Copyright © 2023 by the author(s). Published here under license by the Resilience Alliance.
Franco-Moraes, J., L. V. Braga, and C. R. Clement. 2023. The Zoʻé perspective on what scientists call "forest management" and its implications for floristic diversity and biocultural conservation. Ecology and Society 28(1):37. https://doi.org/10.5751/ES-13711-280137

Research

The Zoʻé perspective on what scientists call "forest management" and its implications for floristic diversity and biocultural conservation

Juliano Franco-Moraes [1], *Leonardo Viana Braga* [2,3] *and Charles Roland Clement* [4]

ABSTRACT. Indigenous perspectives on forest management are grounded in traditional ecological knowledge (TEK), so that socioculture influences the ways Indigenous Peoples transform their landscapes. However, how socioculture structures Indigenous perspectives on forest management is unclear. Moreover, little is known about the influence of Indigenous landscape transformations on forest succession and floristic diversity. Here, we test hypotheses from biocultural and ecological theories suggesting that: (i) key social-ecological relationships with specific taxa structure Indigenous perspectives on forest management; (ii) such relationships guide sustainable management that generates resilient forest regrowth; and (iii) this management promotes floristic diversity by acting as an intermediate disturbance. We collected information about cosmology, occupation history and management among the Zoʻé, in Brazilian Amazonia. We also carried out floristic inventories in old-growth forests and in old Zoʻé swidden-fallow areas to analyze forest structure and alpha- and beta-diversity along a gradient of forest successional stages. We show that the Zoʻé perspective on forest management is structured by an ethical principle involving a social-ecological relationship with different beings, especially the spider monkey (*Ateles* sp.). This relationship generates mobility among the Zoʻé that allows forest regrowth in their fallow areas, so that in 28 years, forest basal area may equal that of old-growth forests. Also, Zoʻé forest management has increased alpha- and beta-diversity by increasing species richness and diversity in intermediate secondary forests and promoting floristic turnover at the landscape-level. These results show that some aspects of Zoʻé cosmology influence forest disturbance regimes that generate a sustainable social-ecological system, therefore being key for Zoʻé well-being and local biodiversity conservation. We believe that Indigenous perspectives about forest management should be included in forest conservation efforts aimed at protecting Amazonian biocultural diversity, thus valuing TEK and engendering sustainable social-ecological systems.

Key Words: *Amazon forest; forest succession; historical ecology; Indigenous cosmologies; Indigenous sustainability; social-ecological system; traditional ecological knowledge*

INTRODUCTION

Forest management is the implementation of sustainable practices that maintain forest changes and extend environmental, economic, or sociocultural conservation objectives (FAO 2022). Indigenous perspectives on forest management are grounded in traditional ecological knowledge (TEK), a transformative and cumulative body of knowledge-practice-belief about the relationships of living beings (including humans) with one another and with their environment (Berkes et al. 2000). Sociocultural elements associated with TEK (e.g., cosmologies, social relations, species knowledge, etc.) influence Indigenous forest management (Poffenberger and McGean 1993, de Oliveira 2016), which, in turn, influence forest successional processes (Gómez-Pompa 1987, Balée and Gély 1989, Douterlungne et al. 2010). However, how such sociocultural elements structure Indigenous perspectives on forest management is unclear. Moreover, little is known about how Indigenous management influences forest succession and floristic diversity. Understanding these issues is paramount, because Indigenous TEK represents a source of new social-ecological concepts, conjectures, and theories that can improve our ability to understand and sustainably act on social-ecological systems (Tengö et al. 2014, Coscieme et al. 2020).

Social-ecological systems represent the interconnection between biological and cultural diversities, which is called biocultural diversity (Gavin et al. 2015, Hill et al. 2019). Studies on biocultural diversity have suggested that social-ecological systems are structured by keystone biocultural traits (i.e., social-ecological relationships with specific taxa), whose top-down effects on biocultural diversity are large relative to other elements within the systems (Winter et al. 2018). These keystone biocultural traits promote effects in ecological processes and patterns (Franco-Moraes et al. 2021), generate biocultural unities (i.e., relationships shared by the same group of people) for social-ecological systems (Reyes-Valdés and Kantartzi 2020), and influence management sustainability (Datta 2015). In social-ecological systems that are dependent on shifting cultivation, an important indicator of sustainability is the resilience of forest regrowth in fallows (Lawrence et al. 2010). The main factor limiting resilience in forest recovery is land-use intensification (Jakovac et al. 2015), and the most common proxy used for assessing forest recovery is basal area increment (Nikinmaa et al. 2020). Therefore, it is expected that key social-ecological relationships structure the ways Indigenous Peoples understand forest management, thus influencing resilience as measured by the basal area increment during forest regrowth in fallows.

Amazonia has some of the richest biocultural diversity in the world (Loh and Harmon 2005). Amazonian Indigenous Peoples understand that non-humans (i.e., animals, plants, etc.) involved in social-ecological relationships have social lives (de Castro 1998,

[1]Department of Ecology, Institute of Biosciences, Universidade de São Paulo, [2]Department of Social Anthropology, Universidade de São Paulo, [3]Programa Zo'é of Iepé - Instituto de Pesquisa e Formação Indígena, [4]Technology and Innovation Division, Instituto Nacional de Pesquisas da Amazônia

Descola 2005) and transform landscapes according to their own interests (da Cunha 2019). For sociocultural reasons associated with social-ecological relationships, these peoples value and promote the presence of different non-humans and the existence of different landscapes (da Cunha 2017, Fausto and Neves 2018, Fausto 2019). For example, Amazonian Indigenous TEK values swiddens containing different species and species varieties (Emperaire 2005, Rival and McKey 2008, da Cunha 2017). This appreciation leads these peoples to promote inter- and intra-specific differences in their swiddens (Perrault-Archambault and Coomes 2008, de Oliveira 2019, Emperaire et al. 2021).

When Indigenous swiddens are harvested they give way to fallows where forest regrowth can occur sustainably, often in association with management of remnant crops and trees/palms (Levis et al. 2018, Franco-Moraes et al. 2019). Although Indigenous understandings of sustainability vary (Fernández-Llamazares and Virtanen 2020, Virtanen et al. 2020), TEK of most Amazonian Indigenous Peoples considers that forest sustainability requires opening and fallowing of swiddens in space-time, i.e., shifting cultivation (Denevan 2001). This practice prevents land-use intensification and engenders different forest successional stages at the landscape-level (Saldarriaga et al. 1988, Franco-Moraes 2021). Because these stages contain different species and represent distinct landscapes (Finegan 1996, Chazdon 2003, Mesquita et al. 2015), it is expected that Amazonian Indigenous TEK values not only different swiddens, but also different forest successional stages, so that local perspectives on forest management are based on social-ecological relationships associated with such understanding.

In many Indigenous Amazonian social-ecological systems, relationships with non-humans occur through an ethic of moderation, i.e., through behaviors of decorum and precaution (Lévi-Strauss 1968, Gallois 1988, Aparício 2020). Among the Zo'é, an Indigenous People of recent contact in northern Brazilian Amazonia, these behaviors include not overhunting diverse types of game (or during inappropriate periods), and moving away from game in some situations because they can be vindictive, which causes a necessary social distancing in relation to game (Braga et al. 2020). This distancing influences Zo'é mobility, because the practice of opening and fallowing swiddens in new regions results, among other reasons, from this ethic of moderation in relation to game (Havt 2001, Braga 2021a). This practice, in turn, should lead to higher alpha diversity (i.e., at the local level) in old swidden-fallow patches with an intermediate successional recovery time (counting since the last disturbance), because these patches encompass both opportunistic and competing species (Sheil and Burslem 2013).

Higher biodiversity in forests with intermediate levels of disturbance, whether in relation to frequency, intensity, or the time elapsed since it occurred, is a classical hypothesis in ecology known as the intermediate disturbance hypothesis (IDH; Connell 1978). Although implications of the IDH are debatable, and some attempts to corroborate them failed (Fox 2013, Barabás et al. 2018), empirical support for IDH in tropical forest plant communities is increasingly reported (e.g., in relation to disturbance intensity and frequency; Molino and Sabatier 2001, Svensson et al. 2012, Guitet et al. 2018). In fact, the IDH represents a general framework that can regroup various hypotheses regarding specific disturbance mechanisms and the level of biodiversity across space and time (Sheil and Burslem 2013). From the IDH framework, we can also expect that Zo'é shifting cultivation should lead to higher beta diversity (i.e., at the landscape level) by creating forest patches with different alpha-diversities and compositions (Balée 2006, Guèze et al. 2015, Odonne et al. 2019).

Shifting cultivation has been a widespread practice among Amazonian Indigenous Peoples for thousands of years (Denevan 2001). Although some authors have shown that intensification of shifting cultivation reduces recovery of floristic diversity and structure (Jakovac et al. 2015, Villa et al. 2018), others have shown that recovery can occur over time (Saldarriaga et al. 1988, Mukul et al. 2020). Testing the IDH for forest recovery time in Indigenous social-ecological systems can help us understand the long-term consequences of shifting cultivation (Balée 2006), thus contributing useful information to environmental agendas aimed at the resilience of social-ecological systems (Sterk et al. 2017). For this, sociocultural aspects should be considered, because they influence the way Indigenous Peoples transform their landscapes (Franco-Moraes et al. 2021). Cosmological aspects, for example, are behind Indigenous Peoples' management practices and are critical for ensuring long-term sustainability of Indigenous social-ecological systems (Fernández-Llamazares and Virtanen 2020).

We present a case study among the Zo'é that aims to determine if there is a key social-ecological relationship that structures the Zo'é's perspective on forest management. We collected ethnographic information about Zo'é TEK on forest succession, and about behaviors of decorum and precaution. We also investigated if such a relationship guided management that generated resilient forest regrowth along a gradient of forest patches in different successional stages that encompass old swidden-fallow areas and old-growth forests. For this, we compared forest structure (basal area and ethnospecies density) along the gradient. Finally, we tested (1) if alpha diversity is maximal in forest patches of intermediate age, i.e., patches that have been regenerating for decades but have not reached their mature state, and (2) if the gradient of forest patches promoted beta diversity at the landscape scale. For this, we assessed ethnospecies richness and diversity (alpha diversity), and ethnospecies relative abundance and floristic composition (beta diversity) along the gradient.

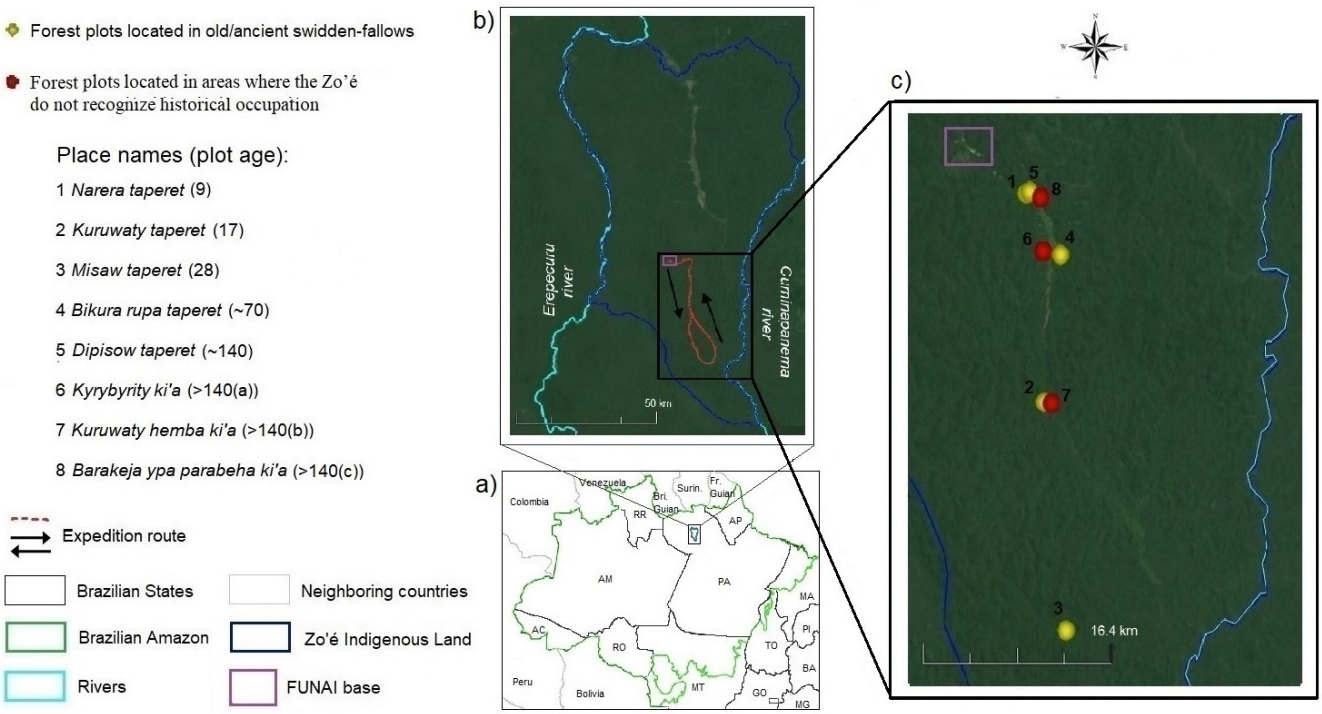
METHODS

Study area and population

Fieldwork was conducted on the Zo'é Indigenous land (Fig. 1a). Local landscapes are composed of large, open terra-firme forest areas, várzea forest areas, and small-medium patches of savannah (Pires and Prance 1985). Soils are similar among forested areas: they are acidic, nutrient-poor, have a low cation-exchange capacity, and are predominantly red-yellow Podzols and Oxisols (Venturieri et al. 2000). The climate is seasonal, humid tropical with a rainy season between December to June and a dry season between July to November. Mean annual rainfall and temperature are 2192 mm and 27.5 °C, respectively (INMET 2020).

The Zo'é are a people of recent contact that live on their Indigenous land, which was ratified in 2009, and is located in interfluvial forests between the Cuminapanema and Erepecuru Rivers, in northern Pará State, Brazil. They were officially contacted in 1982 by missionaries of the New Tribes Mission,

Fig. 1. Location of the Zo'é Indigenous Land, Pará, Brazil, and floristic plots. a) Location of the Zo'é Indigenous Land in the Brazilian Amazon; b) Route of the expedition we carried out in the Zo'é Indigenous Land; c) Location of the floristic plots with names and ages in legend.



who started living near Zo'é villages to evangelize them. In 1991, after a fifth of the Zo'é population had died of diseases transmitted by non-Indigenous People, the National Indian Foundation (FUNAI) removed the missionaries and created a base in the region (Iepé and FPEC 2019).

Currently, 320 Zo'é live on their Indigenous land. They speak a language of the Tupi-Guarani family, and some local chiefs and young people also speak Portuguese; hereafter, terms in the Zo'é language appear in italics. The Zo'é are divided into four local groups that alternate periods in semi-permanent villages and in temporary camps, and their management system consists of shifting cultivation, hunting-gathering, and fishing (Iepé and FPEC 2019).

Data collection

Ethnographic data

Ethnographic data, including semi-structured and structured interviews, were collected during a 45-day expedition (May–June 2019) that we carried out together with members of different Zo'é families (Fig. 1b); the expedition occurred as part of seasonal hunting-gathering activities carried out by the Zo'é. Semi-structured interviews based on directed but open-ended questions offered greater flexibility to probe oral histories and other aspects of TEK (Bernard 1988). Semi-structured interviews about historical occupation, mobility, and management practices were conducted with 12 men aged 26 to 74. Structured interviews, which were appropriate for obtaining responses to ordered questions (Bernard 1988), involved describing the usefulness of the most abundant ethnospecies present in our plots and were conducted with five men aged 36 to 74 and one woman aged 54. We also collected information about cosmology, social relations, mobility, and occupation history among the Zo'é from the available literature (Braga 2017, 2021a, Braga et al. 2020, Gallois et al. 2020).

Floristic data

During our expedition, we stayed for a few days in four regions pre-established by the Zo'é according to their travel plan. In these regions, we carried out floristic inventories in fallowed forest patches that were left in succession from nine to ~140 years ago (Fig. 1c; Table 1), counting from the last clearance until 2019 (although the Zo'é returned to them to open temporary camps). The year the area was left in succession was calculated from documents and/or Zo'é ancestral memory (Appendix 1). This sampling method (called chronosequence), allowed us to view temporal products of successional dynamics by analyzing floristic patterns of different forest successional stages (Walker et al. 2010). Overall, our sampling encompassed forest patches with ages varying from 9, 17, 28, ~70 to ~140. In three of the four regions, we carried out an inventory in a forest patch where the Zo'é said they had never cleared, although they had hunted and collected there. Because of logistical issues, this type of forest was not sampled in the southernmost region and could only be sampled

Table 1. Year of the evacuation and coordinates of the forest plots studied in the Zo'é Indigenous Land, Pará State, Brazil.

