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Forest species for biocultural restoration in eastern Amazon, Brazil

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ABSTRACT

Amazon deforestation damages nature, people, and their closer biocultural relationship, eroding fundamental elements for its reproduction. The recognition and use of traditional knowledge to plan and implement restoration efforts are essential to its success. This study identified forest tree species of biocultural value for indigenous communities, *quilombolas*, and settled farmers in Maranhão state, eastern Brazilian Amazon. Semi-structured interviews, informal conversations, Free Lists, and guided walks were carried out in three different landscapes to identify species with ecological importance and/or use-value according to local communities' perceptions. Eight categories of species use were defined (food, woody, medicinal, income, cultural, hunting, honey, and energy); and the Smith Salience Index (S) was utilized to identify species with higher importance. A total of 58 native trees ($S > 0.1$) were listed as biocultural species, five of which were cited for ecological importance only, without a use-value associated. The highest number of species with cultural salience ($S > 0.1$) was reported in the indigenous group (47), followed by settlers (11) and *quilombolas* (9). Among the indigenous, we identified a higher number of uses for the same species, and a remarkable spiritual relationship with plants from their cosmological vision. The reproduction of biocultural values in societies needs to receive more attention in the restoration science and praxis. The identification of species of biocultural value can serve as an important ally for the assertive design of conservation and restoration initiatives.

Keywords: Biocultural restoration; Associated Traditional Knowledge; Amazon.

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SIGNIFICANCE STATEMENT

The Amazon region of Maranhão state lost 76% of its original forest cover (6.2 million hectares) to illegal deforestation, forest fires, and land conversion to agriculture. At the same time, indigenous people and traditional communities are victims of violence and social injuries. The restoration of Amazon Forest in Maranhão is needed for ecosystem functionality reestablishment and also human sociocultural resilience. The recognition and use of traditional knowledge to plan and implement restoration efforts are essential to its success. This study identified forest species with biocultural value for restoration, defined through traditional knowledge and socio-cultural needs.

INTRODUCTION

Preserved landscapes are not synonymous with pristine landscapes. Scientific studies have shown the importance of native peoples for the formation of many natural environments, as we know them today, such as the Amazon Forest whose hyper-dominance of edible species is a result of the enrichment promoted by pre-Columbian societies (Maezumi et al. 2018; Balée 2013). Landscapes are, therefore, means for cultural and human reproduction, and the material results of this dynamic (Almeida et al. 2016). The knowledge, associated with landscape dynamics, contributes to understanding nature-society plural relationships and, consequently, is essential for conservation and restoration initiatives.

In practice, culture, based on the social memory of people, is an important reference for accessing necessary information about the history of landscapes (Barthel et al. 2013). Projects aimed at conservation and ecological restoration must consider the livelihoods and memories of local populations (Lyver et al. 2015). This approach is not only a strategy to successfully restore an ecosystem, but also a matter of social justice, especially when it considers the dynamics of historical land use that reduced traditional population size and restricted their territories.

The loss of biocultural patrimony occurs when habitats, values, languages and ways of life encounter barriers to being reproduced, representing one of the main threats to diverse cultures (Zent 2009; Barthel et al. 2013; Poole 2018, Lyver et al. 2019). Environmental degradation is one of the main barriers to this reproduction and is strongly related to the dominant economy of large-scale development, which degrades ecosystems and displaces local populations (Escobar 2011). In Brazil, this process is largely stimulated by inappropriate political systems.

Indigenous peoples and traditional populations are fundamental to the protection and development of biodiverse forest cover. According to FAO (2019), indigenous people comprise 5% of the world's population, but are guardians of 80% of global biodiversity. This should be strategically valued by governments and considered in the planning of ecological restoration projects, thus safeguarding the rights of these peoples over their lands. It is necessary to ensure the protection of the rights of indigenous peoples and other traditional landowners, as well as to recognize the importance of these peoples in maintaining the conserved areas in their territories.

Ecological restoration is "the process of assisting in the recovery of an ecosystem that has been degraded, damaged or destroyed" (SERI 2004). One restoration approach that integrates sociocultural values is known as Biocultural Restoration, which aims to revitalize ecosystems and at the same time the cultures historically responsible for them (Gavin et al. 2015; Schmidt et al. 2021). This context demonstrates the importance of participation of local communities in planning, decision-making and implementation of restoration projects (Bortolamiol et al. 2018).

The Amazon region of Maranhão lost 76% of the original forest cover (Silva Junior et al. 2020), while the remaining forest is found in highly threatened protected areas (five indigenous territories and one conservation unit) (Celentano et al. 2017). Ecological restoration initiatives in this region are needed to guarantee not only the reproduction of livelihoods, but also the implementation of environmental laws and commitments. In this sense, the approach of biocultural restoration may allow for a historic repair of landscapes and ensure conditions for the reproduction of traditional ways of life.

Biocultural restoration recognizes the knowledge of traditional and local communities as crucial elements for biodiversity conservation (Barthel et al. 2013). In degraded landscapes, this knowledge is even more important, since it becomes one of the main sources of reference information for planning when there are no conserved areas. Furthermore, people plant trees for utility more often than for other reasons (Martin et al. 2021). An effective strategy to involve communities in the restoration process is through the surveying and identification of species of cultural importance, which ensure the reproduction of the identity and ways of life of the human populations that depend on them (Garibaldi and Turner 2004). According to Sena et al. (2021), local knowledge must be assessed, valued, and utilized to indicate species and increase the success of restoration initiatives. This study aimed to identify forest species with biocultural value for restoration, defined through traditional knowledge and socio-cultural needs.

