

<https://helda.helsinki.fi>

The Role of Guadua Bamboo in Land Management and Indigenous Perspectives on Bamboo Ecosystems in Southwestern Amazonia

Virtanen, Pirjo Kristiina

2022-12

Virtanen , P K , Apurinã , F , Ruokolainen , K & Manchineri , L 2022 , ' The Role of Guadua Bamboo in Land Management and Indigenous Perspectives on Bamboo Ecosystems in Southwestern Amazonia ' , Human Ecology , no. 50 , pp. 1077 1088 . h

<http://hdl.handle.net/10138/353227>

<https://doi.org/10.1007/s10745-022-00376-8>

cc_by

publishedVersion

Downloaded from Helda, University of Helsinki institutional repository.

This is an electronic reprint of the original article.

This reprint may differ from the original in pagination and typographic detail.

Please cite the original version.



The Role of *Guadua* Bamboo in Land Management and Indigenous Perspectives on Bamboo Ecosystems in Southwestern Amazonia

Pirjo Kristiina Virtanen¹ · Francisco Apurinã¹ · Kalle Ruokolainen² · Lucas Manchineri³

Accepted: 5 November 2022 / Published online: 21 December 2022
© The Author(s) 2022

Abstract

We examine the Indigenous uses, oral histories, and knowledge of native *Guadua* bamboo species in southwestern Amazonia. Two *Guadua* species form dense stands in which individual plants die en masse at regular intervals of about 28 years. Scholars suggested that pre-colonial earth builders took advantage of these die-off events as a natural aid in removing the forest to construct geometric earthworks. Our results show that *Guadua* species have a significant position in Indigenous socio-cosmologies, land use, and as a protector of diverse resources. Indigenous ontological understandings cannot be separated from discussions of the abundance and geographical distribution of *Guadua* as a critical controlling factor in the vegetation structure and function of southwestern Amazonian rain forests. Furthermore, oral histories point to the connection between land management and bamboo, as well as bamboo and the use of fire, conforming to the suggestion of opening ceremonial spaces in bamboo patches in pre-colonial earthwork societies.

Keywords *Guadua* bamboo · Indigenous onto-epistemology · Animacy · Forest structure · Pre-colonial geoglyphs · Southwestern Amazonia · Brazil

Introduction

In southwestern Amazonia, at least two *Guadua* bamboo species form dense stands in which individual plants die en masse at intervals of about 28 years (Dalagnol et al., 2018; de Carvalho et al., 2013). These bamboo forests cover large areas. It has been suggested that pre-colonial earth builders took advantage of these die-off events using the dead bamboo biomass for fuel in fires that helped them to remove

the forest in order to construct giant ceremonial geoglyphs (McMichael et al., 2013, 2014; Pärssinen et al., 2020; Watling et al., 2017). Indigenous views, use, and knowledge of the native *Guadua* species and forests have not been addressed in depth.

Thus far, hundreds of geometric earthworks structures, geoglyphs, typically 100–200 m in diameter, have been discovered in deforested areas of southwestern Brazilian Amazonia as well as in Bolivian Amazonia (Pärssinen et al., 2009, 2020; Saunaluoma & Schaan, 2012; Virtanen & Saunaluoma, 2017; Saunaluoma et al., 2018). The building of geoglyphs declined hundreds of years before Europeans arrived (Pärssinen et al., 2003, 2009; Saunaluoma et al., 2018), and mound-building societies continued in the area until colonization began (Saunaluoma et al., 2019). The construction of a geoglyph was a massive collective effort that must have been a significant undertaking involving a great deal of logistic planning and skilled engineering abilities to move considerable amounts of earth.

The *Guadua* bamboo was instrumental in constructing and developing the earth builders' culture. In that case, traces of the ancient importance of bamboo might still be detectable in the socio-cosmology and oral history of Indigenous peoples presently inhabiting the area of the pre-colonial

✉ Pirjo Kristiina Virtanen
pirjo.virtanen@helsinki.fi

Francisco Apurinã
fr.apurina@gmail.com

Kalle Ruokolainen
kalle.ruokolainen@utu.fi

Lucas Manchineri
pohtomanxineru@gmail.com

¹ Indigenous Studies, University of Helsinki, P.O 24
Unioninkatu 40, 00014 Helsinki, Finland

² Biology, University of Turku, Turku, Finland

³ Manchineri People, Assis Brasil, Brazil

earthworks. No written documentation or evidence of the specific nations of the geoglyph-builders exists. A parsimonious assumption is that some of the Indigenous populations currently living in the area may have inherited knowledge of these pre-colonial societies. We examine the contemporary uses, practices, cognitive structures, socio-cosmologies, and oral stories of current Indigenous societies as they relate to *Guadua* bamboo forests in Southwestern Amazonia. We focus on two Arawak-speaking peoples, the Apurinã and the Manxineru, along the Purus River in Brazil.

Our results reveal that Manxineru and Apurinã regard the *Guadua* species as one of the crucial actors in a complex human–environment collective and thus show respect for and protection of *Guadua* bamboos in their practices, as well as engage with the *Guadua* species ontologically as persons. Epistemological and ontological understandings affect the abundance and distribution of *Guadua*, a critical component of the flora in Southwestern Amazonia. The local Indigenous societies believe that the *Guadua* forests offer fertile lands for cultivation, host a diversity of game animals, and offer crucial resources for cultural objects. Furthermore, local oral traditions point to early connections between working the land and native bamboo. These stories conform to the suggestion of opening ceremonial spaces in bamboo patches in pre-colonial earthwork societies in Southwestern Amazonia.

Research Setting

Study Area and Interlocutors of the Research

Our study area is situated in southwestern Brazil, where *Guadua* bamboo form dense stands that dominate the forest canopy and where pre-colonial geoglyphs have been found (Fig. 1). Several Indigenous peoples, belonging especially to the Arawakan, Panoan, Tacano, and Arawá language families live in this region. We have worked primarily with the Apurinã (Pupŷkary) and Manxineru (Manchineri/Manchinery) societies, who have historically lived in large areas of the Purus River drainage, typically in interfluvial areas (Chandless, 1866). Their principal subsistence modes are hunting, gathering, fishing, and small-scale agriculture, except for some Apurinãs living in cities or close to urban areas, where salaried work has become an essential basis of livelihood. The Apurinã number around 10,000 persons, while the Manxineru population is approximately 1,000. They are part of the Yine society living in Peruvian Amazonia.

The Manxineru interlocutors live in the Mamoodate reserve in the upper Purus River, and the Apurinã interlocutors live in the reserves of Camicuã and Tumiã lower down the river. At

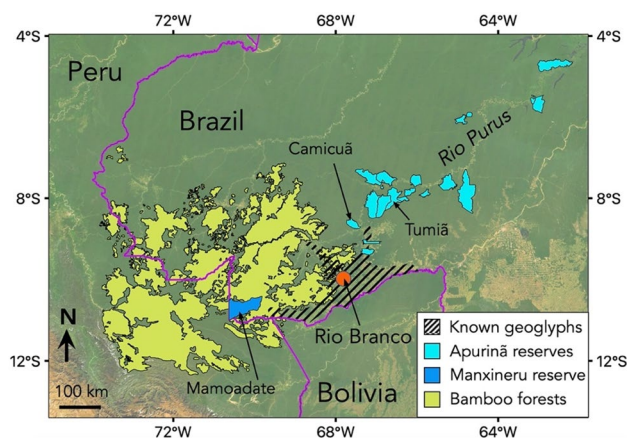


Fig. 1 The distribution of *Guadua* bamboo forests (Carvalho et al., 2013), the area of known geoglyphs (Pärssinen et al., 2020) in Southwestern Amazonia, and the present locations of Indigenous reserves of the Apurinã and Manxineru (who also live in areas outside the reserves)

the same time, some elders and knowledge-holders dwell on the margins of the city of Rio Branco (Fig. 1).