Name of the forest plot area	Year the area was evacuated	Latitude	Longitude
Forests located in old/ancient swidden-fallows			
Narera taperet	2010	-0.21224	-55.4738
Kuruwaty taperet	2002	-0.29467	-55.4648
Misaw taperet	1991	-0.38575	-55.4548
Bikura rupa taperet	~1950	-0.21187	-55.4728
Dipisow taperet	~1880	-0.23506	-55.4610
Forests located in areas where the Zo'é do not recognize historical occupation			
Kyrybyrity ki'a	< 1876	-0.23421	-55.4650
Kuruwaty hemba ki'a	< 1876	-0.29493	-55.4627
Barakeja ypa parabeha ki'a	< 1876	-0.21327	-55.4657

once in each of the other three regions. These forest patches were the closest representation we could find of old-growth forests, which are defined as forests in a late stage of succession that were not subjected to large disturbances in the past, such as clearance for swiddens (Chazdon 2014). In 2019, the Zo'é had an ancestral memory of eight generations (Appendix 1), so we inferred that these three old-growth forests had not been cleared for at least 140 years (Table 1).

Forest patches in which plots were established were selected considering oral histories, logistical issues, and the availability of Zo'é collaborators. To avoid floristic differences associated with soil variability in our samples, we only carried out inventories in patches with black soil (*ywy byk,* which, according to Zo'é, are soils suitable for swidden; archaeological surveys are being done to verify if *ywy byk* represents Amazonian Dark Earth). In addition, because the vast majority of tree and palm species in tropical forests disperse seeds less than 100 m (Kettle 2012), to avoid short-distance seed dispersal effects among plots within the same region we established plots at distances greater than 100 m (Table 2). Nevertheless, long-distance seed dispersal by mammals and birds can influence floristic variability, mainly within a radius of 1.5 km (Link and Di Fiore 2006, Kitamura 2011). Soil collection was not authorized by the Zo'é.

Because Zo'é swiddens are ~0.5 ha (JF-M, *personal observations*), to capture floristic variability across the forest patch (Gordon and Newton 2006), we established four subplots of 25 x 10 m (0.025 ha) for floristic inventories in each forest patch, so that the sum of these subplots corresponds to one plot of 0.1 ha. With randomized sampling, we established two subplots in different edges and two subplots in different areas of the center of the patches. For basal area assessments, we measured the CBH (circumference at breast height) of all trees/palms ≥ 10 cm, i.e., 3.18 cm DBH (diameter at breast height). This is an appropriate threshold as reliable basal area assessments for plot sizes of 0.1 ha in Amazonia should include DBH thresholds < 10 cm (Oliveira et al. 2014).

Table 2. Distances (km) among the eight forest plots we carried out floristic inventories in the Zo'é Indigenous Land, Pará, Brazil.

Age	9	17	28	~70	~140	> 140(a)	> 140(b)	> 140(c)
9	-							
17	15.61	-						
28	32.57	17.08	-					
~70	5.44	11.05	27.87	-				
~140	0.33†	15.72	32.79	5.41	-			
> 140(a)	4.54	11.26	28.25	1.54†	4.55	-		
> 140(b)	15.68	0.64†	16.87	11.04	15.83	11.30	-	
> 140(c)	1.31†	15.17	32.23	4.57	1.05†	3.98	15.32	-

†Distance between plots located in the same region.

Ethnospecies identification

Because we were interested in Zo'é TEK on floristic composition, all trees/palms ≥ 10 cm CBH were identified with Zo'é ethnospecies names. A Zo'é specialist of trees/palms identification, (Biri, a 74-year-old Zo'é man who in 2019 owned land in areas we visited and who best knew the regions) accompanied us throughout data collection, along with another 19 Zo'é collaborators, all of whom participated in identification. Ethnospecies identification by the Zo'é was based on their own morphological, phenological, and social-ecological criteria, so that these ethnospecies might not necessarily match scientific taxa. Although we understand the importance of scientific identification for these ethnospecies for purposes of comparisons with other studies, plant collection was not authorized by the Zo'é. However, because some ethnospecies were also identified by popular names by the Zo'é, in a few cases we were able to identify them with a scientific name, because such popular names were scientifically well established; in the text, such ethnospecies are presented with their respective scientific names. We also investigated the local use of the most abundant trees/palms by grouping them into five categories: food, manufacturing, therapeutic, construction, and fuel (Prance et al. 1987, Phillips and Gentry 1993).

Floristic data analysis

To investigate differences among plots, we compared alpha- and beta diversity, composition, and structure. As a proxy for alpha-diversity (intra-plot diversity), we calculated the ethnospecies richness for each plot using a species rarefaction curve (Gotelli and Colwell 2001). As a proxy for beta diversity (inter-plot diversity), we compared dissimilarity among plots in relation to the relative abundance of the 10 most abundant ethnospecies in each plot, totaling 47 ethnospecies (~70% of the total abundance of all plots). We used non-metric multidimensional scaling (NMDS) with ordination in one dimension (McCune and Grace 2002) and applied the Bray-Curtis dissimilarity index (Faith et al. 1987). Although this analysis does not represent a statistical hypothesis test, by sorting plots along a gradient of relative abundance, it showed possible floristic variability among plots, which is beta diversity (Whittaker 1967, Faith et al. 1987). To compare diversity profiles among plots, we used Hill's series, an equation that calculates different biodiversity indexes for the same dataset (Tóthmérész 1995). With the Hill index we compared these different indexes (e.g., species richness, Shannon, Simpson,

Table 3. Forest community structure characteristics of the eight forest plots in the Zo'é Indigenous Land, Pará, Brazil, where we carried out floristic inventories.

Area name	*Narera taperet*	*Kuruwaty taperet*	*Misaw taperet*	*Bikura taperet*	*Dipisow taperet*	*Kyrybyrity ki'a*	*Kuruwaty hemba ki'a*	*Barakeja ypa parabeha ki'a*
Forest age	9	17	28	~70	~140	> 140(a)	> 140(b)	> 140(c)
Total basal area[†] (m^2 0,1 ha^{-1})	1.75	5.54	8.40	7.22	6.93	8.04	4.38	7.14
Ethnospecies density (ethnosp. 0,1 ha^{-1})	32	58	58	79	64	79	59	82
Total abundance (ind. 0,1 ha^{-1})	202	178	168	178	221	274	136	208
Canopy	Open	Open	Semi-open	Semi-open	Semi-open	Semi-open	Semi-open and open areas	Semi-open
Gap with fallen tress	-	-	Two small	One medium-size	-	Two small	Three medium-size and one large-size	Two medium-size
Vines and lianas	Many small	A few small	Many small- and medium-size	A few thick	Many thick	Many thick	-	Many small- and thick
Strata	Under-canopy, shrub, and herbaceous layers	Canopy, under-canopy, shrub, and herbaceous layers	Emergent, canopy, and under-canopy layers	Emergent, canopy, under-canopy, and shrub layers	Emergent, canopy, and under-canopy layers	Emergent, canopy, and under-canopy layers	Emergent, canopy, under-canopy, and shrub layers	Emergent, canopy, and under-canopy layers
Ancient Zo'é dump heaps	-	-	One	Three	One	-	-	-

[†]Total basal area is the sum of the basal area of all trees/palms greater than 10 cm CBH found in the forest plot. Ethnospecies density is the number of ethnospecies found in the forest plot. Total abundance is the number of trees/palms, greater than 10 cm CBH, found in the forest plot.

evenness, etc.), which emphasize different ecological aspects, such as quantity of species, species dominance, and rarity of species. To compare floristic composition among plots, we carried out a hierarchical clustering analysis based on the presence-absence of all 230 ethnospecies and applied the Jaccard similarity index (Legendre and Legendre 2012a). To compare floristic structure among plots, we calculated the total basal area, ethnospecies density, and total abundance for each plot (Table 3). Analyses were performed using R v.3.6.0 software (R Core Team 2019; Appendix 2).

RESULTS

Zo'é's forest TEK

According to Zo'é cosmology, animals and plants have volitions and interact through partnership, chieftainship, war, etc., so that what ecologists call ecological interactions the Zo'é describe as social relations. For example, they say that the tapir (*Tapirus terrestris*) *jiawu*/calls the *taman* (a small hawk) to take its ticks off, as the *taman* is its *ribe*/pet; the agouti (*Dasyprocta aguti*) *jaty*/plants its flour (Brazil nut [*Bertholletia excelsa*]) and gets *doryj*/unhappy when the paca (*Cuniculus paca*) steals its food; the Harpy Eagle (*Harpia harpyja*) is *juke ijet*/chieftain at killing, because it hunts large animals, such as spider monkeys (*Ateles* sp.); certain trees (e.g., *Cecropia* sp.) *ory*/rejoice with other trees (e.g., *Schefflera* sp.) and help them to grow, thus promoting a *pijã*/partnership. Places where these and other social relations (involving humans and/or non-humans) occur represent *tekoha*/social territory, because the development of these relations promotes a *tekoha,* which is a place where beings grow their food, hunt, sleep, etc. For example, swiddens are part of the *tekoha* of the Zo'é, but also of other non-humans that inhabit them, such as crops. Upland forest patches are the *tekoha* of spider monkeys, who understand large trees (e.g., Angelim [*Dinizia excelsa*]) as their *kiha*/hammock, but are also the *tekoha* of some Zo'é groups because such forests include their hunting trails. Therefore, all beings have their own *tekoha* that are located in certain places, and these places are relational as they express an entanglement of *tekoha* of different beings according to their points of view (cf. de Castro 1998, de Oliveira 2016).

In this context, the Zo'é describe forest succession as transformations of entanglements of human and non-human *tekoha*. Such transformations occur as social relations arise and disappear, and the *tekoha* of certain beings are transformed into others, so that the Zo'é understand different forest successional stages as different *tekoha* entanglements. For example, they say that in their mature swiddens, reduced cassava manioc (*Manihot esculenta*) production results from the volition of the very crop who gets *doryj*/unhappy as its roots are perforated by flechal (*Gynerium sagittatum*), who want to establish their *tekoha* there. Over time, some trees (e.g., *babake*/Embaúba [*Cecropia* sp.]) and palms (e.g., *takumã*/Tukumã [*Astrocaryum aculeatum*]) expel the flechal, and other trees (e.g., *tapery*/Tapereba (*Spondias mombin*) and *nã*/Brazil nut) and palms (e.g., *ijeja*/Inajá [*Attalea maripa*]) sprout from Zo'é dump heaps. These trees/palms attract rodents, small birds, and monkeys, who start to manifest their own social relations there. Then, *kuduaru* frogs (cf. *Trachycephalus* sp.) establish their *tekoha* in some hollow trees, and the tapir, being *ory*/happy with frog songs, defecates seeds next to these trees. Gradually, *tekoha* transformations occur as forest regrowth occurs.

The Zo'é understand that *tekoha* transformations are the result not only of non-human volitions, but also of Zo'é agency. Such understanding occurs because when the Zo'é occupy a forest

patch, they transform non-humans' *tekoha* into their own *tekoha*. For example, as the Zo'é implement practices of slashing and burning, non-human *tekoha* are transformed into human *tekoha*. In turn, when the Zo'é fallow their swiddens, they make possible the establishment of non-human *tekoha* in that area. Therefore, Zo'é mobility associated with the practice of opening and fallowing swiddens influences the existence of non-human *tekoha* transformations.

Along with seasonality and sociohistorical aspects, cosmological aspects also influence Zo'é mobility and are central in determining local movements. In this sense, the Zo'é say that the *piji* (the Zo'é's aroma) determines behaviors of approach/departure and precaution, both among the Zo'é themselves and with other beings. For example, a hunter's *piji* can attract or drive game away, and a newborn's *piji* can attract predators, thus requiring their relatives not to work in their swiddens, hunt, or gather in order to protect the newborn. As the Zo'é transform landscapes and establish villages and swiddens, their *piji* impregnates these areas and thus attracts game, mainly spider monkeys, who want to be *pijã*/partner of the Zo'é. Nonetheless, when *piji* gets excessive in an area and the spider monkeys perceive that the Zo'é want to kill them, what would be a partnership for the spider monkeys reveals itself to be a *dipisi*/war, and the spider monkeys become vindictive and can send diseases to hunters and their families. Because of these and other reactions of game, plants, and other beings, the Zo'é consider moderation in their behaviors as an ethical principle. This moderation governs respect for social and territorial distances in relation to non-humans. After years of occupying a region, the relative scarcity of game leads the Zo'é to temporarily vacate it to look for other regions where game, mainly spider monkeys, are not used to Zo'é's *piji*.

Besides landscape transformations for opening villages and swiddens, Zo'é mobility also includes landscape transformations associated with opening of camps (sometimes on ancient villages) and fallow management. In these cases, they can hunt, gather, manage trees/palms, and harvest remnant crops. Camps are established by selecting small trees (DAP ≤ ~7 cm) for cutting in areas of ~250 m², so that the canopy remains. In some camps, we observed hundreds of *ijeja*/Inajá and *patawá*/Patauá (*Oenocarpus bataua*) seeds scattered on the ground by the Zo'é, as well as fallow areas where remnant crops, such as *pako*/Banana (*Musa* sp.), *kuj*/Cuia (*Crescentia cujete*), and *ruku*/Urucum (*Bixa orellana*), remained because of the Zo'é recurrently opening small gaps in the canopy. Close to these crops, we observed houseposts and pottery remnants of ancient occupations (Fig. 2). It is common that such camps and fallows contain a mix of pioneer and late succession trees, palms with edible fruits, and crops. According to the Zo'é, their management practices influence the existence of this ethnospecies mixture in their camps/fallows that favors the existence of different game species in the forest patch so that the game start to establish their *tekoha* there.

The Zo'é perspective that non-humans have their own *tekoha*, relate socially, and therefore can be vindictive reinforces respect and the need for distancing in relation to these non-humans. In this context, the Zo'é understand forest management as the implementation of mobility associated with practices for opening/vacating forest patches, that ensures both the existence of different human and non-human *tekoka*, and certain distancing in relation to vindictive game. The foundation of the social-ecological relations that structure this understanding is the ethic of moderation, especially with game, among which the relationship with the spider monkey stands out, so that the search for fat game is the main driving force of Zo'é mobility. At least during the last 140 years, such mobility has triggered landscape transformations that have made possible the existence of forest patches in different successional stages, in either old swidden-fallow or camping areas, such as the five areas we inventoried.

Impact of Zo'é's forest TEK on forest structure and alpha diversity

Values of total basal area and ethnospecies density in forest plots over 28 and ~70 years old, respectively, were similar to old-growth forests (Table 3). In old-growth forests, total basal area, ethnospecies density, and total abundance values varied. For example, in the old-growth forest ≥ 140b, values of these variables were similar to young forests (Table 3), although its ethnospecies relative abundance and composition remained similar to the old-growth forest ≥ 140c (Figs. 3 and 4).

Forest plots of ~70 and ≥ 140c years old showed the greatest values of species richness, and the nine-year-old forest plot the smallest value (Fig. 5). Species richness in the intermediate aged (~70 years old) forest plot was 27.5% and 14.7% higher than in the old-growth forests ≥ 140a and ≥ 140b, respectively (Fig. 5). Regarding diversity profiles, 28- and ~70-year-old forests show higher stability (i.e., lower curve slope that indicates greater floristic evenness and less dominance of abundant ethnospecies) than old-growth forests (Fig. 6). Diversity profiles also show the highest values of Shannon and Simpson indexes for the ~70-year-old forest plot (Fig. 6). Overall, these results show highest alpha diversity (i.e., local diversity) in the intermediate aged ~70-year-old forest plot.

Impact of Zo'é's forest TEK on beta diversity

Ordination of variation in ethnospecies relative abundance among plots by NMDS captured 83% of the variance in the original matrix and shows a floristic turnover across a gradient of successional stages related to forest patch ages (Fig. 3). This gradient shows that beta diversity (i.e., floristic variability among plots) is higher in landscapes with an ensemble of different successional stages than in old-growth forests alone. In these landscapes, young (nine and 17), intermediate (28, ~70, and ~140), and old-growth (> 140) forests are dominated by pioneer (e.g., *nengansing*, *babake,* and *wire'i*), secondary (e.g., *tapery, buburu,* and *tura pirang*), and late successional (e.g., *rowa'y*, *kapu*, and *siri'y*) ethnospecies, respectively (Fig. 3). Importantly, most of the useful ethnospecies found in our plots are secondary ethnospecies. In turn, landscapes dominated by old-growth forests are dominated mainly by late successional ethnospecies. Floristic composition also varied among plots, and composition of young and intermediate forests was distinct from old-growth forests (≥ 140b/≥ 140c isolated branch in Fig. 4), except the 28-year-old forest, which was similar to the old-growth forest ≥140a (Fig. 4). Floristic composition was related to forest age independently of proximity among plots (Fig. 1c; Table 2).

Fig. 2. Traces of the Zo'é occupation in areas located close to their camps. a) Urucum (Bixa orellana); b and c) Cuia (Crescentia cujete); d) and e) Banana (Musa sp.); f) and g) Banana resprouting; h), i) and j) houseposts; k) pottery.