MATERIAL AND METHODS

Studied areas

The research took place from November 2017 to April 2020, in three areas in the Amazon region of Maranhão state, Brazil: Agrovilas (rural villages built for relocated Quilombolas communities) of the Alcântara municipality; Aldeia (indigenous village) Awa, in the Indigenous Territories (IT) Caru (Bom Jardim municipality); and Vila Bom Jesus, a community belonging to the Amazônia Settlement Project (PA) – overlapping the Gurupi Biological Reserve (Bom Jardim municipality) (Figure 1).

Socio-environmental characterization

The Amazon region corresponds to 34% of Maranhão state (81,208.40 km^2), encompassing 62 municipalities (Martins and Oliveira 2011). It is located in the most deforested region of the Brazilian Amazon, where poverty, violence and environmental degradation are consequences of a violent conflict over land and natural resources (Celentano et al. 2018). The scenario of expropriation of traditional communities and small farmers from their territories, and the consequent tenure disorder, evidence the conflictual context in the region.

Characterization of the community areas

a) **Agrovilas of Alcântara:** Located in the northeast of the Amazon region of Maranhão, between the hydrographic basins of the Grande and Pepital rivers, in the municipality of Alcântara (44°46'75,33"W 2°35'40,30"S). In this municipality, in 1987, about 300 fisher families, self-denominated remnants of quilombos (descendants of slaves), were relocated from their traditional territories to seven agrovilas – rural villages built by the Ministry of Aeronautics, to guarantee the demographic emptying of 236 km2, considered a safe area for the installation of the Alcântara Launch Center (CLA) - a satellite launching base. In this research, four communities were selected: Espera, Cajueiro, Marudá and Pepital, where, from 2015, after a socio-environmental diagnosis (Celentano et al. 2014), experiences of agroecological transition began, through two systems, namely no-fire farming and agroforestry (Loch et al. 2020). The dominant landscape is composed of young secondary vegetation (Figure 2A), but small fragments of old-growth forests still exist (Zelarayán et al. 2015). The soil is characterized as plinthosol with low fertility (Anjos et al., 1995). The altitude varies between 25 and 50 meters. Annual precipitation ranges from 1,000 to 1,800 mm, distributed into a rainy season (December to May) and a dry season (from June to November); the average annual temperature is 25ºC (Brito and Rego 2001).

b) **Aldeia Awa:** Located in the Caru Indigenous Territories (IT), in the northwest of the Amazon region of Maranhão, in the municipalities of Bom Jardim and São João do Caru (46°15'44,39"W 3°75'88,10"S). Awa Guajá and Guajajara peoples live in Caru IT divided into four villages (Aldeia Awa, Aldeia Tiracambu, Aldeia Guajá and Aldeia Maçaranduba). There are also isolated Awa Guajá indigenous people who move between the Alto Turiaçu IT, Awa IT and Gurupi Biological Reserve. The Caru IT has been recognized since 1982 (Brazil 1982). Despite this, the indigenous people who live in this protected territory are frequently threatened by illegal loggers, hunters, cattle ranchers and farmers (Celentano et al. 2018). The area is also impacted by the Carajás Railroad, inaugurated in 1985 to transport iron ore from the company Vale S.A., which is close to its limits. During the day and night, there is transit of railway trains with 330 freight cars each (Ferreira 2017). This situation seriously harms the survival of the Awa Guajá, whose livelihood is derived from hunting and gathering, especially isolated individuals (nomads), who do not have agricultural habits, and are considered one of the most vulnerable ethnic groups in the world (Berto et al. 2019; Survival International 2019). Caru IT is part of the Gurupi Mosaic, with the last protected forest remnants of the Belém Endemism Area (Celentano et al. 2018). The dominant phytophysionomy is dense rainforest. The region's forests still present a good state of conservation (Figure 2B). The region has soils of the yellow Latosol type (Almeida and Vieira 2010). The altitude varies from 45 to 150 m. The predominant climate is tropical, hot and humid, with two well-defined seasons: a rainy season (December to May) and a dry season (June to November), with rainfall of 2000 mm per year (Farias Filho et al. 2019).

c) **Vila Bom Jesus:** Located in the Amazônia Settlement Project superimposed on the Gurupi Biological Reserve, in the northwest of