Guadua Bamboo

Guadua is a genus of bamboo of about 35 species. Two *Guadua* species (*G. weberbaueri* Pilger and *G. sarcocarpa*) (Londoño & Peterson, 1991) are particularly ecologically important as they are the dominant species in about 160,000 km² of Amazonian rain forests, mainly in the state of Acre in Brazil and Madre de Dios in Peru (Fig. 1; Dalagnol et al., 2018; de Carvalho et al., 2013; Van doninck et al., 2020). Such patches exist in our study area, for example, in the Camicuã and Tumiã reserves. Both species also occur outside this area as smaller stands that do not reach the forest canopy and therefore are practically impossible to map by remote sensing.

The stems of these bamboos are ca. 5–10 cm thick, over 20 m long, fast-growing, and too flexible to stand upright on their own. However, with the help of robust thorns, they can attach themselves to tree branches and gain access to light in the forest canopy. In this way, they can grow over mid-sized canopy trees, and their weight often breaks the branches and main stems of smaller trees (Griscom & Ashton, 2006; Silveira, 1999). The bamboo is a clonal plant, and when an individual plant attains a favorable growing position, it will produce an underground rhizome from which new culms will sprout. A successful bamboo stand can be said to dominate the forest and have over 1,000 culms per hectare (Costa et al., 2012). Both *G. weberbaueri* Pilger and *G. sarcocarpa* have a peculiar life strategy of synchronized gregarious flowering and subsequent fruiting just once in a

lifetime of an estimated 28 years (de Carvalho et al., 2013; Van doninck et al., 2020). Soon after reproduction, the plant dies. Bamboo plants with the exact reproductive synchrony populate vast areas, up to some thousands of square kilometers (Dalagnol et al., 2018; de Carvalho et al., 2013; Van doninck et al., 2020).

Methods

We applied ethnographic methods, including semi-structured interviews, participant observation, storytelling, and a review of biological and ethnobotanical literature. Our interlocutors included elders, adults, and young people of both genders. The selection was based on their knowledge of native bamboo, familiarity with the local vegetation, and oral histories. We interviewed 20 persons, but many conversations were organized as talking circles in which community members of different ages participated. Oral histories and stories are typically complemented by the people present at the moment of storytelling; some are more gifted storytellers than others. The discussions and stories were held in their native language and Portuguese. These were recorded, transcribed, and later the first author translated them into English. Information has been produced over a long period, roughly since 2005, while human-bamboo relations have become a focus since 2018 as their possible connection with geoglyph-building societies became more evident. All the study locations produced a similar number of recorded discussions and participant observations.

The authors represent different disciplinary backgrounds: Indigenous studies, anthropology, biology, and language studies. The first author has carried out ethnographic research with the Apurinã and Manxineru for a long time, especially in the Tumiã and the Mamoadate reserves, and participated in cross-disciplinary studies on the past of the region and has collaborated closely in Apurinã language studies with the Study Group of Arawak languages at the Federal University of Pará. She is also familiar with other Indigenous peoples in the region, especially the Panoan-speaking Huni Kuin (Kaxinawá). The second and fourth authors come respectively from the Mamoadate and Camicuã reserves, and in addition to their academic background, they draw on traditional ecological knowledge produced intergenerationally. The third author has extended research experience in the ecology of Amazonian tropical forests, and in this study, he contributed significantly to the literature review. Overall, this study produces information by combining different types of knowledge by applying the multiple evidence base approach (see Tengö et al., 2014) and land- and place-based Indigenous experiences. The sources presented here deal with native bamboo nomenclature, oral histories mentioning bamboo, ecological perceptions of

bamboo, the use of bamboo resources, land use, and ritual life related to bamboo.

Results and Discussion

Native Bamboo Nomenclature

The characteristics that the Manxineru and Apurinã describe as distinctive for each *Guadua* taxon include growth form and the color and thickness of culms. These features are also used to differentiate scientific taxa from each other. The presence of robust spines is a unique feature of *Guadua* among Neotropical bamboo genera (Judziewicz et al., 1999). Therefore in the subsequent text, we use the genus name *Guadua* for any bamboo species that the Manxineru or Apurinã describe as having spines.

The Apurinã and the Manxineru have numerous terms for spiny bamboo, known locally in Portuguese as *taboca* (Table 1). For Apurinã socio-cosmology, two native *Guadua* bamboos, *sukunaky* and *waxapiry* (also known as *iawiru*), are particularly important. Both have green culms and spines and grow in *terra firme*. *Waxapiry* (*iawiru*), which is thinner, typically grows under Brazil nut trees. The Apurinã also use the generic term *iuwata* for native bamboo, while the Manxineru still use its cognate, *hwata*. The Manxineru identify two native *Guadua* bamboos, *hwata* and *tseypiro*. *Tseypiro* and Apurinã's *waxapiry* are also cognates. There are several species of bamboo in the Purus area, and the Apurinã terminology for them is rich, including bamboos that are considered to have been introduced into the region later, such as “the bamboo of the White people,” also known as yellow bamboo. In the upper Purus Apurinã lands, the following names are also known for thin native bamboos: *sÿpyrywatany*, *kuxinha*, *txikuty kãpyâtary* (“the bamboo of *Cebus apella* monkeys”), and *kurukawary*. *Kuxinha* and *sÿpyrywatany* are typical of riversides, *txikuty kãpyâtary* grows in *terra firme*, and *kurukawary* forms tall-growing open patches that can be quickly passed through at ground level. In the central Purus Apurinã lands, a bamboo called *purenaru*, an alternative word in the Apurinã language for bamboo, is found in *terra firme*.

Human History Intertwined with *Guadua* Bamboo

The oral histories of the Manxineru and Apurinã point to interconnections between human history and native bamboo. Apurinã society comprises two cross-marrying patrilinear moieties, the Meetymanety and the Xiwapuryneru. These two moieties inhabit different Apurinã settlements and are often identified by separate group names (*wakury*) based on the physical characteristics of the people forming the group. These characteristics can be associated with specific plant

Table 1 Names and qualities for native bamboos among the Apurinã and Manxineru of the Purus River area