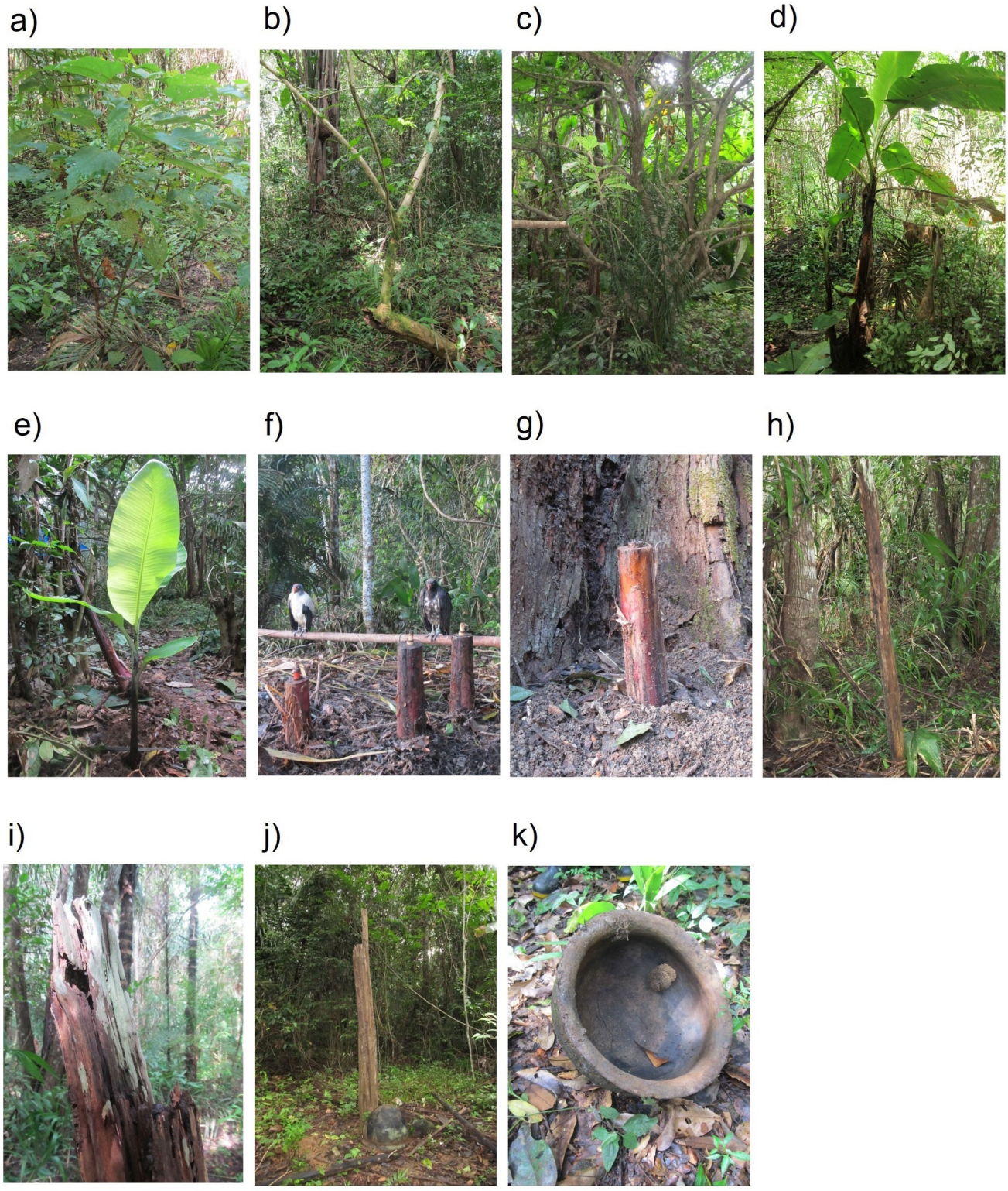


Fig. 3. Gradient of relative abundance of ethnospecies ordered by the one-dimensional NMDS in eight forest plots studied in the Zo'é Indigenous Land, Pará, Brazil. The 10 most abundant ethnospecies in each plot were used for the analysis, totaling 47 ethnospecies, or ~70% of the total tree/palm abundance in all plots. The stress value for NMDS was 0.11, a satisfactory value (see McCune and Grace 2002). In the analysis, additional dimensions contributed little to the percentage of variation explained. Each column represents one plot, and the numbers below columns represent the age of the forest patch where each plot was established. Zo'é names for the ethnospecies are listed to the right of the chart. The size of the bars within columns represents the relative abundance of each ethnospecies in that plot in relation to its total abundance in all plots. The use of each ethnospecies is indicated on the right of each zo'é ethnospecies name. All ethnospecies in this analysis are also used as fuel, thus we did not put this category in the image. Score values of each forest plot are provided across the top of the gradient and indicate the similarity among plots in relation to the relative abundance of ethnospecies. The size of the bars represents the score value; the closer score values are to each other, the more similar the forest plots are. As can be seen, the gradient was related to forest age, suggesting ethnospecies turnover over time during forest succession. Thus, the gradient shows that different forest successional stages, located in different locations in space, have distinct sets of ethnospecies and ethnospecies abundances, showing that landscapes with a mosaic encompassing young, secondary and old-growth/mature forests have higher beta diversity than landscapes with only old-growth/mature forests.

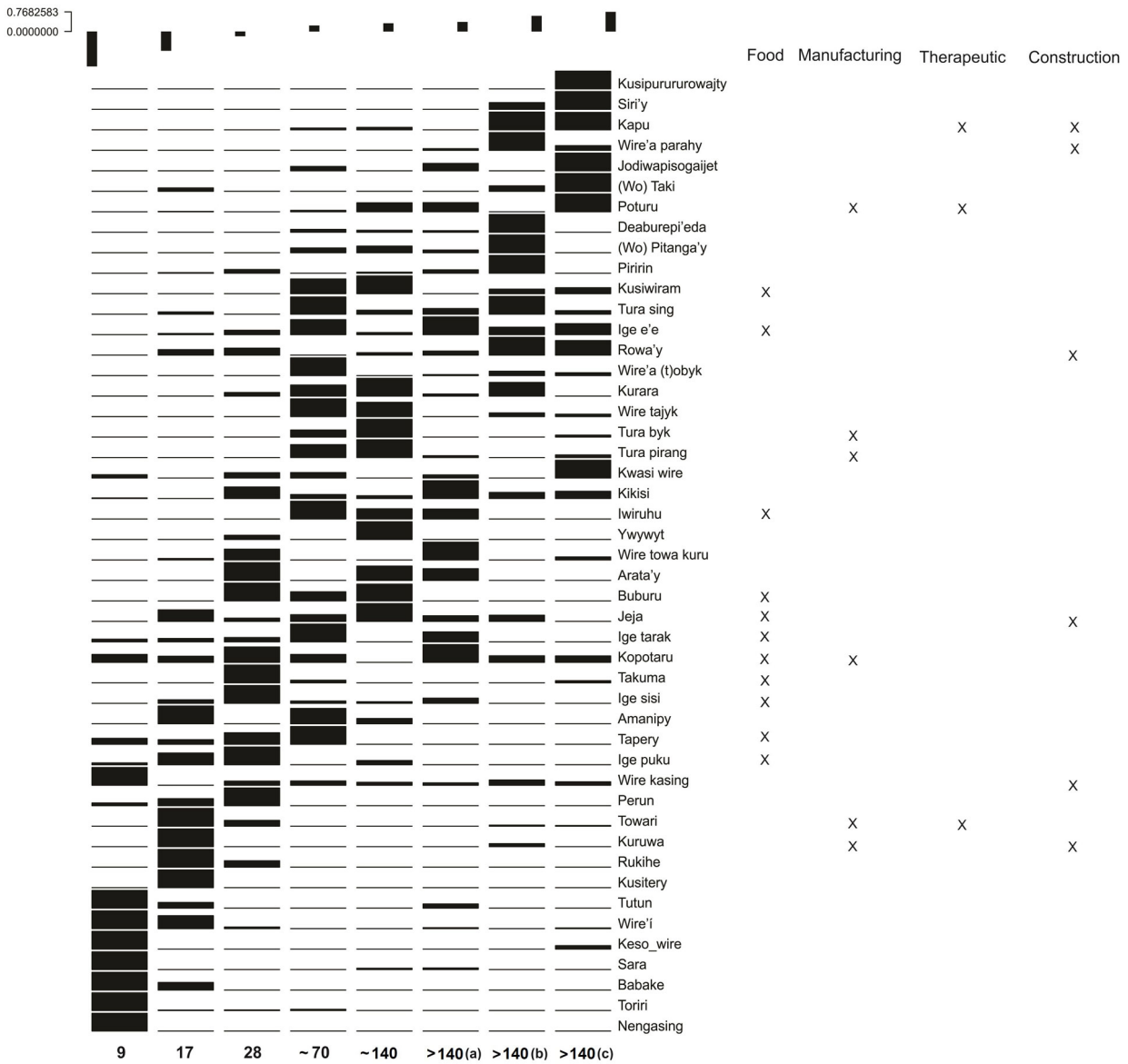
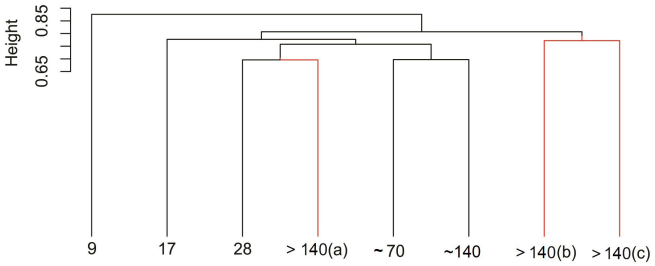


Fig. 4. Dendrogram of the hierarchical clustering analysis to compare floristic composition among eight forest plots studied in the Zoʻé Indigenous land, Pará, Brazil. The analysis was based on the presence-absence of all ethnospecies (abundant and rare ethnospecies, total of 230 ethnospecies) and the Jaccard similarity index. The cophenetic correlation coefficient for the clustering was 0.8, a satisfactory value (Legendre and Legendre 2012b). In the dendrogram, each vertical line corresponds to one forest plot. The ages of the plots are presented below each line. Black lines correspond to forest plots located in old/ancient swidden-fallows and red lines in areas where the Zoʻé do not recognize historical occupations. The height of the grouping, provided on the vertical axis on the left of the dendrogram, indicates the dissimilarity value between two observations; the higher the height, the less similar the observations are. The analysis shows that the nine-year-old forest plot has the most different floristic composition among all plots.



DISCUSSION

The Zoʻé perspective on forest management: sustainability within an ethic of moderation

A key aspect to understanding forest management is sustainability (McDonald et al. 2004, Gough et al. 2008). Indigenous understandings of sustainability are underpinned by sociocosmological aspects (Fernández-Llamazares and Virtanen 2020, Virtanen et al. 2020), so understanding their forest management requires considering their perspectives (Franco-Moraes et al. 2021). For example, among the Kaʻapor, from eastern Brazilian Amazonia, sustainability means implementing practices for opening/vacating forest patches mainly in response to a social-ecological relationship with a specific tortoise (*Geochelone denticulata*; Balée 1985). In the Zoʻé case, sustainability means producing their own *tekoha*/social territory (a concept present in many Tupi-Guarani speaking Indigenous Peoples; Mondardo 2019) through an ethic of moderation (cf. Lévi-Strauss 1968, Gallois 1988, Aparício 2020), i.e., through behaviors of decorum and precaution with non-humans (cf. Braga et al. 2020). This ethic results not only in the promotion of Zoʻé *tekoha* but also of non-human *tekoha*, so that it sustains biocultural diversity in Zoʻé landscapes: a sustainable world for the Zoʻé means a world in which human and non-human sociabilities thrive together. Therefore, social-ecological relationships (Winter et al. 2018) among the Zoʻé and non-humans allow the existence of these different non-human *tekoha*. It is in this context that Zoʻé forest management occurs, because the implementation of practices of opening/vacating forest patches, as well as of establishing camps and taking care of old-fallows, has sociocultural objectives associated with an ethic of moderation with non-humans, mainly spider monkeys.

The ethic of moderation with spider monkeys is justified by the Zoʻé because these monkeys are thought to be vindictive after recognizing the Zoʻé's *piji* (i.e., the Zoʻé's aroma). Therefore, sensible qualities associated with olfactory aspects are central in the interpretation of ecological processes associated with spider monkey behaviors, thus manifesting a "logic of sensible qualities" (cf. Lévi-Strauss 1962), in which aromas, pains, colors, flavors, sounds, and textures compose people's systems of knowledge. Just as occurs in relation to cultivation, cooking, and couvade (Braga 2017, 2021b), the Zoʻé express an ethic of moderation in forest management through behaviors associated with such a logic. This suggests that among Amazonian Indigenous Peoples the ethic of moderation is not necessarily expressed through social-ecological relationships mediated by non-human masters (i.e., spiritual beings who own animals and plants; Fausto 2008, Fausto and Neves 2018), which implies that grounding notions of sustainability in mastery (Fernández-Llamazares and Virtanen 2020) is not as pervasive as has been thought. As we have shown, sustainability in Zoʻé management is ensured through an ethic of moderation associated with a logic of sensible qualities, even if relationships among the Zoʻé and animals, plants, and other beings are not mediated by non-human masters.

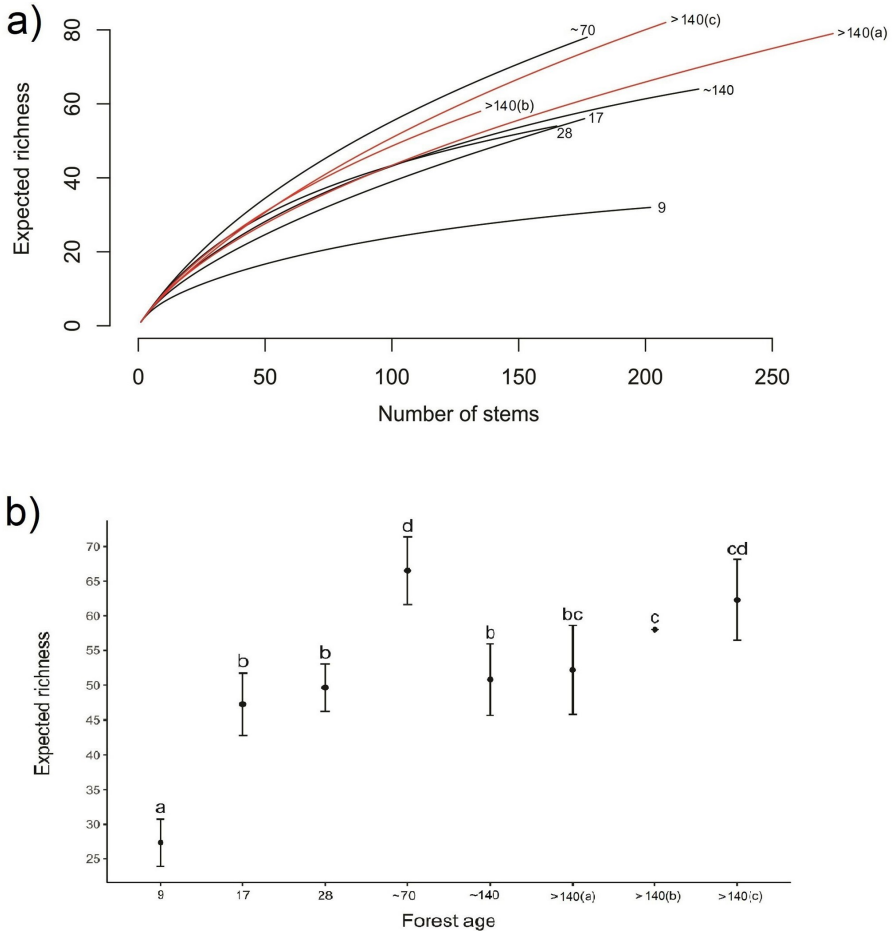
The Zoʻé perspective of forest management is based on an ethic of moderation, and the moderation with spider monkeys represents a keystone biocultural trait (cf. Winter et al. 2018) structuring such a perspective. To our knowledge, although some Amazonian Indigenous Peoples relate to spider monkeys in different ways (Cormier and Urbani 2008), this is the first study that shows that a keystone biocultural trait of moderation can structure many social-ecological relationships and forest management practices, therefore corroborating the hypothesis of Winter et al. (2018). This keystone biocultural trait could thus be used to further study the link between biological and cultural diversity using information entropy criteria (Reyes-Valdés and Kantartzi 2020).

Following the social-ecological framework proposed by Franco-Moraes et al. (2021), the Zoʻé perspective on forest management develops as follows: cosmological aspects (understanding that non-humans have social lives) ground a social-ecological relationship (moderation with spider monkeys) that guides practices (opening/vacating swiddens and camps). In turn, these practices are influenced by information about animals and plants (e.g., spider monkey behaviors) that are interpreted according to a logic of sensible qualities that is centered in olfactory attributes of ethnospecies. It is in this context that Zoʻé forest management promotes different *tekoha* entanglements in space-time, thus promoting landscape transformations that make possible the existence of forest patches in different successional stages.