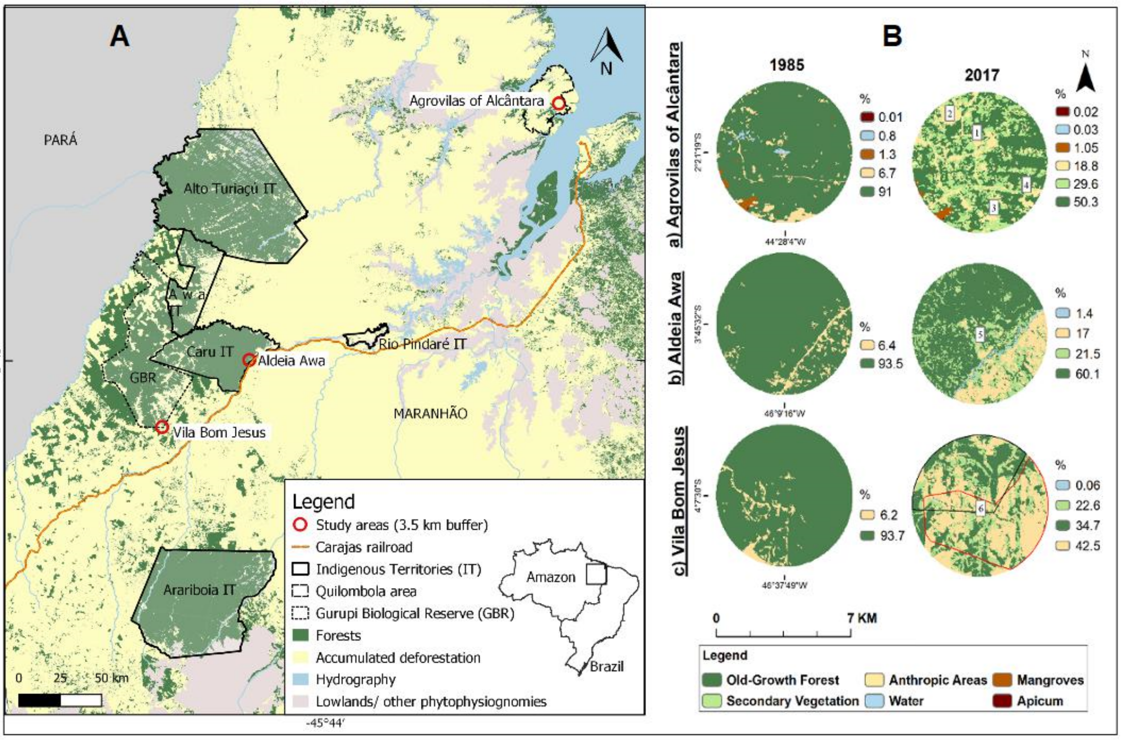

Figura 1. (A) Locational map of the communities studied (Aldeia Awa, Agrovilas of Alcântara and Vila Bom Jesus) in the Amazon region of Maranhão state, Brazil; and (B) Classification of the landscapes (3.5 km radius), in 1985 and 2017, in the studied areas: Agrovilas of Alcantara (1 - Pepital, 2 - Marudá, 3 - Cajueiro, 4 - Espera), Aldeia Awa (5), and Vila Bom Jesus (6) (Mapbiomas, 2020). In Aldeia Awa, the Pindaré River represents the borders of the Caru IT with the neighboring municipality. In Vila Bom Jesus, the black and red lines represent, respectively, the limits of the Gurupi Biological Reserve and the borders of the PA Amazônia.

the Amazon region of Maranhão (4663'00.07"W 4°12'49.15"S), between the basins of the Gurupi and Pindaré rivers, in the municipality of Bom Jardim. Gurupi Reserve is a strictly protected area (Category I according to IUCN) created in 1988 (Brazil 1988). Despite its restrictive category for use and management, human occupation and land-grabbing are two of the main challenges of the reserve. Currently, there are two Settlement Projects, fourteen villages, ranchers and squatters established there, totaling 6,536 inhabitants (Moura et al. 2011). The PA Amazônia was created in 1999 and 128 families are settled in its area of 4,605 hectares (Incra 2020). In 2016, a plan for riparian forest restoration to comply with Brazilian environmental law (Brazil 2012) was initiated with the settlers of Vila Bom Jesus, in partnership with the Chico Mendes Institute for the Conservation of Biodiversity (ICMBio) and Museu Paraense Emílio Goeldi. The objective is the restoration of the natural waterways, but the only stage carried out was reconnaissance of the areas, and the plan is suspended due to a lack of financial resources. The phytophysiognomy of the area is composed of dense lowland rainforest, dense submontane rainforest, secondary vegetation and agrosilvopastoral landscapes (Buss et al. 2017). The predominant soil is yellow Latosol (Almeida and Vieira 2010). The climate is characterized by two well-defined seasons: a rainy season (December to May) and a dry season (June to November). The altitude varies from 100 to 160 m. Average annual rainfall varies from 1,750 to 2,000 mm, and temperature between 24 and 26ºC (Birdlife International 2020).

Environmental Perception

Through the Snowball technique (Albuquerque et al. 2014), members of the studied communities were identified by non-probabilistic (intentional) sampling. In Alcântara (n= 41) and Vila Bom Jesus (n=15), an informant indicated another informant, and reiterated the process until the names started to repeat themsel-