Apurinã species term	Habitat	Characteristics	Uses	Socio-cosmology
Sukunaky	<i>Terra firme</i>	Spines, thin green culms, provides fruit, water protection for animals	Edible fruit for animals, potable water in internodes, soil fertilizer, hollow internode used as a container, arrowheads and shafts, knives, flutes and ritual objects	One of the ancestor groups, has a strong “chief spirit.”
Waxapiry /iawiru (Upper Purus River area)	<i>Terra firme</i> and riverside	Spines, green culms, provides fruit, water habitat and provides habitat and protection for animals	Abundant potable water in the internodes, soil fertilizer, edible fruits for animals, hollow internode used as a container, arrowheads and shafts, knives, flutes and ritual objects, blowpipes (for poisonous hunting darts)	Has a strong “chief spirit”
Iuwata “ancient word for bamboo”	<i>Terra firme</i>	Spines, green culms	iuwata also means ‘knife’	One of the ancestor groups
Kurukawary (Upper Purus River area)	<i>Terra firme</i>	Spines, open and easily passable space under its canopy		
Txikuty kāpyātary (Upper Purus River area)	<i>Terra firme</i>	Spines, protects animals	occasionally used for arrowheads	
Sỹpyriwatana (Upper Purus River area)	Riverside	Spines, green culms		Has a strong “chief spirit”
Purenaru (Central and lower Purus River area)	<i>Terra firme</i>	Green culms	Flutes	Has a strong “chief spirit”
Kuxinha	Riverside	Spines	blowpipes of poison darts for hunting (from the upper part, the lower one lacks hollow internodes)	Has a strong “chief spirit”
Manxineru species term	Habitat	Characteristics	Uses	Socio-cosmology
Hwata	<i>Terra firme</i>	Spines, green culms, provides fruits, water, and protection for animals, soil fertilizer	Edible fruits for humans and animals, drinkable water in internodes, soil fertilizer, arrowheads and shafts, knives	One of the ancestors, has a strong “chief spirit.”
Tseyopiro	<i>Terra firme</i>	Spines, green culms, thinner than <i>hwata</i> , provides fruit, water, and protection for animals, soil fertilizer	Edible fruit for animals, drinkable water in internodes, flutes, soil fertilizer, arrowheads and shafts, knives	Has a strong “chief spirit”

or animal species or the features of the geographical place where a particular Apurinã group lives.

One of the oldest groups in the area of the Camicuã reserve is the Sukunakywakury, which translates as the “People of *sukunaky* bamboo,” and the Iuwatawakury, or the “People of the *iuwata*” (a generic word for native bamboo). The current residents in the Camicuã Indigenous territory

say they are Sukunakywakury, meaning they are descendants of the Sukunakywakury. This group is associated with the Meetymanety moiety patrilineally. The following two excerpts from interlocutors from the Camicuã territory explain the common Apurinã ancestry with *Guadua* bamboos:

We are the kin of the *taboca*... There is a kind of *taboca* that we call *sukunaky*; it doesn't grow much, it's thin. This is our kin; it is *Meetymanety*. At the beginning of the world, these old lineages brought with them arrows made of *sukunaky*. They made arrows from the *sukunaky* bamboo and could kill game animals. They also made blowpipes of bamboo to hunt from distance....

Our people are numerous; we are divided into groups. The *Sukunakywakury* are a type of *Apurinā* people, similar to the *Meetymanety* and the *Xiwapurynyry*. Our old lineage was generated from *taboca*. They are persons, just like us. Nowadays, people don't talk about it anymore, but in the past, there was much respect for *tabocas*; no one could cut or burn them. *Tabocas* are born, grow, flower, and give seeds naturally. No one has to do anything. It is living nature in itself. *Taboca* is the chief of our "old stem" [an expression used for ancestors]....

The yellow *taboca* is not ours, it's a *kariua* [non-Indian] plant. They brought it from abroad and planted it on their land. The *tabocas* I mentioned and that we *Apurinā* know are all greenish.

The term *iuwata*, used for bamboo, is also mentioned in oral histories, and one of the ancestral *Apurinā* groups is also associated with *iuwata*. This group is mentioned in the same story as another subgroup called *Tsuminerywakury* (the Worm People), who killed a *Iuwatawakury* hunter. In the past, conflicts between subgroups were common. The region is known for pre-colonial earthworks, and the connection between the bamboo and the people rearranging the land and the soil is remarkable. The story of the *Iuwata* bamboo People, *Iuwatawakury*, and the people of *tsumy* worms (earthworms, *Oligochaeta*), the *Tsuminerywakury*, can be summarized as follows: A *Iuwatawakury* man hunting in a forest was killed by a *Tsuminerywakury*. The wife of the *Iuwatawakury* man witnessed his death as she accompanied the man and saw the killing at a distance. She decided to follow the *Tsuminery* man to his people's village. To her surprise, the woman saw that the *Tsuminerywakury*'s houses were built underground.

The *Iuwatawakury* decided to take revenge against the *Tsuminerywakury* for the death of their kinsman. They prepared a poison from pepper and added it to dry tree leaves. A large group of the *Iuwata* people went to the enemy's village, filled all the burrow entrances to their houses with poisoned leaves, and set them on fire. They sealed holes in the homes of the *Tsuminerywakury*, who started coughing because of the poisonous smoke. They coughed until everything was silent. Eventually, the *Iuwatawakury* found only one small boy still alive in a pot in a sitting position (described as the ancient burial tradition). The *Iuwatawakury* took him to their village to eat him later, as was the past practice for dealing

with enemies. As with many other *Apurinā* stories, there are variations of this story in different parts of the Purus River area (Virtanen et al., 2021). In the central and lower parts of the Purus, the story usually ends by noting that one person of the *Tsumineriwakury* still exists among the *Apurinā*. In the upper parts of the Purus River, the story is rarely told in its entire length, which can be a sign of distancing from a painful story of one of the *Apurinā* groups describing a massacre of their *Apurinā* ancestor group, with whom the residents in the region identify.

If the story of the *Tsuminerywakury* is analyzed within the structuralist framework (e.g., Lévi-Strauss, 1964), there is a clear connection between bamboo and digging or otherwise working the earth. This is an intriguing interpretation because it has been suggested in earlier studies (Carson et al., 2014; McMichael et al., 2014) that the bamboo's mass die-off event would have offered an opportunity to more easily clear a forest patch, allowing the construction of a geometric earthwork at that spot. Having in the same oral history two ancestor groups who managed the land – one identified with *iuwata* bamboo and the other with *tsumy* worms – may originate from or point to the memories of a society for whom the building of a geoglyph coincided with a bamboo die-off event. The die-off event of a given bamboo patch happens so rarely that special skills are needed to predict its occurrence correctly.

The *Apurinā* and *Manxineru* narrate that there were many enemy groups in their past, and constant fights and killings of people led to a perpetual chain of revenge. Significantly, a common way to find protection was to dig holes in the ground. Women and children could hide in these holes, and warriors could use them to stage a surprise attack against their enemies or hide from them. Based on archeological and ethnographical evidence, earthwork ditches may have also been used as hiding places (Virtanen, 2011; Pärssinen, 2021). However, the earthwork constructions were mainly used for ritual purposes based on the evidence of rich ceremonial pottery and the lack of residential sites (Pärssinen et al., 2009; Virtanen & Saunaluoma, 2017).