Zoʻé forest management as a sustainable ecological disturbance promoting forest resilience

After 28 years, basal area in old swidden-fallow forest patches reached similar levels as that of old-growth forests (Table 3), thus suggesting forest biomass resilience after Zoʻé disturbances. Two reasons may contribute to such a recovery in Zoʻé landscapes: (i) local mobility associated with the opening and vacating of forest patches, thus avoiding land-use intensification (Jakovac et al. 2015); (ii) soil improvement because of old burning for opening swiddens

Fig. 5. Comparison among eight forest plots in the Zo'é Indigenous Land, Pará, Brazil, in terms of ethnospecies richness (proxy for alpha diversity). (a) Sample-based rarefaction curves for trees/palms greater than 10 cm CBH for forest plots in different successional stages. Forest plot ages are given next to each solid line. Black lines indicate forest plots located in ancient/old swidden-fallows. Red lines indicate forest plots located in areas where the Zo'é do not recognize historical occupations; (b) Expected richness for forest plots. The expected richness for each plot is represented by black circles, which represent the number of ethnospecies per 135 individuals sampled. The standard value of 135 individuals reflects the smallest number of stems found in our forest plots (i.e., forest plot > 140[b]). Vertical lines represent 95% confidence intervals based on the sample-based rarefaction. Different letters above the lines (a, b, c, and d) identify differences in ethnospecies richness based on the 95% confidence intervals, so that entries sharing the same letter are not different according to the confidence intervals. The results show that after 17 years, fallows can reach richness values similar to old-growth forests (e.g., > 140[a]), and that after ~70 years, these forests can reach the highest richness values of old-growth forests (e.g., > 140[c]).

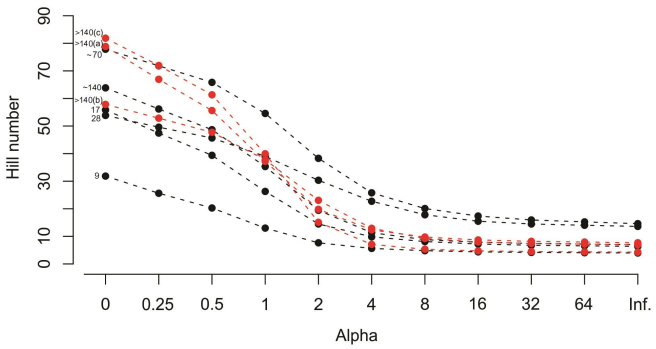


(Franco-Moraes et al. 2019, Levis et al. 2020). Regarding ethnospecies density, our results show that after 17 years, secondary forests may have 70% of the ethnospecies density found in old-growth forests, indicating ethnospecies density resilience.

Secondary and old-growth forests had different floristic compositions in general (Fig. 4), although one old-growth forest plot (≥ 140a) had floristic composition similar to the 28-year-old forest plot. Whereas in secondary forests multiple successional trajectories can explain high floristic variability (Chazdon 2008, Norden et al. 2015), in old-growth forests natural small disturbances can allow colonization by secondary species, so that composition becomes similar to intermediate secondary forests (Chazdon 2003, Schietti et al. 2016). Natural disturbances are common in old-growth forests and may explain, for example, the variation in values of total basal area, ethnospecies density, and total abundance among these forests in our plots (Table 3), although they did not cause changes in the relative abundance of ethnospecies (Fig. 3).

Overall, these results suggest that Zo'é management acts as a sustainable ecological disturbance (cf. Uhl et al. 1990, López-Zent and Zent 2004) by making possible the existence of resilient forest patches with ethnospecies compositions and abundances not found even in disturbed old-growth forests. From the Zo'é's perspective, this occurs because social relations among non-humans in old-swidden fallow areas are different from those in old-growth forests, a perspective also described for the Wajãpi from northeastern Amazonia (de Oliveira 2012).

Fig. 6. Diversity profiles for eight forest plots in the Zo'é Indigenous Land, Pará, Brazil, using Hill's series. The Hill's series consists of an equation that calculates different diversity indexes for the same dataset. Each dotted line represents a forest plot, and the age of the plot is indicated just to the left of the line. Black dotted lines represent forest plots located in ancient/old swidden-fallows, and red lines in areas where the Zo'é do not recognize historical occupations. Alpha is a parameter that represents a certain diversity index. For each Alpha value there is a Hill number that estimates how diverse that forest plot is (black and red circles) according to that diversity index. For example, when the parameter Alpha = 0, the diversity value (Hill number) is the number of ethnospecies in the forest plot. When the parameter Alpha = 1, the diversity value is equivalent to the Shannon Index, which can be obtained by calculating ln(Hill number). For Alpha = 2, the diversity value is equivalent to the Simpson Index, which can be obtained by calculating 1/D (D is the dominance value in the Simpson Index). As the Alpha value increases, richness becomes less important and evenness of ethnospecies becomes more important in the diversity index. When Alpha tends to infinity (Alpha = Inf.), the diversity value is equivalent to ethnospecies evenness.



Zo'é ecological disturbances boost alpha and beta diversity

The intermediate ~70-year-old secondary forest shows the highest values of ethnospecies richness (together with the old-growth forest ≥ 140c; Fig. 5), Shannon and Simpson diversity indexes and ethnospecies evenness (Fig. 6), and a mixture of ethnospecies from young and old-growth forests (Fig. 3). These findings can result from the fact that intermediate successional forests contain opportunistic and competing species coexisting without dominance, which generates a lower degree of competitive exclusion, and thus higher floristic diversity (Connell 1978, Sheil and Burslem 2013). More broadly, our findings suggest that testing the intermediate disturbance hypothesis (IDH) is still a promising avenue (but see Fox 2013, Sheil and Burslem 2013, Barabaìs et al. 2018) to understand biodiversity in forest systems not only from an ecological perspective of disturbance intensity and frequency (Molino and Sabatier 2001, Svensson et al. 2012, Guitet et al. 2018), but also from a biocultural perspective of forest recovery time since the last human disturbance. Moreover, we call attention to the fact that disturbance is only one of the factors that can influence floristic diversity in tropical forests, because topography, dispersal limitation, and soil water availability, among others also influence floristic diversity (Bongers et al. 2009). These factors may explain, for example, the high value of ethnospecies richness found in the old-growth forest ≥ 140c, that made the curve in Figure 5b look bimodal and not unimodal as predicted by the IDH (cf. Johst and Huth 2005).

We also found that the Zo'é's sociocultural strategy of creating spatially heterogeneous successional stages at a landscape scale had a positive impact on beta diversity, because Zo'é landscape transformations promote different ethnospecies compositions across these successional stages (Figs. 3 and 4). We can also interpret these results within the IDH framework at the landscape-scale, as landscapes with intermediate levels of disturbances are expected to have greater beta diversity (Solar et al. 2015). This occurs because beta diversity is low when the set of forest patches are either disturbed or undisturbed in similar ways, and reaches its maximal value when there is a set of forest patches containing both disturbed and undisturbed areas with different alpha diversities and compositions, each implying different recovery time since the last disturbance (Balée 2006, Guèze et al. 2015, Odonne et al. 2019). Overall, these results support previous calls to keep testing the impact of spatial disturbance regimes on beta diversity for ecological understanding (Solar et al. 2015), as well as for biocultural understanding (Maffi 2007).

Different ethnospecies compositions may have resulted not only from natural forest regrowth, but also from the influence of Zo'é practices, such as scattering seeds, cutting trees, and opening gaps. Amazonian Indigenous Peoples have directly influenced species compositions and abundances through these practices (Ferreira et al. 2019, Franco-Moraes et al. 2019), which appears to have occurred in the Zo'é case. For example, greater abundance of ethnospecies used as food in forests between 17 and 140 years old than in old-growth forests (Fig. 3) may be related to these practices, as expected from forest domestication (Levis et al. 2018, Flores and Levis 2021). The Zo'é know the processes that promote this divergence in ethnospecies compositions and have interest in such promotion. However, although this promotion generates food, this interest does not represent an intention to domesticate the forest to produce food, instead, as we show, it is associated with cosmological aspects (cf. da Cunha 2019, Aparício 2020, Santos and Soares 2021), whose result is the emergence of domesticated forests (Levis et al. 2018).

We acknowledge that a greater number of chronosequence samples could further improve our understanding about the influence of Zo'é landscape transformations on biodiversity. One of the most difficult tasks in chronosequence studies is figuring out the age of forest patches in advanced stages of succession, and, in fact, the lack of such information is one of the main reasons why chronosequence-based studies often deviate from long-term monitoring (Walker et al. 2010). In this sense, our study provides important empirical evidence rarely presented in chronosequence studies as we collected information about land use history and age of forest patches in advanced successional stages. Moreover, to our knowledge, this is the first study to show how sociocultural elements associated with Indigenous TEK (i.e., cosmologies, social relations, etc.) have influenced the promotion of floristic diversity in tropical forests.

Overall, our results are relevant to the Zo'é because they highlight the importance of their socioculture for the promotion of local floristic diversity, thus showing the central role of Zo'é TEK in local biodiversity conservation. More broadly, our results highlight how Indigenous forest disturbance regimes can be important for the maintenance or even enhancement of Amazonian floristic diversity, as well as for the resilience of local social-ecological systems.

Implications for biocultural conservation

Biocultural diversity includes biological and cultural diversity, which have coevolved together (Maffi 2007, Gavin et al. 2015), and are threatened by the same political-economic interests (Gorenflo et al. 2012, Aswani et al. 2018, Clement et al. 2020). Biocultural conservation requires acknowledging local perspectives that favor biodiversity according to their own understanding of what diversity is (Rozzi 2018). Here, by taking into account Zo'é knowledge about floristic composition, we show that the Zo'é perspective on forest management influences the promotion of floristic diversity, so that Zo'é TEK leads to ecological outcomes that are expected from biocultural and ecological theories. In this sense, we argue that Indigenous TEK could be of importance for scientific theories that are frequently used to design conservation planning in social-ecological systems (Fernández-Llamazares and Cabeza 2018, Albuquerque et al. 2021). Especially in science assessments, where both the sustainability indicators that we use and how we do our biodiversity analyses influence the results that can be used in political decisions (Sterling et al. 2017), Indigenous TEK can contribute to test hypotheses and assess local outcomes of management practices without causing social injustice (Virtanen et al. 2020, Franco-Moraes et al. 2021).

In 2019, the Zo'é created on their PGTA (Territorial and Environmental Management Plan; Iepé and FPEC 2019), which is an instrument of the Brazilian PNGATI (National Policy for Territorial and Environmental Management of Indigenous Lands). The Zo'é PGTA defines guidelines to ensure Zo'é's territorial autonomy, physical/cultural reproduction, environmental sustainability, and food sovereignty according to Zo'é perspectives. However, proper implementation of the PNGATI and other Indigenous public policies by the Brazilian government has not occurred (Testa et al. 2019), and Brazilian Indigenous Peoples have criticized such negligence (APIB 2019). Along with the PNGATI, other public policies that seek to empower Indigenous Peoples through local governance and stewardship (Ross et al. 2011, Artelle et al. 2019) are important not only from an Indigenous perspective, but also from a scientific perspective. Respecting Indigenous Peoples' land rights and ensuring their governance have improved forests' carbon storage (Stevens et al. 2014, Frechette et al. 2018) and conserved biodiversity (Corrigan et al. 2018, Schuster et al. 2019) worldwide. In this context, we hope that a better understanding of forest management from the Indigenous perspective—by scientists, conservationists, and policy makers—can enrich scientific knowledge, improve our ability to sustainably act on biocultural diversity, and promote social justice.

CONCLUSIONS

Zo'é cosmological aspects underlie a forest management perspective that influences forest disturbance regimes that generate a sustainable social-ecological system. This occurs through the promotion of floristic diversity on both the local level (i.e., in forest patches of intermediate age) and landscape level (i.e., in landscapes with a set of disturbed and undisturbed forests). Zo'é well-being and local forest resilience depend on these forest disturbance regimes, so that the sustainability of the Zo'é social-ecological system is structured by sociocultural aspects that enable sustainable landscape management. We believe that Indigenous perspectives about forest management, which includes cosmological aspects, should be included in forest conservation efforts aimed at protecting Amazonian biocultural diversity (cf. Fernández-Llamazares and Virtanen 2020, Virtanen et al. 2020). Such inclusion should occur by considering local attitudes toward conservation (Kohler and Brondizio 2016), such as the Zo'é forest disturbance regimes. The appreciation of these attitudes can guide inclusive and policy-relevant options for people and nature (cf. McElwee et al. 2020), thus generating resilient and sustainable social-ecological systems.

Author Contributions:

J. F.-M and L. V. B conceived of the project and collected field data; J. F.-M analyzed the data and wrote the initial draft; J. F.-M, L. V. B, and C. R. C revised successive drafts.

Acknowledgments:

We thank all the Zo'é who collaborated with us for their patience, assistance, and knowledge about their forests. We thank Hugo P. S. Pedreira (USP and Iepé) for his assistance during fieldwork, and Alexandre A. Oliveira (USP), Ulysses P. Albuquerque (UFPE), and one anonymous reviewer for numerous useful suggestions to improve the manuscript. J. F.-M thanks the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior for a doctoral scholarship (88882.327879/2019-01), and CRC thanks the Conselho Nacional de Desenvolvimento Científico e Tecnológico for a research fellowship (303477/2018-0). Ethical approval for this study was granted by the Ethics Committee of the Instituto de Biociências of the Universidade de São Paulo (CAAE 53067521.0.0000.5464), and the CONEP (National Research Ethics Committee; report number 5.174.441). Custom R scripts used in our analyses are provided in Appendix 2. Through a Technical Cooperation Agreement between the FUNAI (Fundação Nacional do Índio), the Brazilian governmental agency for Indigenous Peoples, and the Iepé (Instituto de Pesquisa e Formação Indígena), the Iepé and the Zo'é developed collaborative activities between September 2016 and August 2019, funded by Fundo Amazônia. These activities aimed to elaborate the Plano de Gestão Socioambiental (Socioenvironmental Management Plan) of the Zo'é Indigenous Land (Iepé and FPEC 2019). Fieldwork of this study occurred as part of these activities, and the publication of data collected during this fieldwork was authorized by the Zo'é and the Iepé (Appendix 3).

Data Availability:

Data are openly available at https://doi.org/10.17605/OSF.IO/R3WSB

LITERATURE CITED

Albuquerque, U. P., D. Ludwig, I. S. Feitosa, J. M. B. de Moura, P. H. S. Gonçalves, R. H. da Silva, T. C. da Silva, T. Gonçalves-Souza, and W. S. Ferreira Júnior. 2021. Integrating traditional ecological knowledge into academic research at local and global scales. Regional Environmental Change 21:1-11. https://doi.org/10.1007/s10113-021-01774-2

Aparício, M. 2020. Contradomesticação na Amazônia indígena: a botânica da precaução. Pages 189-212 in J. Cabral-Oliveira, M. Amoroso, A. G. Morim de Lima, K. Shiratori, S. Marras, and L. Emperaire, editors. Vozes vegetais: diversidade, resistências e histórias da floresta. Ubu Editora, São Paulo, Brasil.

Artelle, K. A., M. Zurba, J. Bhattacharyya, D. E. Chan, K. Brown, J. Housty, and F. Moola. 2019. Supporting resurgent Indigenous-led governance: a nascent mechanism for just and effective conservation. Biological Conservation 240:108284. https://doi.org/10.1016/j.biocon.2019.108284

Articulação dos Povos Indígenas do Brasil (APIB). 2019. Resistimos há 519 anos e continuaremos resistindo. Mobilização Nacional Indígena. https://mobilizacaonacionalindigena.wordpress.com/2019/04/26/documento-final-do-xv-acampamento-terra-livre/

Aswani, S., A. Lemahieu, and W. H. H. Sauer. 2018. Global trends of local ecological knowledge and future implications. PLoS ONE 13(4):e0195440. https://doi.org/10.1371/journal.pone.0195440

Balée, W. 2006. The research program of historical ecology. Annual Review of Anthropology 35:75-98. https://doi.org/10.1146/annurev.anthro.35.081705.123231

Balée W., and A. Gély. 1989. Managed forest succession in Amazonia: the Ka'apor case. Advances in Economic Botany 7:129-158.

Barabìs, G., R. D'Andrea, and S. M. Stump. 2018. Chesson's coexistence theory. Ecological Monographs 88:277-303. https://doi.org/10.1002/ecm.1302

Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10:1251-1262. https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2

Bernard, H. R. 1988. Research methods in cultural anthropology. Sage, Newbury Park, California, USA.

Bongers, F., L. Poorter, W. D. Hawthorne, and D. Sheil. 2009. The intermediate disturbance hypothesis applies to tropical forests, but disturbance contributes little to tree diversity. Ecology Letters 12:798-805. https://doi.org/10.1111/j.1461-0248.2009.01329.x

Braga, L. V. 2017. Pani'em: um esboço sobre os modos de saber entre os Zo'é. Thesis. Universidade de São Paulo, São Paulo, Brazil.

Braga, L. V. 2021a. Eremi'u rupa. Abrindo roças. Iepé/FPEC-FUNAI/Fundo de Artesanato Zo'é-FAC, São Paulo, Brasil.