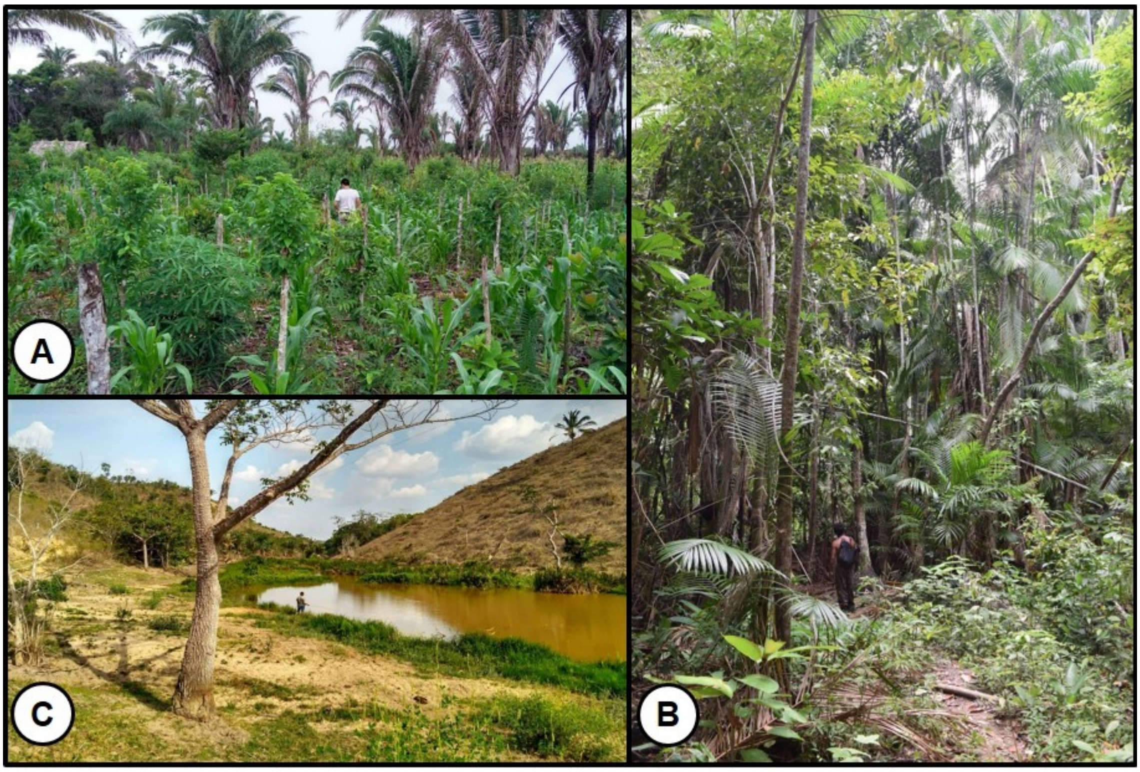

Figura 2. Landscapes of the studied areas in the Amazon region of Maranhão state, Brazil: (A) Slash-and-mulch field in Agrovilas of Alcântara, (B) Old Forest in Aldeia Awa; and (C) Lagoa degraded area in Vila Bom Jesus. (Photos by Vivian Loch)

ves, while in Aldeia Awa all Portuguese-speaking indigenous persons (n=7) participated in the survey. Interviews were conducted to ascertain the population's perception of environmental changes, the associated causes and the importance of conserved areas (How and why has the forest changed? Have the period and amount of rain remained the same? and the river? What do you think is causing these changes?). In Alcântara and Vila Bom Jesus, these questions were answered through semi-structured interviews (Albuquerque et al. 2014). With the Awa Guajá, these topics were addressed in informal interviews, usually in a participatory meeting, given that most of them speak only the Guajá language and only a few men use Portuguese in public (Berto et al. 2019). Thus, the Awa Guajá who spoke Portuguese performed the translation during the dialogues.

Surveying species of biocultural value

After ascertaining the respondents' perception about the dynamics of use and cover of the surrounding landscapes and their contributions to people's well-being, we sought to identify the cultural salience of ecologically important forest species and utilitarian values in the communities studied, through Free Lists (Quinlan 2005):

Question 1 Free List of species of ecological importance: Which tree species are important for ensuring forest conservation? Question 2 Free List of species of use-value: Tell me about the forest trees you use. (Which part is used? What is its use?)

To facilitate communication with the Awa Guajá, Question 2 was asked during guided walks (Albuquerque et al. 2014), where the indigenous persons pointed out the species used during the journey. We consider "Species of Biocultural Value" the integration between the two lists (species with ecological importance and/or use-value).

Processing of the collected botanical material

The species were identified in the field by giving the popular name, with the help of a local specialist (Figure 3). When possible, the botanical material in the reproductive stage (flowers or fruits) was collected and sent to the Rosa Mochel Herbarium at the State University of Maranhão (SLUI), where it was herborized for subsequent taxonomic identification and incorporation into the collection. A specialized bibliography and comparison with previously identified materials from the Herbarium and from other works already carried out in the areas were used (Balée 2013; Cormier 2000; Celentano et al. 2014; Souza and Lorenzi 2012), in addition to the aid of experts. The classification system adopted for the family level was APG IV (2016) and the spelling of scientific names followed the database of the Virtual Herbarium of Reflora/CNPq (Flora of Brazil 2020) and Missouri Botanical Garden (Tropicos 2019). For the correct spelling of plant names in Awa Guajá, we had the collaboration of a teacher and expert linguist. From this survey, qualitative and quantitative analyses were made.