In the *Apurinā* socio-cosmos *sukunaky* and *iuwata* are one of the *Apurinā* ancestors' groups, and according to various *Apurinā* traditional storytellers, the *Iuwatawakury* (the Bamboo people) originate from the man, *Iuwatawakury*, whose body after his death turned into *iuwata* bamboo. His community found out that he had actually eaten his wives, started then even to eat himself, eventually felling into a fire. From his ashes grew *iuwata* bamboo. Despite the distance, the *Manxineru* mention *hwata* and *tseyopiro* in the similar story that explains the origin of the core species of the people. *Hwata*, *tseyopiro*, and main *Manxineru* staples and medicinal plants are also said to be born from the body of a man, *Hwatawero*. The name *Hwatawero* refers to the bamboo

hwata, and he is said to be large and known for eating vast quantities of food. According to the story, Hwatawero asked permission to marry a man's oldest daughter. After some time, Hwatawero returned to the man crying, explaining that his wife had disappeared. Thus, he asked that the middle sister would become his wife. After some time, Hwatawero again asked for the third sister, claiming that the second sister had also disappeared.

Once, when Hwatawero was hunting, the third young woman went to the kapok tree, where he had told her not to go. Then a great tragedy was revealed to her as she found the remains of her sisters. When Hwatawero left next time to hunt, the third sister hid nearby. After some hours, Hwatawero returned from hunting with a catch of several monkeys. He sat beside the fire and called his wife to prepare the meat. There was no answer, as she did not reply. Hwatawero ate all the monkeys by the fire, and then he wondered, "Maybe I am myself tasty," and started to cut parts of his own body, grill them, and eat them. He kept grilling more body parts, and eventually, he could no longer walk. Then he called his wife. Then she came and said that she had found out that Hwatawero had eaten them. She did not want to save the man, and then the man asked that his corpse be burned, as from his ashes would grow crucial things for the new generations to survive. Many people looked for firewood, then lit a fire. In three days, from the ashes of Hwatawero's body were born *hwata* bamboo, *tseyopiro* bamboo, bananas, manioc, yam, sweet potato, and other important staple crop species. In this story, sometimes the medicinal plant *kamalampi* is mentioned. Although the details of Manxineru stories may vary contextually, and have some differences to the Apurinã one, the main storyline remains the same. Significantly, bamboo is mentioned in the ancestral story, and in the Manxineru version, only bamboo and core medicinal plants are mentioned besides the edible ones.

The relationship between myths and history is a topic that has been investigated for some time (e.g., Gow, 2001; Lévi-Strauss, 1964; Turner, 1988), and their structures offer fascinating ways to rethink the past and its layers in the present time. The story of *Hwatawero*, and *Iuwatanery* respectively, describes an invasive person who eats other people, yet eventually, he contributes to the community's well-being. Hwatawero's story and the story of the Iuwatawakury and Tsuminerywakury describe ancestral times when fire was already used.

Contemporary sentient ecology (Ingold, 2000), considering humans interacting with sentient and personified ancestral beings, deepen the academic understanding of why *Guadua* thickets are respected in Apurinã and Manxineru societies. This also becomes evident in the stories on the intergenerational ecological relations with bamboo, its use as a material resource for diverse purposes, and land management, as presented in the following sections.

Ecological Perceptions of Bamboo

Our Indigenous interlocutors typically state that no one can plant native bamboo and that they have a life of their own. They describe how the bamboo grows in thickets or *tabocales*. The Apurinã term for a *sukunaky* thicket is *sukunakype*. The suffix *-pe* indicates that *sukunaky* has spread over a large area, thus revealing the perception of an actor that has multiplied in abundance.

The Apurinã and the Manxineru are well aware of the periodical mass-flowering of native bamboo. Their life cycle is locally said to be 20–30 years. A single die-off event is observed to last several years, which makes it difficult to give a precise year for the die-off event of a given bamboo patch. The explanation for the gradual die-off is teleological: it enables animals living in bamboo thickets to have time to find a new place.

The Apurinã and Manxineru say that *Guadua* thickets provide a protective place for animals such as peccaries, armadillos, turtles, diverse birds, agouti, paca, deer (Ap. *manhiti*), tortoises (Ap. *xutuuiu*), the *Plecturocebus grovesi* monkey (Ap. *kuã*), and the *Callithrix pygmaea* monkey (Ap. *amãtxuary*). Concerning monkeys, which are valued as game animals, the *Guadua* were described in the following way by a resident in the Camicuã reserve's area:

Animals, such as jaguars and monkeys – *macaco preto* and *macaco de taboca* – use *Guadua* patches as places to live and hide. Animals that live in bamboo thickets do not go far from them. They leave them to eat some fruit but soon return to their home. In bamboo thickets live a kind of monkey (*macaco soin*) which is very different from those we are used to seeing. It looks like a lion, not in size, because it is small but has a broad back and a very hairy head.

Bamboo thickets are not only described as places where game animals like to live. They are also considered crucial for protection and healing if a hunter or another animal has wounded an animal. An injured animal is said to leave the bamboo thicket – its "hospital," as expressed by several Apurinã – only when it has recovered. The Apurinã and the Manxineru noted that humans are generally not keen to enter bamboo-dominated forests. This reluctance is partly due to the sheer density of thorny culms and because there are always bent and more or less collapsed culms under tension, which are dangerous to cut or move.

Guadua is thus seen as crucial for animals' well-being. Our interlocutors emphasized that this role culminates at the time of fruiting and die-off when massive amounts of *Guadua* fruit attract game animals, such as monkeys, peccaries, paca, agouti, armadillos, and tortoises, among others. Likewise, Rockwell and Kainer (2015) also mention an increase in the number of parrots and macaws at this time.

Bamboo as a Source of Nutrition, Water, and Cultural Objects

Guadua patches provide essential human food resources as they are inhabited by many species and individual game animals, as described earlier. The game would be in short supply without bamboo protecting the animals. Bamboo fruit is not a particularly relevant part of a human diet. However, the Manxineru say they eat raw bamboo fruit when hunting, traveling, or gathering in the forest. Another food the bamboo provides is insect larvae that at least the Peruvian Matsigenka collect from bamboo internodes (Shepard & Chicchón, 2001).

Additionally, as our interlocutors indicated, *Guadua* is a good source of drinking water for humans and animals, such as peccaries, monkeys, and woodpeckers, which can all make a hole in the bamboo culms. Most *Guadua* contain water year-round and are thus especially important in the dry summer when people move from place to place and trek a lot. The Apurinã say that *waxapiry* (*iawiruru*) provides the most considerable amounts of water, while *sukunaky* has water, especially when it is about to flower. Young bamboos generally contain the most significant amounts of water.

Several individual rescue stories about hunters far from rivers are associated with bamboo, which offer lifesaving water. Among others, an Apurinã man in the Camicua reserve narrated the following:

The *taboca* saved my life. I was hunting once. That time I was alone, and then my attention was drawn to a boa constrictor. I had gone off the path pursuing a group of black monkeys (*macaco preto*) when I realized that I didn't know how to return to the path that led back to the village. I was very scared because it was getting late, the day was already ending. Facing this situation, I ended up setting the monkeys aside and began to look for the way [home]. I tried countless times, but all attempts were in vain. The funny thing is that I always returned to the same place every time. After many attempts, I remembered that my grandfather had told us that when this happened, it was because we were being attracted or enchanted by a snake. And to add to that, I was dying of thirst and there were no streams or any other source of water nearby. That's when I also remembered that the *taboca* holds water inside it, and luckily there was a bamboo thicket right next to where I was. I went there and cut two bamboos and drank enough water to quench my thirst. (...) I escaped from being attacked by the boa constrictor, but it was the bamboo that quenched my thirst, because surely if I hadn't drunk its water, I think I would have died.