Braga, L. V. 2021b. Panem. Sobre seu viés de gênero entre os Zo'é. Mana 27:1-30. https://doi.org/https://doi.org/10.1590/1678-49442021v27n2a201

Braga, L. V., H. P. S. Pedreira, and F. D. Cabalzar. 2020. Fazer saber a própria terra. Pages 133-165 in N. R. Moraes, L. A. Baptaglin, L. E. Vilella, A. C. Campos, and R. F. Azerêdo, editors. Povos originários e comunidades tradicionais: trabalhos de pesquisa e de extensão universitária, vol. 4. Fi, Porto Alegre, Brasil.

Chazdon, R. L. 2003. Tropical forest recovery: legacies of human impact and natural disturbances. Perspectives in Plant Ecology, Evolution and Systematics 6:51-71. https://doi.org/10.1078/143-3-8319-00042

Chazdon, R. L. 2008. Chance and determinism in tropical forest succession. Pages 384-408 in W. P. Carlson, and S. A. Schnitzer, editors. Tropical forest community ecology. Blackwell, Hoboken, New Jersey, USA.

Chazdon, R. L. 2014. Tropical forest dynamics and disturbance regimes. Pages 55-72 in Second growth: the promise of tropical forest regeneration in an age of deforestation. The University of Chicago Press, Chicago, Illinois, USA. https://doi.org/10.7208/chicago/9780226118109.003.0004

Clement, C. R., C. Levis, J. Franco-Moraes, and A. B. Junqueira. 2020. Domesticated nature: the culturally constructed niche of humanity. Pages 35-51 in C. Baldalf, editor. Participatory biodiversity conservation: concepts, experiences, and perspectives. Springer, Cham, Switzerland. https://doi.org/10.1007/978-3-030-41686-7_3

Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs: high diversity of trees and corals is maintained only in a nonequilibrium state. Science 199:1302-1310. https://doi.org/10.1126/science.199.4335.1302

Cormier, L. A., and B. Urbani. 2008. The ethnoprimatology of spider monkeys (*Ateles* spp.): from past to present. Pages 377-403 in C. J. Campbell, editor. Spider monkeys: behavior, ecology and evolution of the genus *Ateles*. Cambridge University Press, Cambridge, UK. https://doi.org/10.1017/CBO9780511721915.014

Corrigan, C., H. Bingham, Y. Shi, E. Lewis, A. Chauvenet, and N. Kingston. 2018. Quantifying the contribution to biodiversity conservation of protected areas governed by Indigenous peoples and local communities. Biological Conservation 227:403-412. https://doi.org/10.1016/j.biocon.2018.09.007

Coscieme, L., H. da Silva Hyldmo, Á. Fernández-Llamazares, I. Palomo, T. H. Mwampamba, O. Selomane, N. Sitas, P. Jaureguiberry, Y. Takahasi, M. Lim, M. P. Barral, J. S. Farinaci, J. Diaz-José, S. Ghosh, J. Ojino, A. Alassaf, B. N. Baatuuwie, L. Balint, Z. Basher, F. Boeraeve, S. Budiharta, R. Chen, M. Desrousseaux, G. Dowo, C. Febria, H. Ghazi, Z. V. Harmáčková, R. Jaffe, M. M. Kalemba, C. K. Lambini, F. P. S. Lasmana, A. A. A. Mohamed, A. Niamir, P. Pliscoff, R. Sabyrbekov, U. B. Shrestha, A. Samakov, A. A. Sidorovich, L. Thompson, and M. Valle. 2020. Multiple conceptualizations of nature are key to inclusivity and legitimacy in global environmental governance. Environmental Science & Policy 104:36-42. https://doi.org/10.1016/j.envsci.2019.10.018

da Cunha, M. C. 2017. Traditional people, collectors of diversity. Pages 257-272 in M. Brightman, and J. Lewis, editors. The

anthropology of sustainability. Palgrave Macmillan, New York, New York, USA. https://doi.org/10.1057/978-1-137-56636-2_15

da Cunha, M. 2019. Antidomestication in the Amazon: swidden and its foes. HAU: Journal of Ethnographic Theory 9:126-136. https://doi.org/10.1086/703870

Datta, R. 2015. A relational theoretical framework and meanings of land, nature, and sustainability for research with Indigenous communities. Local Environment 20:102-113. https://doi.org/10.1080/13549839.2013.818957

de Castro, E. 1998. Cosmological deixis and Amerindian perspectivism. Journal of the Royal Anthropological Institute 4:469-488. https://doi.org/10.2307/3034157

de Oliveira, J. 2012. Entre plantas e palavras. Modos de constituição dos saberes entre os Wajãpi (AP). Thesis. Universidade de São Paulo, São Paulo, Brazil.

de Oliveira, J. 2016. Worlds of gardens and forests. Boletim do Museu Paraense Emílio Goeldi: Ciências Humanas 11:115-131. https://doi.org/https://doi.org/10.1590/1981.81222016000100007

de Oliveira, J. 2019. A sedução das mandiocas. Pages 73-85 in B. C. Labate, and S. L. Goulart, editors. O uso de plantas psicoativas nas Américas. Gramma, Rio de Janeiro, Brasil.

Denevan, W. M. 2001. Cultivated landscapes of native Amazonia and the Andes. Oxford University Press, Oxford, UK.

Descola, P. 2005. Ecology as cosmological analysis. Pages 22-35 in A. Surrallés, and P. G. Hierro, editors. The land within: Indigenous territory and the perception of the environment. IWGIA, Copenhagen, Denmark.

Douterlungne D., S. I. Levy-Tacher, D. J. Golicher, and F. R. Dañobeytia. 2010. Applying Indigenous knowledge to the restoration of degraded tropical rain forest clearings dominated by bracken fern. Restoration Ecology 18:322-329. https://doi.org/10.1111/j.1526-100X.2008.00459.x

Emperaire, L. 2005. A biodiversidade agrícola na Amazônia brasileira: recurso e patrimônio. Revista do Patrimônio Histórico e Artístico Nacional 32:31-43.

Emperaire, L., P. G. Bustamante, C. Fausto, F. Freitas, G. Mendes, and M. Smith. Agrobiodiversidade e roças. 2021. Pages 18-56 in M. C. da Cunha, S. B. Magalhães, and C. Adams, editors. Povos tradicionais e biodiversidade no Brasil—contribuições dos povos indígenas, quilombolas e comunidades tradicionais para a biodiversidade, políticas e ameaças, vol. 7. SBPC, São Paulo, Brasil.

Faith, D. P., P. R. Minchin, and L. Belbin. 1987. Compositional dissimilarity as a robust measure of ecological distance. Vegetatio 69:57-68. https://doi.org/10.1007/BF00038687

Fausto, C. 2008. Too many owners: mastery and ownership in Amazonia. Mana 19:329-366. https://doi.org/10.1590/S0104-93132008000200003

Fausto, C. 2019. La diversité en petits intervalles: logique de variation en Amazonie. Pages 315-328 in G. Cometti, P. Le Roux, T. Manicone, and N. Martin, editors. Au seuil de la forêt. Hommage à Philippe Descola, l'anthropologue de la nature. Tautem, Strasbourg, France.

Fausto, C., and E. G. Neves. 2018. Was there ever a Neolithic in the Neotropics? Plant familiarisation and biodiversity in the Amazon. Antiquity 92:1604-1618. https://doi.org/10.15184/aqy.2018.157

Fernández-Llamazares, Á., and M. Cabeza. 2018. Rediscovering the potential of Indigenous storytelling for conservation practice. Conservation Letters 11:e12398. https://doi.org/10.1111/conl.12398

Fernández-Llamazares, Á., and P. K. Virtanen. 2020. Game masters and Amazonian Indigenous views on sustainability. Current Opinion in Environmental Sustainability 43:21-27. https://doi.org/10.1016/j.cosust.2020.01.004

Ferreira, M. J., C. Levis, J. Iriarte, and C. R. Clement. 2019. Legacies of intensive management in forests around pre-columbian and modern settlements in the Madeira-Tapajós interfluve, Amazonia. Acta Botanica Brasilica 33:212-220. https://doi.org/10.1590/0102-33062018abb0339

Finegan, B. 1996. Pattern and process in neotropical secondary rain forests: the first 100 years of succession. Trends in Ecology & Evolution 11:119-124. https://doi.org/https://doi.org/10.1016/0169-5347(96)81090-1

Flores, B. M., and C. Levis. 2021. Human-food feedback in tropical forests. Science 372:1146-1147. https://doi.org/10.1126/science.abh1806

Food and Agriculture Organization of the United Nations (FAO). 2022. Forest management planning. Sustainable forest management (SFM) toolbox. FAO, Rome, Italy. http://www.fao.org/sustainable-forest-management/toolbox/modules/forest-management-planning/basic-knowledge/en/

Fox, J. 2013. The intermediate disturbance hypothesis should be abandoned. Trends in Ecology & Evolution 28:86-92. https://doi.org/10.1016/j.tree.2012.08.014

Franco-Moraes, J. 2021. Sucessão florestal e o manejo indígena na Amazônia brasileira. Pages 227-229 in M. Carneiro da Cunha, S. B. Magalhães, and C. Adams, editors. Povos tradicionais e biodiversidade no Brasil—contribuições dos povos indígenas, quilombolas e comunidades tradicionais para a biodiversidade, políticas e ameaças. v.7. SBPC, São Paulo, Brasil.

Franco-Moraes, J., A. F. M. B. Baniwa, F. R. C. Costa, H. P. Lima, C. R. Clement, and G. H. Shepard Jr. 2019. Historical landscape domestication in ancestral forests with nutrient-poor soils in northwestern Amazonia. Forest Ecology and Management 446:317-330. https://doi.org/10.1016/j.foreco.2019.04.020

Franco-Moraes, J., C. R. Clement, J. C. de Oliveira, and A. A. de Oliveira. 2021. A framework for identifying and integrating sociocultural and environmental elements of Indigenous peoples' and local communities' landscape transformations. Perspectives in Ecology and Conservation 19:143-152. https://doi.org/10.1016/j.pecon.2021.02.008

Frechette, A., C. Ginsburg, W. Walker, S. Gorelik, S. Keene, C. Meyer, K. Reytar, and P. Veit. 2018. A global baseline of carbon storage in collective lands. Rights and Resources Initiative, Washington, D.C., USA.

Gallois, D. T. 1988. Movimento na cosmologia waiapi: criação, expansão e transformação do universo. Thesis. Universidade de São Paulo, São Paulo, Brazil.

Gallois, D. T., H. P. da Silva Pedreira, and L. V. Braga. 2020. Construindo um Plano de Gestão Territorial e Ambiental com os Zo'é. Pages 108-131 in L. D. B. Grupioni, editor. Em busca do bem viver. Experiências de elaboração de Planos de Gestão Territorial e Ambiental de Terras Indígenas. Rede de Cooperação Amazônica, São Paulo, Brasil.

Gavin, M. C., J. McCarter, A. Mead, F. Berkes, J. R. Stepp, D. Peterson, and R. Tang. 2015. Defining biocultural approaches to conservation. Trends in Ecology & Evolution 30:140-145. https://doi.org/10.1016/j.tree.2014.12.005

Gómez-Pompa, A. 1987. On Maya silviculture. Mexican Studies/Estudios Mexicanos 3:1-17. https://doi.org/10.2307/4617029

Gordon, J. E., and A. C. Newton. 2006. The potential misapplication of rapid plant diversity assessment in tropical conservation. Journal for Nature Conservation 14:117-126. https://doi.org/10.1016/j.jnc.2006.01.001

Gorenflo, L. J., S. Romaine, R. A. Mittermeier, and K. Walker-Painemilla. 2012. Co-occurrence of linguistic and biological diversity in biodiversity hotspots and high biodiversity wilderness areas. Proceedings of the National Academy of Sciences 109:8032-8037. https://doi.org/10.1073/pnas.1117511109

Gotelli, N. J., and R. K. Colwell. 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters 4:379-391. https://doi.org/10.1046/j.1461-0248.2001.00230.x

Gough, A. D., J. L. Innes, and S. D. Allen. 2008. Development of common indicators of sustainable forest management. Ecological Indicators 8:425-430. https://doi.org/10.1016/j.ecolind.2007.03.001

Guèze, M., A. C. Luz, J. Paneque-Gálvez, M. J. Macía, M. Orta-Martínez, J. Pino, and V. Reyes-García. 2015. Shifts in Indigenous culture relate to forest tree diversity: a case study from the Tsimane', Bolivian Amazon. Biological Conservation 186:251-259. https://doi.org/10.1016/j.biocon.2015.03.026

Guitet, S., D. Sabatier, O. Brunaux, P. Couteron, T. Denis, V. Freycon, S. Gonzalez, B. Hérault, G. Jaouen, J. -F. Molino, R. Pélissier, C. Richard-Hansen, and G. Vincent. 2018. Disturbance regimes drive the diversity of regional floristic pools across Guianan rainforest landscapes. Scientific Reports 8:1-12. https://doi.org/https://doi.org/10.1038/s41598-018-22209-9

Havt, N. 2001. Representações do ambiente e da territorialidade entre os Zo'é/PA. Thesis. Universidade de São Paulo, São Paulo, Brazil.

Hill, R., G. Nates-Parra, J. J. G. Quezada-Euán, D. Buchori, G. LeBuhn, M. M. Maués, P. L. Pert, P. K. Kwapong, S. Saeed, S. J. Breslow, M. C. da Cunha, L. V. Dicks, L. Galetto, M. Gikungu, B. G. Howlett, V. L. Imperatriz-Fonseca, P. O'B. Lyver, B. Martín-López, E. Oteros-Rozas, S. G. Potts, and M. Roué. 2019. Biocultural approaches to pollinator conservation. Nature Sustainability 2:214-222. https://doi.org/10.1038/s41893-019-0244-z

Iepé, Instituto de Pesquisa e Formação Indígena, and FPEC, Frente de Proteção Etnoambiental Cuminapanema. 2019. Jo'e rekoha bokituteha ram: planejando como vamos continuar vivendo bem no futuro - Plano de Gestão Territorial e Ambiental da TI Zo'é. Iepé, São Paulo, Brasil.

Instituto Nacional de Meteorologia (INMET). 2020. INMET, Setor Sudoeste, Brasil. http://www.inmet.gov.br/portal/

Jakovac, C. C., M. Peña-Claros, T. W. Kuyper, and F. Bongers. 2015. Loss of secondary-forest resilience by land-use intensification in the Amazon. Journal of Ecology 103:67-77. https://doi.org/10.1111/1365-2745.12298

Johst, K., and A. Huth. 2005. Testing the intermediate disturbance hypothesis: when will there be two peaks of diversity? Diversity and Distributions 11:111-120. https://doi.org/https://doi.org/10.1111/j.1366-9516.2005.00133.x

Kettle, C. J. 2012. Seeding ecological restoration of tropical forests: priority setting under REDD+. Biological Conservation 154:34-41. https://doi.org/10.1016/j.biocon.2012.03.016

Kitamura, S. 2011. Frugivory and seed dispersal by Hornbills (*Bucerotidae*) in tropical forests. Acta Oecologica 37:531-541. https://doi.org/10.1016/j.actao.2011.01.015

Kohler, F., and E. S. Brondizio. 2017. Considering the needs of Indigenous and local populations in conservation programs. Conservation Biology 31:245-251. https://doi.org/10.1111/cobi.12843

Lawrence, D., C. Radel, K. Tully, B. Schmook, and L. Schneider. 2010. Untangling a decline in tropical forest resilience: constraints on the sustainability of shifting cultivation across the globe. Biotropica 42:21-30. https://doi.org/10.1111/j.1744-7429.2009.00599.x

Legendre, P., and L. Legendre. 2012a. Ecological resemblance. Pages 265-336 in Numerical ecology, third edition. Elsevier, Amsterdam, The Netherlands. https://doi.org/https://doi.org/10.1016/B978-0-444-53868-0.50007-1

Legendre, P., and L. Legendre. 2012b. Cluster analysis. Pages 337-424 in Numerical ecology, third edition. Elsevier, Amsterdam, The Netherlands. https://doi.org/https://doi.org/10.1016/B978-0-444-53868-0.50008-3

Levis, C., B. M. Flores, P. A. Moreira, B. G. Luize, R. P. Alves, J. Franco-Moraes, J Lins, E. Konings, M. Peña-Claros, F. Bongers, F. R. C. Costa, and C. R. Clement. 2018. How people domesticated Amazonian forests. Frontiers in Ecology and Evolution 5:171. https://doi.org/10.3389/fevo.2017.00171

Levis, C., M. Peña-Claros, C. R. Clement, F. R. C. Costa, R. P. Alves, M. J. Ferreira, C. G. Figueiredo, and F. Bongers. 2020. Pre-Columbian soil fertilization and current management maintain food resource availability in old-growth Amazonian forests. Plant and Soil 450:29-48. https://doi.org/10.1007/s11104-020-04461-z

Lévi-Strauss, C. 1962. The savage mind. University of Chicago, Chicago, Illinois, USA.

Lévi-Strauss, C. 1968. Mythologiques III: "Origine des manières de table. Librairie Plon, Paris, France.