Data analysis

Descriptive methods were used for qualitative analyses of environmental perceptions. For the Free Lists, a species accumulation curve was elaborated (Gotelli and Colwell 2010) to verify the sampling sufficiency of the information collected in the study areas. Next, the Smith Salience Index (S) was calculated to identify the species with the greatest ecological importance and the highest use-value, through the program Anthropac 4.0 (Borgatti 1992), which measures the index by means of the following formula:

$S = (((L - Rj + 1) / L)) / N$ Equation 1

where "S" is the mean rank of an item across all lists in the sample, "L" is the length of a list, "Rj" is the rank of item j in the list, and "N" is the number of lists in the sample (Smith and Borgatti 1997). The use of plants in each studied community were represented using a graph and compared through a Chi-squared test with a significance of 5% (Ludwinsky and Hanazaki, 2018). Eight categories of use were defined from the interviews: 1) food, 2) woody (includes fibers), 3) medicinal, 4) income, 5) cultural (includes crafts, incense, instruments, rituals), 6) hunting, 7) honey and 8) energy (includes resin and firewood). In the "cultural" category, relational characteristics of plants with humans and non-humans were not considered, because they are specifically associated with Awa cosmology; they are values considered intangible, and therefore detailed separately.

Legal and ethical aspects

Each respondent was asked to sign an Informed Consent Form, fulfilling the requirements of the National Health Council (CNS) (Resolution nº 466 of 2012 and Operational Standard nº 001 of 2013 of the CNS). This study was submitted to and approved by the National Committee for Research Ethics (Authorization Number: 2,798,732), as well as by the National System for the Management of Genetic Patrimony and Associated Traditional Knowledge (Registration No. A59E774, required by Law No. 13.123/2015 Access to Associated Traditional Knowledge) and by the National Indigenous Foundation (Entry Authorization for the Caru Indigenous Territories nº 23/AAEP/-PRES/2018).

RESULTS

Environmental Perception

The studied communities settlements originated at different moments within the time scale (Agrovilas of Alcântara – 1987; Aldeia Awa – 1982; Vila Bom Jesus – 1988), and put pressure on natural resources in distinct ways, according to their sociocultural contexts. Over time, landscapes presented a reduction of mature forests and an increase in anthropized areas and secondary vegetation at different levels (Figure 1). The majority of the *quilombolas* in the Agrovilas of Alcântara perceived a decrease in forest cover (56.1%), and attribute this to human actions such as the uncontrolled use of fire to open new areas of fields. These forest areas are considered the most important for the communities of Alcantara (34.1%), followed by rivers and marshes (29.3%) and secondary vegetation (17.1%). The uses attributed to nature perceived by *quilombolas* were initially related to supplying goods (61%), such as the extractivism of native fruits, the use of wood for construction, and access to water. But contributions from nature that promote regulation in environments were also cited (12.2%), such as fresh air; the scenic beauty of the forests (9.7%); and soil formation (7.31%).

Indigenous respondents from Aldeia Awa perceived changes in the climate, such as the shortening and earlier onset of the rainy season, related to the decrease in forest cover, caused in the areas that exceed the limits of the IT (right bank of the Pindaré River on the sampled landscape, Figure 1) but also by arson and illegal logging by third parties in their territory. The Awa perceived not only a diminution in the number of hunted animals and an increase in the distance traveled for activities related to hunting and gathering, but also consequences of the aforementioned illegal management and the impacts of the Carajás Railroad, which directly impact the well-being, survival and cultural reproduction of the Awa Guajá.

All respondents from Vila Bom Jesus perceived changes in the climate (period and amount of rain and average local temperature), while 80% of them associated the changes with anthropic actions such as fire and deforestation in preservation areas. In the region, fire is utilized to open new field areas and to renovate pastures for cattle ranching. The settlers recognize old-growth forests as the most important areas of the community (60%), followed by secondary vegetation (40%) and rivers and marshes (26.6%). They associ-

Figura 3. Parts of plants collected during guided walks, with subsequent identification, in Aldeia Awa, Maranhão state, Brazil.

ate the conserved forest areas with ensuring the provision of water, wood and charcoal, and with hunting (60%), as well as recognizing the contributions of forests to the formation of soils for future fields (40%), and the rainfall regime (6.6%).

Forest species of biocultural value for restoration

A total of 90 native tree species were listed as bioculturally valuable (with use-value and/or ecological importance), but only 58 species presented high cultural salience ($S > 0.1$; Table 1). The Awa Guajá cited almost twice as many forest tree species ($n = 61$, with an individual average of 23 ± 18.5) when compared to *quilombolas* in Agrovilas of Alcântara ($n = 34$, individual average $= 3 \pm 2.31$) and Vila Bom Jesus ($n = 26$, individual average $= 3 \pm 1.73$). Only seven of the cited species were shared among the three studied communities (*Bagassa guianensis* Aubl., *Caryocar brasiliense* Cambess., *Copaifera langsdorffii* Desf., *Euterpe oleracea* Mart., *Handroanthus* sp., *Hymenaea courbaril* L. and *Manilkara bidentata* (A.D.C) A.Chev.), evidencing the environmental and cultural heterogeneity in the eastern Amazon.

Among the species with use-value, the most cited categories of use were: "food" in Alcântara (58% of citations); "hunting" in Aldeia Awa (42.4%); and "medicinal" in Vila Bom Jesus (61.7%); the uses attributed to forest species differed significantly in the communities studied ($X = 216.9$; $p < 0.0001$) (Figure 4). The vast majority of species considered 'ecologically important' also had use-value, except for one species in Aldeia Awa (*Handroanthus* sp.), one species in Alcântara (*Virola surinamensis* (Rol. ex Rottb.) Warb.), and three in Vila Bom Jesus (*Lecythis pisonis* Cambess., *Pouteria macrophylla* (Lam.) Eyma, *Spondias mombin* L.). Two cited species are listed in the Red Book of Brazilian Flora as vulnerable to extinction (*Virola surinamensis* (Rol. ex Rottb.) Warb., and *Hymenaea parvifolia* Huber).