This salvation story also points to the animate forest spirits, as it narrates how the boa constrictor's spirit is considered to have affected the hunter. The bamboo itself is considered intentionality and a master guardian spirit in its own right, as will be shown later.

Guadua bamboos offer raw material for many artifacts requiring sharpness, lightness, and resistance. Sharpness and resistance mean that bamboo can be used as knives and arrowheads, as our interlocutors pointed out (see also DeWalt et al., 1999; Shepard et al., 2001). The Apurinã word for knife and sharp arrowheads made of bamboo is *iuwata*, which is also the ancient word for bamboo. This word appears especially in oral histories of ancient times, as will be described later, and *iuwata* knives have been used to cut umbilical cords in the past.

Guadua bamboo has been crucial source material for several Amazonian societies. Shepard et al. (2001) have described how, for the Matsigenka in the Peruvian Amazonia, a die-off event of *Guadua weberbaueri* causes a temporary shortage of arrowheads. This decreases human hunting pressure on local populations of game animals, either directly limiting hunting activities or forcing hunters to travel to distant areas. In the upper Purus areas, the Apurinã mention that the *txikuty kāpyātary* bamboo is particularly suitable for making arrowheads.

The qualities of resistance and lightness are appreciated in dishes and storage vessels made of bamboo (see also Davis & Yost, 1983; Zent & Zent, 2020). Even if not familiar to our study area, bamboo culms are occasionally used in construction to make house walls. Furthermore, its use for beds has been reported from the Chazuta valley in Peruvian Amazonia (Sanz-Biset & Cañigueral, 2011).

Interlocutors in both groups told us that bamboo is also used to make musical instruments, such as various flutes. As we later explain, these instruments have an essential role in local cosmology.

Guadua as a Fertilizer and Protector of Southwestern Amazonian Forests

One of the most important findings of our studies concerning the *Guadua* bamboo is that it is regarded as a fertilizer and protector of trees. Bamboo patches are preferred sites for establishing traditional swidden cultivation in the upper Purus region. According to traditional knowledge-holders, the soil in a mass die-off location is fertile and gives a good harvest after the site has been cleared by fire. Our interlocutors report that the land responds well to fire in places where the *Guadua* has died. The soil is already easy to work as if someone had cut the forest for small-scale cultivation, and the bamboo patch produces good-quality fruit of many

cultivated species. This practice is described as the most traditional one for small-scale agriculture.

According to the Manxineru and the Apurinã of the upper Purus, burning bamboo patches not at the die-off stage would be unthinkable. The *Guadua* bamboo patches are associated with powerful spirits, as presented in the following section. *Guadua* is so highly respected that any disturbance to the living plant is avoided, as stated by an Apurinã interlocutor in the Camicuã's reserve area:

We Apurinã do not set fire to the bamboo patch to do either of these two things: to clear the land or to open up our swiddens there.

Nevertheless, despite the respect towards *Guadua*, bamboo thickets have traditionally been burned for cultivation after die-off events. The chemical realism of the perception of both the Apurinã and the Manxineru that bamboo patches provide fertile soil for cultivation is evident. This knowledge fits well with the observation that *Guadua*-dominated forests are predominantly found on haplic cambisols and luvisols (de Carvalho et al., 2013), two soil types with nutrient concentrations that are exceptionally high by Amazonian standards. Furthermore, earlier studies have noted that bamboo forests are also favored sites for slash-and-burn agriculture for the local non-Indigenous population (Rockwell & Kainer, 2015; Silveira, 2001; Stern, 2004), namely rubber tappers and *ribeirinhos* (riverside dwellers). However, Shepard et al. (2001) report that the Matsigenka regard the presence of one particular *Guadua* species (*G. glomerata*) in floodplain forests as an indication of poor agricultural soil. Forests dominated by *G. weberbaueri* and *G. sarcocarpa* are typical in the area. However, the presence of these species is not of any particular indication of agricultural suitability for the Matsigenka (Shepard et al., 2001). We suspect that the apparent difference in the indicator value of *Guadua* between people living in the Andean foothills of Peru and the Amazonian lowlands of Brazil is due to higher soil fertility in the former area.

Interestingly, there is regional variation within the Apurinã group's practice of burning bamboo. In contrast to the upper Purus, where bamboo stands were burned only after fructification, downriver in the Tumiã reserve, several people stated that in the past, bamboo patches at any stage of their life cycle, both in floodplain forests and in *terra firme*, have been burnt by controlled fire for cultivation or to clear the forest. This lower river area is outside of the geoglyph-building society's core area.

The observed difference in the burning practice of bamboo patches may also be related to variations in soil fertility. Haplic cambisols and luvisols are generally rarer the further downriver one goes along the Purus River (de Carvalho et al., 2013). It is, therefore, possible that bamboo patches in areas where the Apurinã burn them even in their sterile

or vegetative life cycle stage are bamboo populations that grow close to their minimum requirement of soil fertility. If this is the case, the bamboo may not be able to regrow as vigorously after a burn as it would in close to optimum soil conditions that presumably prevail in the region of the upper Purus River. The difference in vigor may explain the regional taboo of burning living bamboo: it may have arisen from experiences of resprouting bamboo rapidly occupying any new cultivation that was established by burning a bamboo patch in its sterile life cycle phase.

The observed differences in clearance practices may lead to the regionally different effects of humans on *Guadua* abundance and distribution. The practice of clearance suppresses *Guadua* in the area where it is dominant. Conversely, it may help maintain and even spread *Guadua* outside, where it commonly attains dominance. The justification for this claim is that after the die-off, the seeds of *Guadua* do not form a seed bank but instead germinate practically immediately. Accordingly, a fire directly after a die-off can cause very high mortality of seedlings and even destroy them because they have not yet formed fire-resistant subterraneous rhizomes. After such rhizomes have been developed, *Guadua* can survive fires and benefit from them because resources stored in the rhizome enable rapid regrowth to fill gaps in the vegetation (Barlow et al., 2012; Numata et al., 2017; Smith & Nelson, 2011).

The human influence on bamboo abundance and distribution described above is not strong simply because the present Indigenous population is relatively sparse. Some 500 years ago, the situation might have been different. If the pre-colonial builders of geoglyphs indeed took advantage of bamboo die-offs to facilitate forest clearance (McMichael et al., 2014), they would have gained the additional benefit of simultaneously getting rid of the bamboo itself in the cleared site. Furthermore, focusing on forest clearance in bamboo forests would have guaranteed that the cleared site had relatively fertile soil. This double benefit may have been an essential factor in providing the necessary food resources, allowing the appearance and maintenance of complex societies that could construct monumental earthworks. It seems likely that this era has seen a significant reduction in the abundance and distribution of *Guadua* in southwestern Amazonia. However, it is worth noting that pre-colonial forest clearance in the geoglyph area never resembled modern deforestation. Paleocological evidence suggests that the area has been characterized for several thousand years by the practice of relatively small-scale but temporally continuous forest clearing, ensuring the persistence of both tall forests and patches of bamboo (Watling et al., 2017).

Sombroek (1966) has suggested that modern Amazonian bamboo-dominated forests indicate areas, where forests cleared by Indigenous people have been invaded by bamboo. We believe that *Guadua* is not an invasive species but

rather a species that can tolerate disturbance, which under optimum conditions, can outcompete trees (Ferreira et al., 2020; Griscom & Ashton, 2006). Accordingly, the present-day abundance of bamboo in the geoglyph area merely represents a rebound from the former decline.