Link, A., and A. Di Fiore. 2006. Seed dispersal by spider monkeys and its importance in the maintenance of neotropical rain-forest diversity. Journal of Tropical Ecology 22:235-246. https://doi.org/10.1017/S0266467405003081

Loh, J., and D. Harmon. 2005. A global index of biocultural diversity. Ecological Indicators 5:231-241. https://doi.org/10.1016/j.ecolind.2005.02.005

López-Zent, E., and S. Zent. 2004. Amazonian Indians as ecological disturbance agents: the Hotï of the Sierra de Maigualida, Venezuelan Guayana. Advances in Economic Botany 15:79-112.

Maffi, L. 2007. Biocultural diversity and sustainability. Pages 267-77 in J. Pretty, T. Benton, J. Guivant, D. R. Lee, D. Orr, M. J. Pfeffer, and H. Ward, editors. The SAGE handbook on environment and society. SAGE, London, UK. https://sk.sagepub.com/reference/hdbk_envirosociety/n18.xml#:~:text=https%3A//dx.doi.org/10.4135/9781848607873.n18

McCune, B., and J. B. Grace. 2002. Nonmetric multidimensional scaling. Pages 125-142 in Analysis of ecological communities. Wild Blueberry Media, Corvallis, Oregon, USA.

McDonald, G. T., and M. B. Lane. 2004. Converging global indicators for sustainable forest management. Forest Policy and Economics 6:63-70. https://doi.org/10.1016/S1389-9341(02)00101-6

McElwee, P., Á. Fernández-Llamazares, Y. Aumeeruddy-Thomas, D. Babai, P. Bates, K. Galvin, M. Guèze, J. Liu, Z. Molnár, H. T. Ngo, V. Reyes-García, R. R. Chowdhury, A. Samakov, U. B. Shrestha, S. Díaz, and E. S. Brondízio. 2020. Working with Indigenous and local knowledge (ILK) in large-scale ecological assessments: reviewing the experience of the IPBES Global Assessment. Journal of Applied Ecology 57:1666-1676. https://doi.org/10.1111/1365-2664.13705

Mesquita, R. D. C. G., P. E. D. S. Massoca, C. C. Jakovac, T. V. Bentos, and G. B. Williamson. 2015. Amazon rain forest succession: stochasticity or land-use legacy? BioScience 65:849-861. https://doi.org/10.1093/biosci/biv108

Molino, J. F., and D. Sabatier. 2001. Tree diversity in tropical rain forests: a validation of the intermediate disturbance hypothesis. Science 294:1702-1704. https://doi.org/10.1126/science.1060284

Mondardo, M. 2019. Tekoha: lutas indígenas pelo território. EdUFRR, Roraima, Brasil.

Mukul, S. A., J. Herbohn, and J. Firn. 2020. Rapid recovery of tropical forest diversity and structure after shifting cultivation in the Philippines uplands. Ecology and Evolution 10:7189-7211. https://doi.org/10.1002/ece3.6419

Nikinmaa, L., M. Lindner, E. Cantarello, A. S. Jump, R. Seidl, G. Winkel, and B. Muys. 2020. Reviewing the use of resilience concepts in forest sciences. Current Forestry Reports 6:61-80. https://doi.org/10.1007/s40725-020-00110-x

Norden, N., H. A. Angarita, F. Bongers, M. Martínez-Ramos, I. Granzow-de la Cerda, M. van Breugel, E. Lebrija-Trejos, J. A. Meave, J. Vandermeer, G. B. Williamson, B. Finegan, R. Mesquita, and R. L. Chazdon. 2015. Successional dynamics in Neotropical forests are as uncertain as they are predictable. Proceedings of the National Academy of Sciences 112:8013-8018. https://doi.org/10.1073/pnas.1500403112

Odonne, G., M. van den Bel, M. Burst, O. Brunaux, M. Bruno, E. Dambrine, D. Davy, M. Desprez, J. Engel, B. Ferry, V. Freycon, P. Grenand, S. Jérémie, M. Mestre, J.-F. Molino, P. Petronelli, D. Sabatier, and B. Hérault. 2019. Long-term influence of early human occupations on current forests of the Guiana Shield. Ecology 100:e02806. https://doi.org/10.1002/ecy.2806

Oliveira, M. M., N. Higuchi, C. H. Celes, and F. G. Higuchi. 2014. Tamanho e formas de parcelas para inventários florestais de espécies arbóreas na Amazônia central. Ciência Florestal 24:645-653. https://doi.org/10.5902/1980509815744

Perrault-Archambault, M., and O. T. Coomes. 2008. Distribution of agrobiodiversity in home gardens along the Corrientes River, Peruvian Amazon. Economic Botany 62:109-126. https://doi.org/10.1007/s12231-008-9010-2

Phillips, O. L., and A. H. Gentry. 1993. The useful plants of Tambopata, Peru: II. Additional hypothesis testing in quantitative ethnobotany. Economic Botany 47:33-43. https://doi.org/10.1007/BF02862204

Pires, J. M., and G. T. Prance. 1985. The vegetation types of the Brazilian Amazon. Pages 109-145 in G. T. Prance, and T. E. Lovejoy, editors. Key environments: Amazonia. Elsevier Science & Technology, Oxford, UK.

Poffenberger, M., and B. McGean. 1993. Communities and forest management in east Kalimantan: pathway to environmental stability. Center for Southeast Asia Studies, University of California, Berkeley, California, USA.

Prance, G. T., W. Balee, B. M. Boom, and R. L. Carneiro. 1987. Quantitative ethnobotany and the case for conservation in Amazonia. Conservation Biology 1:296-310. https://doi.org/10.1111/j.1523-1739.1987.tb00050.x

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/

Reyes-Valdés, M. H., and S. K. Kantartzi. 2020. An information theory approach to biocultural complexity. Scientific Reports 10:1-8. https://doi.org/10.1038/s41598-020-64260-5

Rival, L., and D. McKey. 2008. Domestication and diversity in manioc (*Manihot esculenta* Crantz ssp. *esculenta*, Euphorbiaceae). Current Anthropology 49:1119-1128. https://doi.org/10.1086/593119

Ross, A., K. Pickering, J. G. Snodgrass, H. D. Delcore, and R. Sherman. 2011. Indigenous peoples and the collaborative stewardship of nature: knowledge binds and institutional conflicts. Left Coast Press, Walnut Creek, California, USA. https://doi.org/10.4324/9781315426617

Rozzi, R. 2018. Biocultural conservation and biocultural ethics. Pages 303-314 in R. Rozzi, R. H. May Jr., F. S. Chapin III, F. Massardo, M. C. Gavin, I. J. Klaver, A. Pauchard, M. A. Nuñez, and D. Simberloff, editors. Biocultural homogenization to biocultural conservation. Springer, Cham, Switzerland. https://doi.org/10.1007/978-3-319-99513-7_19

Saldarriaga, J. G., D. C. West, M. L. Tharp, and C. Uhl. 1988. Long-term chronosequence of forest succession in the Upper Rio Negro of Colombia and Venezuela. Journal of Ecology 76:938-958. https://doi.org/10.2307/2260625

Santos, G. M., and G. H. Soares. 2021. Amazônia indomável: relações fora do alcance da domesticação. Mundo Amazónico 12:e89601. https://doi.org/https://doi.org/10.15446/ma.v12n1.89601

Schietti, J., D. Martins, T. Emilio, P. F. Souza, C. Levis, F. B. Baccaro, J. L. P. da Veiga Pinto, G. M. Moulatlet, S. C. Stark, K. Sarmento, R. N. O. de Araújo, F. R. C. Costa, J. Schöngart, C. A. Quesada, S. R. Saleska, J. Tomasella, and W. E. Magnusson. 2016. Forest structure along a 600 km transect of natural disturbance and seasonality gradients in central-southern Amazonia. Journal of Ecology 104:1335-1346. https://doi.org/10.1111/1365-2745.12596

Schuster, R., R. R. Germain, J. R. Bennett, N. J. Reo, and P. Arcese. 2019. Vertebrate biodiversity on Indigenous-managed lands in Australia, Brazil, and Canada equals that in protected areas. Environmental Science & Policy 101:1-6. https://doi.org/10.1016/j.envsci.2019.07.002

Sheil, D., and D. F. R. P. Burslem. 2013. Defining and defending Connell's intermediate disturbance hypothesis: a response to Fox. Trends in Ecology & Evolution 28:571-572. https://doi.org/https://doi.org/10.1016/j.tree.2013.07.006

Solar, R. R. C., J. Barlow, J. Ferreira, E. Berenguer, A. C. Lees, J. R. Thomson, J. Louzada, M. Maués, N. G. Moura, V. H. F. Oliveira, J. C. M. Chaul, J. H. Schoereder, I. C. Guimarães Vieira, R. Mac Nally, and T. A. Gardner. 2015. How pervasive is biotic homogenization in human-Zmodified tropical forest landscapes? Ecology Letters 18:1108-1118. https://doi.org/10.1111/ele.12494

Sterk, M., I. A van de Leemput, and E. T. H. M. Peeters. 2017. How to conceptualize and operationalize resilience in socio-ecological systems? Current Opinion in Environmental Sustainability 28:108-113. https://doi.org/https://doi.org/10.1016/j.cosust.2017.09.003

Sterling, E. J., C. Filardi, A. Toomey, A. Sigouin, E. Betley, N. Gazit, J. Newell, S. Albert, D. Alvira, N. Bergamini, et al. 2017. Biocultural approaches to well-being and sustainability indicators across scales. Nature Ecology and Evolution 1:1798-1806. https://doi.org/10.1038/s41559-017-0349-6

Stevens, C., R. Winterbottom, J. Springer, and K. Reytar. 2014. Securing rights, combating climate change: how strengthening community forest rights mitigates climate change. World Resources Institute, Washington, D.C., USA.

Svensson, J. R., M. Lindegarth, P. R. Jonsson, and H. Pavia. 2012. Disturbance-diversity models: what do they really predict and how are they tested? Proceedings of the Royal Society B: Biological Sciences 279:2163-2170. https://doi.org/https://doi.org/10.1098/rspb.2011.2620

Tengö, M., E. S. Brondizio, T. Elmqvist, P. Malmer, and M. Spierenburg. 2014. Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. Ambio 43:579-591. https://doi.org/10.1007/s13280-014-0501-3

Testa, A. Q., A. Clistenes, A. da Cruz, A. R. G. B. Proenç, and G. H. Shepard Jr. 2019. Crisis in the Amazon. New York Review of Books 66:46-46.

Tóthmérész, B. 1995. Comparison of different methods for diversity ordering. Journal of Vegetation Science 6:283-290. https://doi.org/10.2307/3236223

Uhl, C., D. Nepstad, R. Buschbacher, K. Clark, B. Kauffman, and S. Subler. 1990. Studies of ecosystem response to natural and anthropogenic disturbances provide guidelines for designing sustainable land-use systems in Amazonia. Pages 24-42 in A. B. Anderson, editor. Alternatives to deforestation: steps toward sustainable use of the Amazon rain forest. Columbia University Press, New York, New York, USA.

Venturieri, A., O. S. Watrin, M. A. Valente, A. G. S. Campos, and P. B. Silva Neto. 2000. Zoneamento agroecológico nas terras quilombolas Trombetas e Erepecuru. ARQMO-Comissão Pró-Índio de São Paolo, São Paulo, Brasil.

Villa, P. M., S. V. Martins, S. N. de Oliveira Neto, A. C. Rodrigues, L. G. Martorano, L. D. Monsanto, N. M. Cancio, and M. Gastauer. 2018. Intensification of shifting cultivation reduces forest resilience in the northern Amazon. Forest Ecology and Management 430:312-320. https://doi.org/10.1016/j.foreco.2018.08.014

Virtanen, P. K., L. Siragusa, and H. Guttorm. 2020. Introduction: toward more inclusive definitions of sustainability. Current Opinion in Environmental Sustainability 43:77-82. https://doi.org/10.1016/j.cosust.2020.04.003

Walker, L. R., D. A. Wardle, R. D. Bardgett, and B. D. Clarkson. 2010. The use of chronosequences in studies of ecological succession and soil development. Journal of Ecology 98:725-736. https://doi.org/10.1111/j.1365-2745.2010.01664.x

Whittaker, R. H. 1967. Gradient analysis of vegetation. Biological Reviews 49:207-264. https://doi.org/10.1111/j.1469-185X.1967.tb01419.x

Winter, K. B., N. K. Lincoln, and F. Berkes. 2018. The social-ecological keystone concept: a quantifiable metaphor for understanding the structure, function, and resilience of a biocultural system. Sustainability 10:3294. https://doi.org/10.3390/su10093294

Appendix 1.

Maximum genealogical memory of the Zo'é

Records of Zo'é birth dates from 1992 are accurate. The first official census for the Zo'é people was carried out by the Funai in collaboration with the anthropologist Dominique Tilkin Gallois in 1992. Currently, the census is carried out by the Sesai (Secretaria Especial de Saúde Indígena) – the Brazilian governmental agency that coordinates and executes national public policies for the health care of indigenous peoples – that shares the information with the Funai. Nurses of the Sesai act permanently in the Zo'é Indigenous Land and accompany all births. Both, the Funai and Sesai share their censuses with interested institutions, such as the Iepé, and we have access to all data as we are advisors of Iepé.

Birth years prior to 1992 are approximations. Gallois carried out the first kinship survey among the Zo'é and included projections for birth years for all the Zo'é who were alive in 1992. In her calculations, she used the average age for maternity/paternity of 18 year-old. Her kinship data includes a name list of dead Zo'é persons, but without projections for their birth years. We expanded this list through ethnographic information about kinship among the Zo'é collected between 2012 and 2021. Here, we projected birth years for some dead Zo'é persons whose names were on the list. For this, we recalculated the average age for maternity/paternity among the Zo'é by using birth data of Zo'é persons born between 1991 and 2021. The average age was 17.84, a similar value to that used by Gallois in 1992. Therefore, we defined that, in average, every 18 years a new Zo'é generation starts.

We carried out several maternity/paternity genealogies for different Zo'é family lineages, from current generations to the more ancient generations remembered by the Zo'é. The result was a maximum genealogical memory of eight generations for the

lineage shown below (Supplementary Table 3). In this lineage (elaborated in 2021), Jiawu hum (represented in the supplementary table 1 by the generational term “Ego”), born in 2009, does not have children. As we backed tracked the Jiawu hum genealogy according to the Zo’é ancestral memory, we reached the ancestral parental limit due to the lack of information about the ancestrality of Tupã, a Zo’é acknowledged as an important leader in the historical occupation of the region where we carried out our floristic inventories. According to our calculation, Tupã should have been born around 1876, which is about 143 years before the year we carried out our floristic inventories (i.e., 2019). This ancestral memory of eight generations, or 143 years, allowed us estimated the occupation history of the region where we carried out our fieldwork in 2019. Just as the Zo’é know the descendant lineage of Tupã, they also know the territorial movements done by him and their descendants. In this sense, we can affirm that the forest patches inventoried by us named Kyrybyrity ki’a, Kuruwaty hemba ki’a and Barakeja ypa parabyha ki’a were not cleared in the last 143 years at least, and so represent old-growth/mature forests.

Table A1.1. Maximum genealogical memory of the Zo’é.

Generation	People’s name	Gender	Birth date	Information sources
-7	Tupã †	M	~1876	Our calculation
-6	Kanikot †	M	~1894	Our calculation
-5	Awa'e †	M	~1912	Our calculation
-4	Siran †	F	~1930	Our calculation
-3	Ikarong †	M	~1948	Census of Funai and Gallois
-2	Jawara	F	~1976	Census of Funai and Gallois
-1	Uo puku	M	01/06/1994	Census of Funai and Sesai
Ego	Jiawu hum	M	08/10/2009	Census of Funai and Sesai

“Generation” corresponds to the family ancestrality of the lineage; “People’s name” corresponds to the name of the person of the generation and includes the son, father, grandfather, great grandfather and so on; “Gender” includes male (M) and female (F); “Birth date” is the exact date (for Jiawu hum and Uo puku) or the approximate year (all other persons) in which a specific person was born; “Information sources” are the sources used to reach the birth date. The † symbol in front of the names indicates that the person is dead.

Date of village evacuations

The year Narera taperet and Kuruwaty taperet were evacuated was calculated from data contained in the censuses. Both evacuations occurred because of the death of specific persons: Narera taperet in 2010 and Kuruwaty taperet in 2002. Evacuation of Misaw taperet, in turn, is documented in Gallois and Havt (1998) and occurred in 1991.

The approximate year Bikura rupa taperet was evacuated was calculated in terms of the maturity of Biri, our main Zo'é collaborator, born in ~1945. We asked Biri which current Zo'é person he looked like when he met Bikura rupa taperet. Biri pointed to Riru, born in 2004, who in 2019 was 15 years old. Thus, we inferred that Biri was 15 years old when he met Bikura rupa taperet, that is he knew him around 1960. Then, we asked Biri which current fallow is similar to the successional stage of Bikura rupa taperet when he met him. Biri told us that, at that time, Bikura rupa taperet had some palms and tress, as well as a flechal (i.e., a population of *Gynerium sagittatum*, a Poacea species that only occurs in young fallows), and thus looked like a 10 year-old fallow. Therefore, we inferred that Bikura rupa taperet was fallowed around 1950.