The Awa Guajá also present a relational perspective with plants from their cosmological vision that we consider herein as intangible values of forest species, and we present them separately, since they were not found among the respondents from the other areas of study. The Awa Guajá present the concepts of *Jara* and*Karawara*, which concern the relationships established between human and non-human beings (Garcia, 2018). The *Jara* establish relationships of contiguity with other species, in which they would serve as "guardians", a relationship linked to care, exchange,

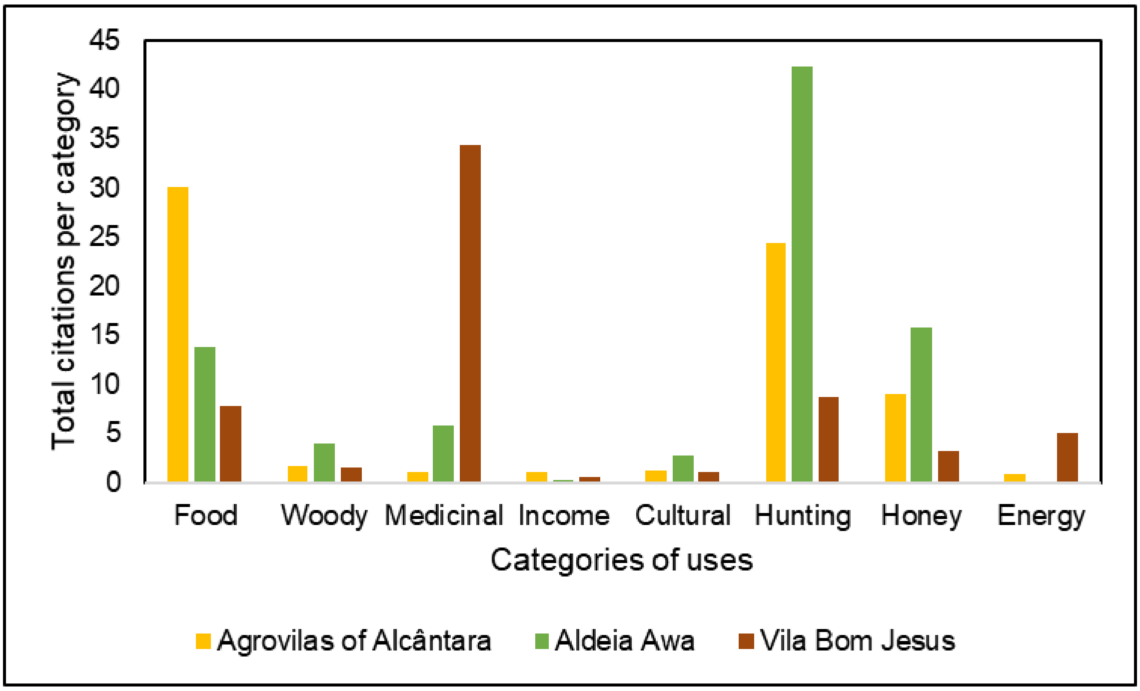

Figura 4. Use of forest species in the communities studied (Aldeia Awa, Agrovilas of Alcântara and Vila Bom Jesus) in the Amazon region of Maranhão state, Brazil.

protection or consumption (Garcia, 2018), whereas *Jara* can still be understood as the "guardian" of the species. The *Karawara* are celestial beings who can establish this *Jara* relationship with earthly species. These beings teach songs related to their *Jara* during shamanic rituals (Garcia, 2018). Of the forest species listed by the Awa Guajá as being culturally salient (S >0.1), more than half (57.7%, $n = 26$) are associated with *Jara*, *Karawara* and/or chants, and are identified by ** in Table 1.

Tabela 1. List of species of biocultural value with the greatest salience ($S > 0.1$), cited by *quilombolas* from the Agrovilas of Alcântara, indigenous Awa Guajá from Aldeia Awa and farmers from Vila Bom Jesus, in the Amazon region of Maranhão state, Brazil.