Terra preta, pre-colonial anthropogenic fertile soil, is not known in Acre but only *terra mulata* (Pärssinen et al., 2020), a less carbon-rich anthroposol is found there. The burning of bamboo patches may have been the method for clearing the forest to build the pre-colonial geometric earthworks (McMichael et al., 2014). Furthermore, traditional oral stories show that bamboos are present in memorizing the events that also describe the use of fire.

For the Apurinã and the Manxineru, the geometric earthworks are still specific places that should not be addressed or approached too frequently, as they are associated with the spirits of ancestors and nonhuman entities (Virtanen & Saunaluoma, 2017). Our suggestions concerning the interplay between soil fertility, bamboo performance, and pre-colonial human perception and utilization of bamboo may be feasible. However, one should note that much information remains speculative until direct evidence of soil fertility and the physiological characteristics of bamboo growth become available. Nevertheless, as sacred and related to ancestors, as described in the stories and practices above, bamboo contributed to the memory and regeneration of knowledge of the specific behavior of *Guadua* species and ideas of its animacy and intentionality.

Animate Bamboo Spirits

In Manxineru and Apurinã views, *Guadua* species are regarded as animate and thus have agency and personhood. They are considered to have a chief spirit that protects animals and humans, offering them resources and teaching them. Injured animals are thus considered to be protected and healed by *Guadua*, not only materially, but also by its animate chief spirit so that no predator can hurt them. Among other things, the *Guadua* chief spirit is considered to punish people who injure forest animals or enter the forest without respecting and addressing the nonhuman presence in the land. The following Apurinã narration describes a story of consequences incurred by an Apurinã man who had not interacted adequately and morally correctly with nonhuman lives during his hunting trip in the Camicuã region:

Taboca has a spirit; it does both good and evil. I've seen a lot of people get hurt and even killed by *tabocas* for not being their friend. Once I was hunting with my cousin when he shot a deer, but unfortunately, this animal was only wounded and ran into the woods. We followed the traces of blood that had dripped onto the leaves. Further on, we noticed that the deer had entered a very dense bamboo thicket which had many spines so

it was difficult for us to enter. My cousin started to cut the bamboo to enter [the bamboo thicket] and follow the deer. He had already cut some, but right in front of him there was a bunch of long and thick bamboo that were all inclined. My cousin used a machete to cut down the outer edge where the thicket was curved. When he lowered his machete to about chest level, it couldn't fully cut down the *taboca*. When that happened, the part that he had cut cracked, and the sharp point went straight into his belly, making a big hole; it looked like he had been stabbed with a knife. (...) When we got home, we asked someone to fetch a shaman from our village to blow on the wound. The shaman repeated this several times, and two weeks later, my cousin was much better. When he got better, the shaman said that he had been injured by the *taboca* because he had failed to respect the *taboca* chief spirit as well as the deer which he had tried to shoot.

Similar to game guardian master spirits, considered highly powerful and respected, bamboo vegetation is considered to provide animals for people to hunt if they agree to use the forest resources sustainably and with due consideration (see Virtanen, 2015). There are also Apurinã stories of persons who have entered a bamboo thicket too quickly while walking in the forest or extracted its natural resources insustainably, and consequently have been captured by the personified bamboo chief spirit and have been held inside the vegetation. Among others, a contemporary Apurinã healer and traditional knowledge-holder in the Camicuã reserve explained a story of an ancient shaman. The latter had saved a man from being inside the sukunaky bamboo thicket by inhaling tobacco snuff, thus negotiating with the sukunaky chief spirit. According to the local cultural protocol, the bamboo's master spirit must be adequately addressed, asking for permission when one extracts its resources, or passes by or through a thicket and thus respecting it. The same idea was expressed to the first author by the Huni Kuin people, the Panoan-speaking people who live in the Jordão area (core *Guadua* area). The Huni Kuin also avoid disturbing *tabocas*.

Earlier studies in the Amazon region have examined the animate personhood of palm trees (e.g., Virtanen, 2011; Hill, 2009), while the *Guadua* species have remained overlooked. Our work shows that similar to palm trees, *Guadua* are also closely linked to the ancestors' time and those spirits that are a crucial part of the local Indigenous societies' social life. *Guadua*, with its unique life cycle, offers diverse resources for animals and humans. Among the Apurinã and the Manxineru, *Guadua* also have several multisensorial ritual uses. Bamboo-made flutes (Ap. *kuitxi*) are considered persons acting in cosmological relations, as is typical among many Indigenous musical traditions in lowland South America (see Hill &

Chaumeil, 2011). These flutes are used to call the chief spirits of animals, as their sounds interact with the spirit realm. For both the Apurinã and the Manxineru, the sound of these instruments materializes the flow and movement in the cosmos in general and also connects the people to mythical ancestral time (see also Fiorini, 2011; Brightman, 2011 on bamboo musical instruments in other parts of Amazonia).

Bamboo flutes are also used to call the wind when burning slashed areas for swiddens, as a wind spirit has agency and intentionality and maintains reproduction and life. The animate wind spirits are diverse, as are the types of winds and their directions. Bamboo flutes are considered crucial for small-scale slash-and-burn agricultural practices, and the Manxineru say that they accelerate or diminish fire with the help of the bamboo flute's sound. Such animate flutes are considered actors who impact humans and other-than-human beings (cf. Hill & Chaumeil, 2011).

The far-reaching sound of Apurinã *kuitxi* flutes renders the invisible world visible or makes the distant spirit world visit humans. They are thus often used in the Apurinã's ritual opening of *kyynyry* festivities to call the wind spirit as well as many other more-than-human beings. On the day of this festivity, relatives from neighboring villages arrive to eat, sing, dance, and enjoy themselves. Larger bamboo flutes are used in the Apurinã's *kamatxi* rituals, a specific type of *kyynyry*. As one of the Apurinã interlocutors said: "With it [*Guadua*], we make different instruments for daily use and sacred rituals, such as the ritual of the *kamatxi*." *Kamatxi* flutes, produced from adult *waxapiry* (*iawiru*) bamboo, are approximately 80 cm in size and have a thickness that varies from 10 to 15 cm. These flutes are related to various powerful *kamatxi* spirits, those of *Guadua*, moriche palms (*kinharya*), and certain fish and frogs, among other plants and animals. Overall, *kamatxi* rituals with music, dances, and foods connect the participant with the mundane realm of spirits. Their purpose is also to celebrate good harvests of agricultural production, its collection, and success in hunting and fishing. The playing of bamboo *kamatxi* flutes and their sounds are accompanied by singing to celebrate fruits, such as: "*athapary txipary, athapary ananã*," "We collect bananas, we collect pineapples." The singing is followed by enjoying banana and pineapple beverages, as well as ritual foods.

There are two types of *kamatxi* rituals. In one, rather than *Guadua* bamboos, larger *kamatxi* flutes are made of the bark of *jutaí* (probably *Hymenea courbaril*) and *violeta* (probably *Leonia crassa*). These flutes have a louder and further-reaching sound and are therefore considered to have stronger powers to call diverse spirits from the spiritual plane. Thus these occasions often involve the initiation of future shamans. The ritual is only allowed for trained and experienced persons, and the *kamatxi* flutes are carefully employed.