Finally, the Dipisow taperet area was part of the village of the ancient leader Dipisow. This fallow was already frequented by Zo'é people from the generation of Biri's grandparents, that is people born two generations earlier than Biri's generation, around 1910. When adults (~1930), these people camped in Dipisow taperet to collect inajá fruits and hunt white-lipped peccaries (*Tayassu pecari*). As the Zo'é have no memory about the leader Dipisow and his descendants, we inferred that Dipisow taperet was fallowed before to the approximate year of Zo'é ancestral memory, that is before 1876.

Appendix 2.

Custom R scripts:

Loading packages and calling the data

```
library(vegan)

library(ggplot2)

setwd(choose.dir())

data<-read.table("sucessao_ABUND.txt", header=T) ### data containing abundances of the 10 most abundant ethnospecies in each plot

species<-data [, 3:49] ### removing the columns “Area” and “Environment”

data2<-read.table("sucessão_final_tudo3.txt", header=T) ### data containing abundances of all 230 ethnospecies

species2<-data2[, 3:232] ### removing the columns “Area” and “Environment”
```

Gradient of relative abundance of ethnospecies ordered by the one-dimensional NMDS (Figure 3)

```
### 1 – Generic function that sorts data###

generic<-function(tabel,gradient,at,grad,axisY,axisX){

tabel<-as.matrix(tabel)

gradient<-as.matrix(gradient)

weighted.average <-colSums(tabel*gradient[,1])/colSums(tabel)

sub.orden<-tabel[order(gradient[,1],decreasing=F),]          # sort plots according to the gradient

sub.orde<-sub.orden[,order(weighted.average,decreasing=T)] # put species sorted by the weighted average

data.pa<-matrix(0,nrow(tabel),ncol(tabel))

data.pa[tabel>0]<-1

ordered<-sub.orde[,which(colSums(data.pa)>0)] ## to delete possible empty columns (species that did not occur)

par(mfrow=c(ncol(ordenado)+1,1),mar=c(0,4,0.2,10),oma=c(3,1,1,6))

layout(matrix(1:(ncol(ordered)+1)),heights=c(3,rep(1,ncol(ordered))))

plot(sort(gradient[,1]),axes=F,ylab="",mfg=c(21,1),lwd=10,las=2,lend="butt",frame.plot=F,xaxt="n",type="h",col="black",ylim=c(min(gradient),max(gradient)))
```

```
axis(side=2,at=c(0,max(gradient)),las=2)
mtext(grad,4,outer=T,font=2,line=-10,padj=-18.5,las=2)
for(i in 1:ncol(ordered)){
barplot(ordered[,i],bty="l",axisnames=F,axes=FALSE,col="black")
#axis(side=2,at=max(ordered[,i]),las=2)
mtext(colnames(ordered)[i],3,line=-1.0,adj=0,at=at,cex=.8,font=3)
}
mtext(axisX,1,outer=T,font=2,line=1.2)
mtext(axisY,2,font=2,outer=T,line=-2)
}

### 2 – NMDS ###
parc1<-decostand(species,"total",MARGIN=1) ### standardization method for ordering rows (ethnospecies abundances)
resu<-metaMDS(parc1,distance = "bray", k=1,trymax=100,autotransform=F)
scor.nmds<-resu$points
summary(lm(vegdist(parc1)~vegdist(scor.nmds,"euclid")))
plot(scor.nmds, type="n", main="NMDS with Vegan") ### NMDS plot
text(scor.nmds)
generic(parc1,scor.nmds, 9.75, "") ### ordering plots by ethnospecies abundances
```

Dendrogram of the hierarchical clustering analysis to compare floristic composition (Figure 4)

```
cluster<-vegdist(species2, method="jaccard", binary=T)
phylogeny<-hclust(cluster, method="average")
plot(phylogeny, hang=-1)
matrix_cof<-cophenetic(phylogeny)
cor(matrix_cof, dist.jac) ### Cophenetic correlation coefficient
```

Comparison among plots in terms of ethnospecies richness (Figure 5)

```
### 1 – Rarefaction curves ###
```

```
rarecurve(species2, lty=1, xlab = "Number of stems", ylab="Expected richness",
      xlim=c(0,280), ylim=c(0,85), col=c("red", "black")[Environment], label=F)
```

Expected richness with 95% confidence intervals

```
min(rowSums(species2)) ### minimum value of abundance showed in the rarefaction curves (value = 135)

Srar<-rarefy(species2, 135, se=T) ### average values of expected richness for each plot (standardized by the minimum value) and their standard errors

rarefaction <-read.table("Rarefação_Confiança.txt", header=T) ### data containing the average values of expected richness for each plot and their 95% confidence intervals (1.96 * standard error)

ggplot(rarefaction, aes(x=Group, y=Average, group=1)) +
    geom_errorbar(aes(ymin= Average-IC, ymax= Average+IC), width=.1) +
    geom_point() +
    theme_bw() +
    theme(panel.border = element_blank(), panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(), axis.line = element_line(colour = "black")) +
    scale_x_discrete(limits=c("1","2","3","4","5","6","7","8")) +
    scale_y_continuous(breaks=seq(0, 70, 5)) +
    labs(x="Forest age", y="Expected richness")
```

Diversity profiles using Hill's series (Figure 6)

Naret, Kuruwaty, Missão, Bikut, Dipisow, MataKoporuhu, MataKuruwaty and MataDipisowNaret are the names of the sampled forest areas

```
Naret<-data2[1, 3:232]

Kuruwaty<- data2 [2, 3:232]

Missão<- data2 [3, 3:232]

Bikut<- data2 [4, 3:232]

Dipisow<- data2[5, 3:232]

MataKoporuhu<- data2[6, 3:232]

MataKuruwaty<- data2[7, 3:232]
```

```
MataDipisowNaret<- data2[8, 3:232]


nine<-renyi(Naret, hill=T)
seventeen<-renyi(Kuruwaty, hill=T)
twentyeight<-renyi(Missão, hill=T)
seventy <-renyi(Bikut, hill=T)
onehundredforty <-renyi(Dipisow, hill=T)
oldforest1<-renyi(MataKoporuhu, hill=T)
oldforest2<-renyi(MataKuruwaty, hill=T)
oldforest3<-renyi(MataDipisowNaret, hill=T)


plot.default(nine, type="l", lty=2, xlab="Alpha", ylab="Hill number", ylim=c(0,90))
points(nine, pch=16)
points(seventeen, type="l", lty=2)
points(seventeen, pch=16)
points(twentyeight, type="l", lty=2)
points(twentyeight, pch=16)
points(seventy, type="l", lty=2)
points(seventy, pch=16)
points(onehundredforty, type="l", lty=2)
points(onehundredforty, pch=16)
points(oldforest1, type="l", lty=2, col="red")
points(oldforest1, col="red", pch=16)
points(oldforest2, type="l", lty=2, col="red")
points(oldforest2, col="red", pch=16)
points(oldforest3, type="l", lty=2, col="red")
points(oldforest3, col="red", pch=16)
```

APPENDIX 3

Document A: Technical Cooperation Agreement

partir de 01/01/2016, alterando as Cláusulas Segunda e Terceira. Fundamento Legal: Lei n° 8.666/93 e suas alterações. Valor Total: R$4.173,20. Fonte: 100000000 - 2016NE800013. Data de Assinatura: 20/05/2016.

(SICON - 30/05/2016) 194035-19208-2016NE800005

COORDENAÇÃO REGIONAL DE MANAUS

EXTRATO DE INEXIGIBILIDADE DE LICITAÇÃO Nº 1/2016 - UASG 194006

Nº Processo: 8769-0007/2016-27 . Objeto: Serviço de fornecimento de água canalizada e esgoto/saneamento, para a CTL de Autazes-AM. Total de Itens Licitados: 00001. Fundamento Legal: Art. 25º, Inciso I da Lei nº 8.666 de 21/06/1993.. Justificativa: O objeto enquadra-se na modalidade pertinente ao Art.25; Inc I, Lei 8.666/93. Declaração de Inexigibilidade em 20/05/2016. IGOR MONTEIRO DE PAULA MEIRA. Chefe Ngcomp. Ratificação em 23/05/2016. EDIVALDO DOS SANTOS OLIVEIRA. Coordenador Regional. Valor Global: R$ 540,00. CNPJ CONTRATADA : 04.406.195/0001-25 COMPANHIA DE SANEAMENTO DO AMAZONAS.

(SIDEC - 30/05/2016) 194035-19208-2016NE800005

EXTRATO DE INEXIGIBILIDADE DE LICITAÇÃO Nº 2/2016 - UASG 194006

Nº Processo: 08769000005201638 . Objeto: Fornecimento de água canalizada e esgoto/ saneamento para CTL de Parintins-AM Total de Itens Licitados: 00001. Fundamento Legal: Art. 25º, Inciso I da Lei nº 8.666 de 21/06/1993.. Justificativa: O objeto enquadra-se na modalidade pertinente ao Art.25; Inc I, Lei 8.666/93 Declaração de Inexigibilidade em 20/05/2016. IGOR MONTEIRO DE PAULA MEIRA. Chefe Ngcomp. Ratificação em 23/05/2016. EDIVALDO DOS SANTOS OLIVEIRA. Coordenador Regional. Valor Global: R$ 996,00. CNPJ CONTRATADA : 04.597.340/0001-00 SERVICO AUTONOMO DE AGUA E ESGOTO DE PARINTINS SAAE.

(SIDEC - 30/05/2016) 194035-19208-2016NE800005

DIRETORIA DE PROMOÇÃO AO DESENVOLVIMENTO SUSTENTÁVEL

EXTRATO DE ACORDO DE COOPERAÇÃO TÉCNICA

Acordo nº 02/2016. Processo nº 08620.089245/2015-77. Partícipes: Fundação Nacional do Índio - FUNAI, CNPJ nº 00.059.311/0001-26, representada por seu Presidente Sr. João Pedro Gonçalves da Costa, CPF nº 041.161.782-68 e o Instituto de Pesquisa e Formação Indígena - IEPÉ, organização não governamental sem fins lucrativos, representado por sua Presidente Sra. Maria Bernadette Arantes Nogueira Franceschini, CPF nº 542.036.008-04. Objeto: Estabelecimento de bases e normas para cooperação técnica, visando a realização de atividades de formação e fortalecimento cultural, político e das formas de gestão comunitária e coletiva para o desenvolvimento sustentável das comunidades indígenas que vivem no Amapá e Norte do Pará.
Dos Recursos: O presente Acordo não possibilita a transferência, direta ou indireta, de recursos financeiros entre os signatários, ficando cada parte responsável pelos recursos necessários à implementação das ações que forem de sua responsabilidade.
Da Vigência: 04 anos, contados da data de sua publicação.
Data de Assinatura: 10/05/2016.

SECRETARIA NACIONAL DE SEGURANÇA PÚBLICA

EXTRATO DE TERMO ADITIVO Nº 1/2016 - UASG 200331

Número do Contrato: 3/2015.
Nº Processo: 08020011476201534.
PREGÃO SRP Nº 37/2014. Contratante: MINISTERIO DA JUSTICA -CNPJ Contratado: 59275792000150. Contratado : GENERAL MOTORS DO BRASIL LTDA -Objeto: Alteração da Cláusula Décima Primeira, prorrogando o prazo de vigência do Contrato nº 03/2015 por mais seis meses a partir de 02 de junho de 2016. Fundamento Legal: Art. 57, II, da Lei 8666/93 .Vigência: 02/06/2016 a 01/12/2016. Data de Assinatura: 30/05/2016.

(SICON - 30/05/2016) 200331-00001-2016NE800049

EDITAL 1º ADITAMENTO À CHAMADA PÚBLICA Nº 1/2016

A SECRETARIA NACIONAL DE SEGURANÇA PÚBLICA - SENASP torna público o aditamento ao Edital de Chamada Pública nº 1, de 29 de março de 2016 (Processo SEI nº 08020.013331/2015-78), publicado no D.O.U. n° 63, de 04 de abril de 2016, Seção 3, pág. 90-92, objetivando a prorrogação de prazo para apresentação de propostas referentes ao programa "Equipagem EPI Corpos de Bombeiros Militares - SENASP 2016", conforme itens 1 e 2 abaixo descritos: 1. Altera-se o subitem 9.1.1, do item 9 (DOS PRAZOS), prorrogando-se por 15 (quinze) dias o prazo para cadastramento de propostas, cujo período passa a ser de 02/05/2016 a 15/06/2016. 2. Permanecem em vigor todos os demais itens e condições do edital.s

REGINA MARIA FILOMENA DE LUCA

SECRETARIA EXTRAORDINÁRIA DE SEGURANÇA PARA GRANDES EVENTOS

EXTRATO DE CONTRATO Nº 24/2016 - UASG 200248

Nº Processo: 58131002545201561.
PREGÃO SRP Nº 13/2016. Contratante: MINISTERIO DA JUSTICA -CNPJ Contratado: 07705053000157. Contratado : SQUADRO COMERCIAL E CONSTRUTORA -LTDA - EPP. Objeto: Contratação de serviços de locação de estrutura de cercamento de segurança para as instalações olímpicas de competição e não competição especificado no Grupo 2 do Termo de Referência, anexo ao Edital de Pregão nº 13/2016. Fundamento Legal: Lei 8.666/93; Lei 10.520/02;Decreto 2.271/97 e IN 02/08 SLTI/MPOG. Vigência: 25/05/2016 a 31/12/2016. Valor Total: R$4.093.719,00. Fonte: 129000000 - 2016NE800162. Data de Assinatura: 25/05/2016.

(SICON - 30/05/2016) 200005-00001-2016NE800003

EXTRATO DE TERMO DE EXECUÇÃO DESCENTRALIZADA Nº 32/2016

Processo: 08131.001706/2016-81. Espécie: Termo de Execução Descentralizada. Partícipes: Secretaria Extraordinária de Segurança para Grandes Eventos - SESGE/MJ e Secretaria Nacional de Segurança Pública - SENASP/MJ. Objeto: Custeio das Operações durante os Jogos Olímpicos e Paralímpicos - Diárias e Passagens. Vigência: Até 30/09/2016. Data da assinatura: 27/05/2016. Valor total: R$ 156.656.822,80. Ação orçamentária: 7U23 - Implementação do Plano Nacional de Segurança Pública para Realização dos Grandes Eventos. Signatários: REGINA MARIA FILOMENA DE LUCA, CPF 052.507.538-09, Secretária Nacional de Segurança Pública e ANDREI AUGUSTO PASSOS RODRIGUES, CPF 573.788.270-53, Secretário Extraordinário de Segurança para Grandes Eventos.

Ministério da Saúde

GABINETE DO MINISTRO

EXTRATO DE RESCISÃO

TERMO DE RESCISÃO DO TERMO DE EXECUÇÃO DESCENTRALIZADA Nº 126/2015
CONVENENTES: Concedente: Ministério da Saúde - CNPJ. nº. 00.530.493/0001-71. Convenente: Comando da Marinha/AM - CNPJ nº. 00.394.502/0020-07.
OBJETO: Fica rescindido, unilateralmente, de pleno direito, a contar da data de assinatura do presente Termo, o Termo de Execução Descentralizada nº 126/2015, firmado com o(a) Comando da Marinha/AM, tendo por objeto "Manutenção de Unidade de Atenção à Saúde das Populações Ribeirinhas da Região Amazônica", com fundamento no art. 80 da Portaria Interministerial nº 507, de 24 de novembro de 2011, do Ministério de Planejamento, Orçamento e Gestão.
PROCESSO: 25000.197002/2015-28.
DATA DE ASSINATURA: 18/5/2016
SIGNATÁRIO: JOSÉ AGENOR ÁLVARES DA SILVA, Secretário-Executivo do Ministério da Saúde, C.P.F. nº. 130.694.036-20..

EXTRATO DE RESILIÇÃO

TERMO DE RESILIÇÃO DO CONVÊNIO N° 2167/2007
CONVENENTES: Concedente: Ministério da Saúde - CNPJ. nº. 00.530.493/0001-71. Concedente: Fundo Estadual de Saude - FES/AM - CNPJ n °. 06.023.708/0001-44.
OBJETO: Fica resilido, de pleno direito, a contar da data de assinatura do presente Termo, o Convênio n° 949/2008, firmado com o(a) Fundo Estadual de Saude - FES/AM, tendo por objeto "Reforma e Aquisicao de Equipamento e Material Permanente Para o Centro de Atencao Integral a Crianca - Caic Alexandre Montoril", conforme o disposto no Ofício nº. 8052/2015 - CGUSAM, de 17/12/2015, do Fundo Estadual de Saude - FES/AM.
PROCESSO: 25000.100165/2008-77.
DATA DE ASSINATURA: 18/5/2016
SIGNATÁRIO: JOSÉ AGENOR ÁLVARES DA SILVA, Secretário-Executivo do Ministério da Saúde, C.P.F. nº. 130.694.036-20.

