Anacardium spp.*	5	0.117	+/+
21	**ama'y**	*Cecropia spp.*	4	0.117	+/+
22	**paju'ã'y**	*Couepia spp.; Parinari sp.;* *Hirtella bicornis*	3	0.107	+/+
23	**japukwai'y**	*Lecythis pisonis*	5	0.107	+/+
24	**yrykywa'y**	*Manilkara huberi*	4	0.104	+/+
25	**ywyse'y**	*Simaruba amara*	4	0.102	+/+
26	**kupa'y**	*Copaifera spp.*	3	0.102	+/+
27	**ynga'y**	*Inga spp.*	5	0.093	+/+
28	**paruru'y**	*Sacoglottis spp.*	3	0.091	+/+
29	**merahytawa**	*Byrsonima sp.*	4	0.088	+/+
30	**kanei'y**	*Protium spp.*	3	0.081	+/+
31	**pajangi'y**	*Vismia guianensis*	2	0.080	-/-
32	**pytyminem**	*Couratari oblongifolia*	4	0.079	+/-
33	**xamato'y**	*?*	3	0.078	?/?
34	**myratã**	*Erythroxylum citrifolium*	2	0.072	-/-
35	**jurupepe'y**	*Dialium guianense*	3	0.071	+/+
36	**kypyhu'y**	*Theobroma grandiflorum*	3	0.066	-/+
37	**jiniro'y**	*Genipa americana*	2	0.065	-/-
38	**taxi'y**	*Tachigali spp.*	2	0.062	+/+
39	**tekweripihun**	*Rollinia exsucca*	3	0.061	+/-
40	**kururu'y**	*Taralea oppositifolia*	3	0.059	-/+
41	**karatu'ã'y**	*Fusaea longifolia*	3	0.059	+/+
42	**pu'ypirang'y**	*Ormosia coccinea*	2	0.055	-/-
43	**kupapa'y**	*Pouteria spp.*	2	0.053	+/+

Appendix 1. *Cont.*

44	**ajuwa'y**	*Lauraceae spp.*	2	0.053	+/+
45	**axiwa'y**	*?*	2	0.052	?/?
46	**yrary**	*Cedrela fissilis*	4	0.052	+/-
47	**marato'y**	*Schefflera morototoni*	2	0.051	+/+
48	**tajytawa**	*Tabebuia sp.*	2	0.050	+/-
49	**kujeri'y**	*Lacmellea aculeata; Ambelania acida*	2	0.050	-/+
50	**ama'yatã**	*Cecropia sp.*	2	0.049	+/+
51	**jeju'y**	*Astronium lecointei*	2	0.047	+/-
52	**ãjãkywa'y**	*Apeiba spp.*	2	0.045	+/+
53	**apa'y**	*Parahancornia spp.*	2	0.043	-/+
54	**xixirupe'y**	*Inga spp.*	3	0.040	+/+
55	**inajayvy**	*?*	2	0.038	?/?
56	**kyky'y**	*Newtonia spp.; Pithecellobium comunis*	2	0.036	+/+
57	**pytymyte**	*Couratari guianensis*	3	0.034	+/+
58	**amangaputyr'y**	*Senna pendula; Cassia fastuosa*	2	0.034	-/-
59	**pakuri'y**	*Platonia insignis*	2	0.034	+/+
60	**yraki'ĩ'y**	*Myrciaria tenella*	3	0.033	+/-
61	**paraku'y**	*Chimarrhis turbinata*	2	0.031	+/+
62	**yngahu'y**	*Inga spp.*	2	0.031	+/+
63	**tamaran'y**	*Zollernia paraensis*	4	0.028	+/-
64	**akuxityrywahu'y**	*Pouteria macrocarpa; Franchetella sp. 1*	2	0.027	+/+
65	**pinuwa'y**	*Oenocarpus distichus*	2	0.027	+/+
66	**tekwery**	*Cordia spp.*	2	0.021	+/+
67	**pyky'a'y**	*Caryocar villosum*	2	0.020	-/-
68	**pakurisõsõ'y**	*Rheedia spp.*	2	0.005	+/+

[1] Presence (+) or absent (-) in anthropogenic forest (F) or high forest (H) inventories (see text).
Data computed in ANTHROPAC 4.983/X software (© 1985-2002 Analytic Technologies).