Besides their use in a more sacred domain of life, *Guadua* flutes are also used to signal humans and animals during hunting trips and when returning from such trips to the village. Furthermore, several narrations describe how *Guadua* is regarded as a powerful entity that can be used as a medicinal substance and mixed with other plants. Overall, *Guadua* is regarded as a crucial agent that can impact other entities. In contrast, according to our Indigenous interlocutors, the most dominant society considers *Guadua* bamboo to be problem-makers that take up too much space and limit human actions and movement in the forest.

Conclusions

Native *Guadua* species have a significant position in the socio-cosmologies of the Indigenous interlocutors of our study and are not separated from human history, its formation, and its future. The Apurinã and the Manxineru have quite similar ontological views that place humans, animals, and plants in complex relations that all support each other. An emphasis on the relations between animals and humans is common to the Apurinã and the Manxineru, and both nations consider *Guadua* bamboo forests crucial in attracting game and a diversity of other animals. *Guadua* bamboo are largely respected, and its presence is considered elemental and beneficial for humans and other species. The resources and shelters that the bamboo thickets and patches offer and the transformative powers associated with the *Guadua* species have significantly impacted how humans have approached and engaged with *Guadua* vegetation. Consequently, *Guadua* species are central to ritual activities related to societal well-being.

Indigenous ontological understanding may affect the abundance and geographical distribution of *Guadua*, either negatively or positively, depending on the human cultural response to geographical variation in the physical environment. These effects are probably relatively small, but the situation may have been quite different in pre-colonial times. Southwestern bamboo forests can therefore be regarded as one more example that shows the strength of past human influence on patterns of Amazonian vegetation and plant species distribution (Clement et al., 2015; Levis et al., 2017; McMichael, 2021). It is clear that Indigenous peoples' practices to protect *Guadua* patches from uncontrolled fire and deforestation, and the overall consideration of *Guadua* as a protector of game animals and source of fertile lands, have primarily contributed to Indigenous ecological practices in the Purus River Region.

Acknowledgements We thank Apurinã and Manxineru communities we have worked with, Indigenous and state authorities, anonymous reviewers for their constructive comments, and Sidney Facundes for the

linguistic expertise. The research was funded by the Academy of Finland and the University of Helsinki.

Funding Open Access funding provided by University of Helsinki including Helsinki University Central Hospital.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Barlow, J., Silveira, J. M., Mestre, L. A. M., Andrade, R. B., D'Andrea, G. C., Louzada, J., Vaz-de-Mello, F. Z., Numata, I., Lacau, S., & Cochrane, M. A. (2012). Wildfires in bamboo-dominated Amazonian forest: Impacts on above-ground biomass and biodiversity. *PLoS ONE*, 7, e33373. <https://doi.org/10.1371/journal.pone.0033373>
- Brightman, M. (2011). Archetypal agents of affinity: “Sacred” musical instruments in the Guianas? *Burst of Breath: Indigenous Ritual Wind Instruments in Lowland South America* (pp. 201–218). Lincoln.
- Carson, J. F., Whitney, B. S., Mayle, F. E., Iriarte, J., Prümers, H., Soto, J. D., & Watling, J. (2014). Environmental impact of geometric earthwork construction in pre-Columbian Amazonia. *Proceedings of the National Academy of Sciences of the United States of America*, 111(29), 10497–10502.
- Chandless, W. (1866). Ascent of the river Purus. *Journal of Royal Geographical Society*, 1, 86–118.
- Clement, R. C., Denevan, W. M., Heckenberger, M. J., Braga Junqueira, A., Neves, E. G., Teixeira, W. G., & Woods, W. I. (2015). The domestication of Amazonia before European conquest. *Proceedings of the Royal Society B*, 282, 20150813. <https://doi.org/10.1098/rspb.2015.0813>
- Costa, S. G., Morato, E. F., & Salimon, C. I. (2012). Bamboo density and population structure of two pioneer tree species in secondary forests of different ages in a remnant forest. *Acre State. Scientia Forestalis*, 40(95), 363–374.
- Dalagnol, R. F. H. W., Galvão, L. S., Nelson, B. W., & Cruz de Aragão, L. E. O. E. (2018). Life cycle of bamboo in the Southwestern Amazon and its relation to fire events. *Biogeosciences*, 15, 6087–6104.
- Davis, E. W., & Yost, J. A. (1983). The ethnobotany of the Waorani of eastern Ecuador. *Botanical Museum Leaflets, Harvard University*, 29(3), 159–217.
- De Carvalho, A. L., Nelson, B. W., Bianchini, M. C., Plagnol, D., Kuplich, T. M., & Daly, D. C. (2013). Bamboo-dominated forests of the Southwest Amazon: Detection, spatial extent, life cycle length and flowering waves. *PLoS ONE*, 8(1), e54852. <https://doi.org/10.1371/journal.pone.0054852>
- DeWalt, S. J., Bourdy, G., Chávez de Michel, L. R., & Quenevo, C. (1999). Ethnobotany of the Tacana: Quantitative inventories of two permanent plots of Northwestern Bolivia. *Economic Botany*, 53, 237–260.
- Ferreira, E., Kalliola, R., & Ruokolainen, K. (2020). Bamboo, climate change and forest use: A critical combination for southwestern Amazonian forests? *Ambio*, 49, 1353–1363. <https://doi.org/10.1007/s13280-019-01299-3>
- Fiorini, M. (2011). Desire in music: Soul-speaking and the power of secrecy. *Burst of Breath: Indigenous Ritual Wind Instruments in Lowland South America* (pp. 171–197). Lincoln.
- Gow, P. (2001). *An Amazonian myth and its history*. Oxford University Press.
- Griscom, B. W., & Ashton, P. M. S. (2006). A self-perpetuating bamboo disturbance cycle in a neotropical forest. *Journal of Tropical Ecology*, 22(5), 587–597.
- Hill, J. D. (2009). The celestial umbilical cord: Wild palm trees, adult male bodies, and sacred wind instruments among the Wakuénai of Venezuela. *Journal for the Study of Religion, Nature, and Culture*, 3(1), 99–125.
- Hill, J., & Chaumeil, J.-P. (Eds.). (2011). *Burst of breath: indigenous ritual wind instruments in lowland South America*. University of Nebraska Press.
- Ingold, T. (2000). *The perception of the environment. Essays on on livelihood, dwelling and skill*. Routledge: London/New York.
- Judziewicz, E. J., Clark, L. G., Londoño, X., & Stern, M. J. (1999). *American bamboos*. Smithsonian Institution Press.
- Lévi-Strauss, C. (1964). *Mythologiques: Le cru et le cuit*. Plon.
- Levis, C., et al. (2017). Persistent effects of pre-Columbian plant domestication on Amazonian forest composition. *Science*, 355, 925–931.
- Londoño, X., & Peterson, P. M. (1991). *Guadua sarcocarpa* (Poaceae: Bambuseae), a new species of Amazonian bamboo with fleshy fruits. *Systematic Botany*, 630–638.
- McMichael, H. C. (2021). Ecological legacies of past human activities in Amazonian forests. *New Phytologist*, 229(5), 2492–2496.
- McMichael, H. C., Bush, M. B., Silman, M. R., Piperno, D. R., Raczka, M., Lobato, L. C., Zimmerman, M., Hagen, S., & Palace, M. (2013). Historical fire and bamboo dynamics in western Amazonia. *Journal of Biogeography*, 40(2), 299–309.
- McMichael, C., Palace, M., & Golightly, M. (2014). Bamboo-dominated forests and pre-Columbian earthwork formations in southwestern Amazonia. *Journal of Biogeography*, 41(9), 1733–1745.
- Numata, I., Silva, S. S., Cochrane, M. A., & d'Oliveira, M. V. N. (2017). Fire and edge effects in a fragmented tropical forest landscape in the Southwestern Amazon. *Forest Ecology and Management*, 401, 135–146.
- Pärssinen, M. (2021). Aquiry: um breve retrato de uma civilização amazônica. In A. Ranzi & M. Pärssinen, *Amazônia - Os geoglifos e a Civilização Aquiry*, pp. 19–64. Helsingue, Madrid : Instituto Ibero-Americano da Finlândia.
- Pärssinen, M., Balée, W., Ranzi, A., & Barbosa, A. (2020). The geoglyph sites of Acre, Brazil: 10 000-year-old land-use practices and climate change in Amazonia. *Antiquity*, 94(378), 1538–1556.
- Pärssinen, M., Ranzi, A., Saunaluoma, S., Siiriäinen, A. (2003). Geometrically patterned ancient earthworks in the Rio Branco region of Acre, Brazil: New evidence of ancient chiefdom formations in Amazonian interfluvial Terra Firme environment. In M. Pärssinen & A. Korpisaari (Eds.), *Western Amazonia—Amazônia Ocidental. Multidisciplinary studies on ancient expansionistic movements, fortifications and sedentary life* (pp. 97–133). Helsinki: University of Helsinki.
- Pärssinen, M., Schaan, D., & Ranzi, A. (2009). Pre-Columbian geometric earthworks in the upper Purús: A complex society in western Amazonia. *Antiquity*, 83(322), 1084–1095.
- Rockwell, C. A., & Kainer, K. A. (2015). Local and scientific perspectives on the bamboo-dominated forest in Acre, Brazil: A complementary knowledge base for multiple-use forest management. *International Forestry Review*, 17(s1), 51–64.