Name in Portuguese / Awa ihá	Scientific name	Smith	Use
	AGROVILAS OF ALCÂNTARA		
Bacuri	*Platonia insignis* Mart.	455	Fo, Wo, Me, In
Buriti	*Mauritia flexuosa* L.f.	264	Fo, Cu
Mirim	*Humiria balsamifera* (Aubl.) A.St.-Hil.	184	Wo
Guanandi	*Symphonia globulifera* L.f.	173	Wo
Babaçu	*Attalea speciosa* Mart. ex Spreng.	141	Fo, Wo, In
Urucurana*	*Virola surinamensis* (Rol. ex Rottb.) Warb.	0.13[£]	
Juçara	*Euterpe oleracea* Mart.	246	Fo
Janaúba	*Himatanthus drasticus* (Mart.) Plumel	116	Wo, Me
Pequi	*Caryocar brasiliense* Cambess	111	Fo, Wo, Me
	ALDEIA AWA		
Mukuria**	*Platonia insignis* Mart.	517	Fo, In, Hu
Aparaihu**	*Manilkara bidentata* (A.DC.) A.Chev.	516	Hu, Ho, E
Mykya'y**	*Caryocar brasiliense* Cambess	511	Fo, Hu
Itawa**	*Hymenaea courbaril* L.	432	Fo, Me, Hu, Ho
Aparaiu**	*Manilkara bidentata* subsp. *surinamensis* (Miq.) T.D.Penn.	332	Fo, Hu
Kypy**	*Theobroma grandiflorum* (Willd. ex Spreng.) K.Schum.	0.304 [¥]	Hu, Ho, Me
Pinawa**	*Oenocarpus distichus* Mart.	301	Fo, Hu
Akaju'ya**	*Anacardium giganteum* W.Hancock ex Engl.	480	Fo, Me, Hu
Tarika'ya**	*Bagassa guianensis* Aubl.	490	Hu
Wawa'ya	*Ziziphus* sp.	875	Hu
Paparana'	*Protium heptaphyllum* (Aubl.) Marchand	397	Hu
Ita'ia*,**	*Hymenaea parvifolia* Huber	837	Fo, Wo, Hu
Jahara**	*Euterpe oleracea* Mart.	400	Fo, Me, Hu
Irapajua'ya**	*Handroanthus* sp.	0.125 [£]	
Aparatan	*Micropholis venulosa* (Mart. &Eichler)	103	Hu
Xixipe/ *Mihatoa* / *Kair awan*	*Inga* sp.	0.61	Fo, Me, Hu
Arakoa'ya	*Bixa orellana* L.	0.56 [¥]	Me
Jawaraxi	*Protium* sp.	0.545 [¥]	Cul
Jaxipyrymy'y **	*Jacaranda copaia* (Aubl) D. Don	0.529 [¥]	Hu
Kapawa **	*Copaifera langsdorffii* Desf.	505	Me, Hu
Takamytyry'ya	*Gustavia augusta* L.	0.47 [¥]	Me, Hu
Amaxa'a	*Cecropia* sp.	0.45	Me, Hu
Arakaxa'a'ya **	*Jacaratia spinosa* (Aubl.) A. DC.	0.44	Hu
Ka'i pir	N.I.1	0.41 [¥]	Hu
Irapira'a	*Licania* sp.	0.39 [¥]	Hu

Name in Portuguese / Awa ihá	Scientific name	Smith	Use
	ALDEIA AWA		
Jo'a **	*Geonoma baculifera* (Poit.) Kunth	0.386 [¥]	Cul, Hu
Watyry'ya	*Lecythis lurida* (Miers) S.A.Mori	0.38 [¥]	Hu, Wo, Ho
Aparatata' **	*Licania kunthiana* Hook.f.	0.37 [¥]	Hu
Tawawa **	*Spondias mombin* L.	0.364 [¥]	Ho, Hu, Cul
Kyryhy'ya **	*Trattinnickia rhoifolia* Willd.	0.35 [¥]	Cul, Hu
Kiripirimi'	*Bactris maraja* Mart.	0.341 [¥]	Fo, Hu
Jata'a	*Syagrus* sp.	0.34 [¥]	Ho
Jamaka'ya **	*Lecythis lanceolata* Poir	0.33	Ho, Hu, Me
Kaxawa **	*Trichilia quadrijuga* Kunth	0.32 [¥]	Ho, Hu, Cul
Ayhu'ya kyn **	*Apeiba tibourbou* Aubl.	0.318 [¥]	Hu
Paparanohõ'ya	N.I.2	0.28	Fo, Hu, Ho
Wara pipiruhu	*Pouteria macrophylla* (Lam.) Eyma	0.273 [¥]	Hu, Wo
Wararo'ya	*Aspidosperma discolor* A.DC.	0.27 [¥]	Ho
Waju'ya	*Pouteria* sp.	0.26 [¥]	Hu
Wapupun	N.I.3	0.24	Hu
Inajã'ya **	*Attalea maripa* (Aubl.) Mart.	0.236 [¥]	Fo, Hu, Ho, Cul
Wajha'y **	*Lecythis* sp.	0.23 [¥]	Ho, Hu, Wo
Aka'ao **	*Theobroma speciosum* Willd. ex Spreng.	0.223 [¥]	Fo, Hu, Ho
Wariwa	*Brosimum acutifolium* Huber	0.22 [¥]	Hu
Xamuhũ' ya **	*Ceiba pentandra* (L.) Gaertn.	0.21 [¥]	Ho, Hu, Cul
Irawaxi	*Bactris* sp.	0.198 [¥]	Hu
Xymy'ya	*Pseudopiptadenia psilostachya* (DC.) G.P.Lewis & M.P.Lima	0.16 [¥]	Me
	VILA BOM JESUS		
Ipê	*Handroanthus* sp.	539	Wo, Me
Maçaranduba	*Manilkara bidentata* (A.DC.) A.Chev.	177	Wo, E
Cajá	*Spondias mombin* L.	0.167 [£]	
Jarana	*Lecythis lurida* (Miers) S.A.Mori	142	Wo, Me
Sapucaia	*Lecythis pisonis* Cambess.	0.139 [£]	
Copaíba	*Copaifera langsdorffii* Ducke	231	Wo, Me
Taturuba	*Pouteria macrophylla* (Lam.) Eyma	0.111 [£]	
Tatajuba	*Bagassa guianensis* Aubl.	107	E
Jatobá	*Hymenaea courbaril* L.	156	Wo, Me
Pau santo	*Zollernia paraensis* Huber	129	Wo, Me, E
Açoita cavalo	*Luehea* sp.	0.129 [¥]	Me

Uses: Fo (Food); Wo (Woody); Me (Medicinal); In (Income); Cu (Cultural); Hu (Hunting); Ho (Honey); E (Energy). [£] Species cited only for Ecological Importance. [¥] Species cited only for use-value. [*] Species considered vulnerable to extinction (Martinelli and Moraes, 2013). ** Species that possess *jaras*, *karawaras* and/or chants.