SECRETARIA EXECUTIVA

EXTRATO DO TERMO DE EXECUÇÃO DESCENTRALIZADA DE RECURSOS Nº 25/2016

CONVENENTES: Celebram entre si a União Federal, através do Ministério da Saúde - CNPJ nº 00.530.493/0001-71, e a(o) LABORATORIO QUIMICO FARMACEUTICO DO EXERCITO/RJ - CNPJ nº 10.266.175/0001-07.
OBJETO: Dar apoio financeiro para "Aquisição e Distribuição de Medicamentos - Aquisição e Distribuição de Micofenolato de Sódio 180 Mg e 360 Mg", visando ao fortalecimento do Sistema Único de Saúde - SUS.
PROCESSO: 25000.057247/2016-02.
CRÉDITO: Os recursos decorrentes do presente Convênio são provenientes: 1) MINISTÉRIO: R$ 155.868.103,20, UG: 257001, Gestão: 00001, Programa de Trabalho: 10.303.2015.4705.0001, Natureza de Despesa: 33.90.30, Fonte de Recursos: 6153000000.
RECURSOS FINANCEIROS: R$ 155.868.103,20 (Cento e cinquenta e cinco milhões, oitocentos e sessenta e oito mil, cento e três reais e vinte centavos).
VIGÊNCIA: Entrará em vigor a partir de sua assinatura até 15/05/2017.
DATA DE ASSINATURA: 20/05/2016
SIGNATÁRIOS: JOSE AGENOR ALVARES DA SILVA, SECRETÁRIO-EXECUTIVO DO MINISTÉRIO DA SAÚDE - CPF nº 130.694.036-20; JOI LUIZ DE JESUS, DIRETOR - CPF nº 560.994.106-78.

EXTRATO DO TERMO DE EXECUÇÃO DESCENTRALIZADA DE RECURSOS Nº 24/2016

CONVENENTES: Celebram entre si a União Federal, através do Ministério da Saúde - CNPJ nº 00.530.493/0001-71, e a(o) UNIVERSIDADE FEDERAL DO RIO GRANDE DO NORTE/RN - CNPJ nº 24.365.710/0001-83.
OBJETO: Dar apoio financeiro para "Promover a Qualificacao e a Educacao Permanente dos Profissionais da Saude do Sistema Unico de Saude", visando ao fortalecimento do Sistema Unico de Saúde - SUS.
PROCESSO: 25000.066684/2016-17.
CRÉDITO: Os recursos decorrentes do presente Convênio são provenientes: 1) MINISTÉRIO: R$ 3.973.154,00, UG: 257001, Gestão: 00001, Programa de Trabalho: 10.128.2015.20YD.0001, Natureza de Despesa: 33.90.39, Fonte de Recursos: 6100000000.
RECURSOS FINANCEIROS: R$ 3.973.154,00 (Três milhões, novecentos e setenta e três mil, cento e cinquenta e quatro reais).
VIGÊNCIA: Entrará em vigor a partir de sua assinatura até 05/05/2019.
DATA DE ASSINATURA: 20/05/2016
SIGNATÁRIOS: JOSE AGENOR ALVARES DA SILVA, MINISTRO DE ESTADO DA SAÚDE DO MINISTÉRIO DA SAÚDE - CPF nº 130.694.036-20; ANGELA MARIA PAIVA CRUZ, REITORA - CPF nº 074.596.964-04.

EXTRATO DO TERMO DE EXECUÇÃO DESCENTRALIZADA DE RECURSOS Nº 27/2016

CONVENENTES: Celebram entre si a União Federal, através do Ministério da Saúde - CNPJ nº 00.530.493/0001-71, e a(o) UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL/RS - CNPJ nº 92.969.856/0001-98.
OBJETO: Dar apoio financeiro para "Manutenção da Farmácia Popular - Rede Própria - Manutenção da Unidade do Programa Farmácia Popular do Brasil Em Porto Alegre", visando ao fortalecimento do Sistema Único de Saúde - SUS.
PROCESSO: 25000.069162/2016-69.
CRÉDITO: Os recursos decorrentes do presente Convênio são provenientes: 1) MINISTÉRIO: R$ 150.000,00, UG: 257001, Gestão: 00001, Programa de Trabalho: 10.303.2015.20YR.0001, Natureza de Despesa: 33.90.39, Fonte de Recursos: 6100000000.
RECURSOS FINANCEIROS: R$ 150.000,00 (Cento e cinquenta mil reais).
VIGÊNCIA: Entrará em vigor a partir de sua assinatura até 15/05/2017.
DATA DE ASSINATURA: 20/05/2016
SIGNATÁRIOS: JOSE AGENOR ALVARES DA SILVA, SECRETÁRIO-EXECUTIVO DO MINISTÉRIO DA SAÚDE - CPF nº 130.694.036-20; CARLOS ALEXANDRE NETTO, REITOR - CPF nº 346.005.820-04.

SUBSECRETARIA DE ASSUNTOS ADMINISTRATIVOS COORDENAÇÃO-GERAL DE MATERIAL E PATRIMÔNIO

RESULTADO DE JULGAMENTO PREGÃO Nº 14/2016

A Pregoeira do Ministério da Saúde torna público aos interessados que a aquisição de botijões de gás GLP de 13 Kg, decorrente do procedimento licitatório acima, foi ADJUDICADA e HOMOLOGADA pelo critério menor preço à seguinte empresa: GJ COMERCIO DE GLP LTDA- CNPJ Nº 15.330.626/0001-33 para o item único no valor global de R$ 39.754,64 Os autos do processo encontram-se disponíveis a quaisquer interessados (Proc. nº 25000.011078/2016-56 - PEC 1064).

KRISHNA OLIVIA VIEIRA DE MELO

(SIDEC - 30/05/2016) 250110-00001-2016NE800194

COORDENAÇÃO-GERAL DE SERVIÇOS GERAIS

EXTRATO DE DISPENSA DE LICITAÇÃO Nº 368/2016 - UASG 250005

Nº Processo: 25000109560201544 . Objeto: Aquisição de 240com OPSUMIT 10MG Total de Itens Licitados: 00001. Fundamento Legal: Art. 24º, Inciso IV da Lei nº 8.666 de 21/06/1993.. Justificativa: Trata-se de Ação Judicial Declaração de Dispensa em 24/05/2016. ALEXANDRE POZZA URNAU SILVA. Coordenador-geral de Análise Das Contratações de Insumos Estratégicos para Saúde - Substituto. Ratificação em 30/05/2016. BRENO VILELA COSTA. Diretor do Departamento de Logística em Saúde. Valor Global: R$ 115.529,19. CNPJ CONTRATADA : Estrangeiro MULTICARE.

(SIDEC - 30/05/2016) 250110-00001-2016NE800177

EMPLEAR DE SOLO F DA IMPRENSA NACIONAL

Translation of Document A

Directorate for promoting sustainable development

Extract of technical cooperation agreement

Agreement number 02/2016. Process number 08620.089245/2015-77. Participants: National Indian Foundation – FUNAI, CNPJ number 00.059.311/0001-26, represented by its President Mr. João Pedro Gonçalves da Costa, CPF number 041.161.782-68 – and the Institute of Indigenous Research and Formation, non-profit non-governmental organization, represented by its President Mr. Maria Bernadette Arantes Nogueira Franceschini, CPF number 542.036.008-04. Issue: Establishment of basis and norms for technical cooperation, aiming to enhance the performance of activities of formation, cultural and political strengthening, and collective and community management for the sustainable development of indigenous peoples from Amapá and northern Pará States.

About funds: This agreement does not allow the direct or indirect transfer of funding between the signatories, so that the participants are responsible by financial sources for the implementation of actions that are of their responsibility.

About validity: 04 years, from the date of publication.

Signature date: 05/10/2016.

Document B: Authorization for using the collected data

Instituto de Pesquisa
e Formação Indígena

São Paulo, 24 de setembro de 2021

Prezado Juliano Franco-Moraes,

Acusamos recebimento de seu pedido de publicação de artigo científico contendo dados obtidos em levantamento realizado em sua visita à TI Zo'é, realizado no âmbito de uma consultoria para o Programa Zo'é do Iepé, em 2019.

Este levantamento assim como outras atividades desenvolvidas pela equipe do Iepé e colaboradores naquela Terra Indígena foram conduzidas em acordo com os objetivos e protocolos definidos pelo Acordo de Cooperação Técnica 002/2016 celebrado entre a Fundação Nacional do Índio – Funai e este Instituto, publicado no Diário Oficial da União em 31 de maio de 2016.

Através desta declaro estar ciente de sua intenção de uso dos dados em questão, tais como contidos no relatório do levantamento realizado e encaminhado por você ao Iepé.

Cordialmente,

Dominique Tilkin Gallois

Coordenadora do Programa Zo'é / Iepé

São Paulo
Rua Professor Monjardino, 19
CEP 05625-160 – São Paulo/SP
(11) 3746-7912

Macapá
Rua Leopoldo Machado, 640
CEP 68908-120 – Macapá/AP
(96) 3223-7633

iepe@institutoiepe.org.br

Oiapoque
Rua Lélio Silva 91
CEP 68980-000 – Oiapoque/AP
(96) 9 8411-3054

Santarém
Rua Silvério Sirotheau,1235
CEP 68005-050 – Santarém/PA
(93) 9 8100-0158

institutoiepe.org.br

Translation of Document B

São Paulo, September 24, 2021

Dear Juliano Franco-Moraes,

We acknowledge receipt of your request to publish a scientific paper containing data from a survey carried out during your visit in the Zo'é Indigenous Land, which occurred in 2019 and consisted of a consultancy for the Iepé Zo'é Program.

This survey, as well as other activities developed by the Iepé team and collaborators in the Zo'é Indigenous Land, was conducted according to the goals and protocols defined by the Technical Cooperation Agreement 002/2016 celebrated between the National Indian Foundation – FUNAI – and this Institute, and published in the Official Record of the Union in May 31, 2016.

Through this letter, I declare awareness of your intention of using the mentioned data, which were collected by you and delivered to the Iepé through a report.

Sincerely,

Dominique Tilkin Gallois,

Coordinator of the Zo'é Program / Iepé

Document C: Authorization for publishing the data

Pedido de autorização para a divulgação dos dados de pesquisa
"Pesquisa" bajiseha rehe dokumetu

Eu, Juliano Franco de Moraes, gostaria de saber: vocês estão de acordo com a divulgação dos meus escritos para outros não indígenas? Há um tempo eu fui até a Terra de vocês para colaborar com o pessoal do Iepé na elaboração do PGTA. Fui às suas antigas aldeias, medir as árvores juntos de vocês. Também fui aos castanhais e à outras partes da sua floresta. Nesse tempo, o pessoal do Iepe queria saber "como é que vocês promovem novas florestas onde antes eram suas antigas aldeias?", então eles me disseram "venha para você colaborar com isso". Antes disso, o pessoal do Iepé me reportou que já havia feito uma reunião com vocês sobre minha ida para esse trabalho, e graças a isso somente eu fui. Por isso eu fui mesmo. Nos últimos dias, já há alguns meses, eu comecei a escrever, e hoje já finalizei o que queria escrever; escrevi junto com o Leo [Leonardo Viana Braga], o Leo sabe bem sobre o que escrevi: já finalizei a pesquisa. Portanto, hoje, para documentar mesmo isso eu escrevo a você para eu ter conhecimento: vocês estão de acordo com a divulgação de minha pesquisa para outros não indígenas?

Ji, Juliano Franco de Moraes, *akuha potat: a'e pete su pa ekusiweha bajisek kirahi amu kõ toesagane? Kome ji aha pehen pe rupaty tapitiwun rane Iepe iwana PGTA apoharehe. A'e aha pehen pe tapererakõ pe, wire ta'am rane pehen pe pori te. Aha nowe nady kõ rupi, amuramu ki'ety aha nowe. A'e rame Iepe iwana okuharahy "batu pehen pe tapererakõ boki'a katu?", a'e "terejori terepitiwun rane", e'i Iepe iwana. Iepe bojiapyt iman ewe pehen pe oparadu jupe ehoharehe, a'e rame tenana aha. Bokope aha rane. Kwahe, jahyreta imanty, akusiweripy, a'e õj akisiwet ba rane. Rew pori te akisiwet, Rew kuha: "pesquisa" ajapoba rane. A'ejerehe, õj dokumetu tajapoj rane ji akisiwet dewe kõ pe takuha katu: a'e pete su pa e"pesquisa" bajisek kirahi amu kõ toesagane?*

Resposta dos Zo'é
Zo'é wajaha

Kome jokuha rane Juriano *ohemha rehe orerupa.* Juriano *ohemha rame kupej Iepe iwana oparadu õ rehe. Obobe'u katu rane Iepe iwana* Juriano *kapiharehe: "wirekõ o'ãha rehe* Juriano *u'upotat", e'i Iepe iwana, "tapererakõpe wirekõ o'ãha potat, nady rupi amurumu, ki'a amu rupi awe", e'i. "Topitiwun PGTA apoharehe", Iepe iwana e'i. A'erame Iepe iwana okuharahy ti "a'e pete su pa* Juriano *toturi pehen pe rupa tokapit none iwana pori", e'i Iepe iwana. Jomuha rane, none iy kõ wajarane: "ere ji rehe"; i'y kõ owajat. Ji aharane* Juriano *rupi. Oho nowe* Rew *akõ,* Ugu *awe. Aesagane* Juriano *kapiha. A'ejerehe jomuha rane, a'e pete rane* Juriano *"pesquisa" japo; a'e pete rane* Juriano *kusiweha bojisek amu kirahity. Kirahi amu kõ* Juliano *"pesquisa" oesagame, a'e kirahikõ muha potat "a'e pete Zo'é rekoha".*

Há tempos nós ficamos sabendo mesmo da vinda de Juliano para nossa Terra. Antes mesmo da vinda de Juliano, o pessoal do Iepé conversou conosco sobre sua vinda. O pessoal do Iepé nos informou bem mesmo sobre o trabalho de Juliano: "ele vem para fazer medições das árvores", disse o pessoal do Iepé, "as árvores presentes nas

capoeiras, nos castanhais e, também, em outras partes da floresta", disseram. "É para contribuir com a elaboração do PGTA", o pessoal do Iepé explicou. Nesse momento, eles nos questionaram "vocês aprovam a vinda de Juliano para trabalhar junto conosco', disse o pessoal do Iepé. Nós refletimos de verdade, todos os líderes pensamos: "Aprovamos", nós respondemos mesmo; as lideranças respondemos. Eu fui mesmo junto de Juliano. O Leo também foi, Hugo [Hugo Prudente da Silva Pedreira] também. Eu vi o trabalho de Juliano. Portanto, nós refletimos e aprovamos a "pesquisa" que Juliano fez; aprovamos mesmo a divulgação de seus escritos para outros não indígenas. Quando os outros não indígenas virem a pesquisa de Juliano, eles vão pensar "como os Zo'é vivem bem em seu território".

HUN

Assinatura da liderança local zo'é

RIRU

Assinatura do interprete zo'é (letrado em língua zo'é)

Juliano Franco de Moraes

Juliano Franco de Moraes

Terra Indígena Zo'é
18 de outubro de 2021

Translation of Document C

Request for authorization for publication of data

"Research" *bajiseha rehe dokumetu*

I, Juliano Franco de Moraes, would like to know: are you in agreement with the publication of my work for other non-indigenous peoples? A while ago, I was in your Indigenous Land to collaborate with the Iepé in the elaboration of your PGTA. I was in your ancient villages to measure trees together with you. I also went to the Castanhais and other forest patches of your territory. At that time, the Iepé wanted to know "how do you promote new forest patches in places where there were ancient Zo'é villages?", so they told me "come for you to collaborate with it". Before that, the Iepé told me that they had a meeting with you to talk about my inclusion in this work, and because of that, I was able to go. Due to that I could go. In the last months, I started to write a paper, and today I have finished it; I wrote together with Leo (Leonardo Viana Braga), and he knows what about I have written; I already finished my research. Therefore, today, in order to publish my work, I am writing to you so that I can know: are you in agreement with the publication of my work for other non-indigenous peoples?

Zo'é's answer

Zo'é wajaha

A while ago, we knew that Juliano would come to our Indigenous Land. Before his arrival, people from Iepé talked about Juliano and his work with us. They told us: "Juliano will be here in order to make measurements in trees found in your fallows, castanhais as well as other parts of the forest". They told us: "These measurements will contribute to the elaboration of your PGTA". Thus, they asked us: "Are you in agreement with Juliano's coming?". So all Zo'é's leaders reflect about that and answered: "We approve". During the measurements, I [Hun] went together with Juliano to make the measurements; Léo also went, and Hugo [Hugo Prudente da Silva Pedreira] as well. I [Hun] saw Juliano's work. Therefore, we reflected and approved the "research" that Juliano have done. We also approve the disclosure of Juliano's writings to other non-indigenous peoples. When other non-indigenous peoples see Juliano's research, they will think: "how well the Zo'é live in their territory".

_____

Signature of the Zo'é leader

_____

Signature of the Zo'é interpreter (literate in Zo'é language)

_____

Juliano Franco de Moraes

Zo'é Indigenous Land

October 18, 2021