- Sanz-Biset, J., & Cañigueral, S. (2011). Plant use in the medicinal practices known as “strict diets” in Chazuta valley (Peruvian Amazon). *Journal of Ethnopharmacology*, 137(1), 271–288. <https://doi.org/10.1016/j.jep.2011.05.021>
- Saunaluoma, S., Anttiroiko, N., & Moat, J. (2019). UAV survey at archaeological earthwork sites in the Brazilian state of Acre, southwestern Amazonia. *Archaeological Prospection*, 26(4), 325–331.
- Saunaluoma, S., Pärssinen, M., & Schaan, D. (2018). Diversity of pre-colonial earthworks in the Brazilian state of Acre. *Southwestern Amazonia. Journal of Field Archaeology*, 43(5), 362–379. <https://doi.org/10.1080/00934690.2018.1483686>
- Saunaluoma, S., & Schaan, D. (2012). Monumentality in western Amazonian formative societies: Geometric ditched enclosures in the Brazilian state of Acre. *Antiqua*, 2(e1).
- Shepard, G.H. Jr., & Chicchón, A. (2001). Resource use and ecology of the Matsigenka of the eastern slopes of the Cordillera Vilcabamba. In L.E. Alonso, A.L. Alonso, T.S. Schulenberg, & F. Dallmeier (Eds.), *Biological and social assessments of the Cordillera de Vilcabamba, Peru. Smithsonian institution/monitoring and assessment of biodiversity program*, 6.
- Shepard, G. H., Wu, D. W., Lizarralde, M., & Italiano, M. (2001). Rainforest habitat classification among the Mantsiguenka of the Peruvian Amazon. *Journal of Ethnobiology*, 21(2), 1–38.
- Silveira, M. (1999). Ecological aspects of bamboo-dominated forest in southwestern Amazonia: An ethnoscience perspective. *Ecotropica*, 5, 213–216.
- Silveira, M. (2001). A floresta aberta com bambu no sudeste da Amazônia: Padrões em processos em múltiplas escalas. [Doctoral dissertation, Universidade de Brasília].
- Smith, M., & Nelson, B. W. (2011). Fire favours expansion of bamboo-dominated forests in the south-west Amazon. *Journal of Tropical Ecology*, 27, 59–64.
- Sombroek, W. G. (1966). A reconnaissance of the soils of the Brazilian Amazon region. Centre for Agricultural Publication and Documentation.
- Stern, M. (2004). Environmental impact assessment of community-based bamboo management in the Cofán center of Dovuno, Sucumbíos, Ecuador. Chemonics International, Biodiversity Conservation in Indigenous Areas. https://pdf.usaid.gov/pdf_docs/Pnada499.pdf
- Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P., & Spierenburgh, M. (2014). Connecting diverse knowledge systems for enhanced ecosystems governance: The multiple evidence based approach. *Ambio*, 43, 579–591. <https://doi.org/10.1007/s13280-014-0501-3>
- Turner, T. (1988). Ethno-ethnohistory: Myth and history in native South American representations of contact with western society. In J. D. Hill (Ed.), *Myth and history in native South American representations of contact with western society* (pp. 235–281). University of Illinois Press.
- Van doninck, J., Westerholm, J., Ruokolainen, K., Tuomisto, H., & Kalliola, R. (2020). Dating flowering cycles of Amazonian bamboo-dominated forests by supervised Landsat time series segmentation. *International Journal of Applied Earth Observation and Geoinformation*, 93, 102196. <https://doi.org/10.1016/j.jag.2020.102196>
- Virtanen, P. K. (2011). Constancy in continuity: Native oral history, iconography and the earthworks of the upper Purus. In A. Hornborg & J. D. Hill (eds.), *Ethnicity in ancient Amazonia: Reconstructing past identities from archaeology, linguistics, and ethnohistory*, pp. 279–298. University Press of Colorado.
- Virtanen, P. K. (2015). Fatal substances: Apurinã’s dangers, movement, and kinship. *Indiana*, 32, 85–103.
- Virtanen, P. K., F. Apurinã, S. Facundes. (2021). Amazonian worlds of other-than humans and the Apurinã through the materiality of oral histories. *Multilingua. Journal of Cross-Cultural and Interlanguage Communication* 40(4):565–582.
- Virtanen, P. K., & Saunaluoma, S. (2017). Visualization and movement as configurations of human-nonhuman engagements: The Geometric earthwork landscapes of the upper Purus, Brazil. *American Anthropologist*, 119(4), 614–630.
- Watling, J., et al. (2017). Impact of pre-Columbian ‘geoglyph’ builders on Amazonian forests. *Proceedings of the National Academy of Sciences of the USA*, 114, 1868–1873.
- Zent, S., & Zent, E. (2020). Co-ecology of Jotí, primates, and other people: A multispecies ethnography in the Venezuelan Guayana. In B. Urbani, M. Lizarralde (Eds.), *Neotropical ethnoprimateology. Indigenous peoples’ perceptions of and interactions with nonhuman primates*, 161–197. Cham: Springer. https://doi.org/10.1007/978-3-030-27504-4_8

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.