DISCUSSION

The indiscriminate use of fire and deforestation diminishes the ecological resilience of environments (Lawrence et al. 2010) and directly impacts the way of life of local communities. Ignoring the social dimension of restoration may lead to the failure of restoration interventions (Celentano et al. 2022). On the contrary, the use of species of biocultural value for the planning and implementation of restoration projects can be a key to inclusive and successful initiatives. This takes into account a scenario where environmental legislation will be enforced effectively.

Biocultural species list

A list of 58 native tree species of biocultural value was identified according to the knowledge of indigenous, traditional and rural communities. The Awa Guajá people cited many more species of biocultural importance strongly related to hunting activities, followed by "food", "honey" and "medicinal". This was described in detail by Cormier (2000), who emphasized that 84% of the species known to the Awa are related to hunted animals in contrast to other uses. In addition, more than half of the forest species quoted in the Awa Village were associated with *Jara* and *Karawara*. The Awa Guajá reveals relationships between humans and non-humans beyond material, utilitarian, and even physical issues, which are often mixed (Garcia 2018). This way of relating between human and non-human beings is common to several indigenous peoples, and is called "Amerindian perspectivism" (Viveiros de Castro 1996). In this sense, *Jara* is associated with the relationship of contiguity established between human and non-human beings, like guardians. The majority of the *Jara* forest species in our study turned out to be terrestrial animals. The *Karawara* can also establish *Jara* relationships with other beings, but they are celestial beings who descend to Earth to hunt and gather fruits during the day, and at night appear only in shamanic rituals, when they teach the Awa Guajá songs of their species of contiguous relationship (Garcia 2018). For Garcia (2018), the ecology of Awa Guajá landscapes can only be interpreted together with the concept of *Karawara*, in which "the *Karawara* would be the ecology itself". The spiritual and cultural perspectives must be considered in forest restoration projects (Schmidt et al. 2021) and be based on participatory approaches to include indigenous and traditional communities in decision-making processes.

Categories of use of species related to food security (food, hunting, honey) were more cited by *quilombolas* from Agrovilas of Alcântara and by the Awa Guajá people than by settlers from Vila Bom Jesus (Figure 4). This may be related to the process of settlement of these peoples in their environments. Vila Bom Jesus settlers mostly come from different municipalities and environments, while the *quilombolas* and indigenous peoples are in their original environments, at least for some generations. It should be remembered that the *quilombolas* of the Agrovilas of Alcântara also underwent a relocation, in which they left their territories, where they had fishing customs, to agrovilas projected in a region with difficult access to the sea, and soils of low natural fertility. This may explain that although more uses was related to the food category, there was a low number of species with utilitarian value mentioned in Agrovilas of Alcântara (average of 3 species/ind), and may warn of possible biocultural amnesia (Barthel et al. 2013) that communities may suffer due to socio-environmental degradation that prevents the reproduction of their ways of life. Furthermore, it evidences environmental racism that has been a consequence of historic exclusion of these communities from the decision-making processes on their territories. The non-existence of past bonds and memories in Vila Bom Jesus can explain the dynamics of the loss of old-growth forests (Figure 1), where food species and other use categories were extinguished from the environment.

The low number of species mentioned with economic utilitarian value in Aldeia Awa may be associated with the fact that the indigenous people who have approximately 50 years of contact are still creating their communication strategies, resistances, and autonomy. While in Alcântara and Vila Bom Jesus livelihood is not associated with forest management, but rather with itinerant agriculture and cattle ranching respectively.

We found low species consensus among the Free Lists. This finding suggests two directions: the first is that large-scale restoration initiatives may hardly succeed at the landscape scale if people's needs and demands are not considered (Celentano et al. 2022), which implies specific lists for each territory and community. The second is that people who live in the last remaining forest areas, such as the Awa, can be a reference for listing forest species.

We recognize that the Awa Guajá may have cited more species for their utilitarian values than other groups because they received more stimuli through guided walks. But the limitation of communication with the indigenous people made us adapt the methods, which were defined by common agreement, since the Awa know the names of most species only in their mother tongue, and not in Portuguese. As the Awa live with very close access to the forest, they are willing to go on walks to teach non-indigenous people. In Alcântara and Vila Bom Jesus, the forest areas are further away from the dwellings. Our results show us the strong correlation of the Awa with the forest landscape for the reproduction of their food habits (hunting, honey, and fruits). This reaffirms the importance of context and sociocultural history for understanding the dynamics of the use and management of natural resources.

Biocultural restoration and implications for forest landscapes

Species of biological and cultural value should be jointly identified not only to ensure local engagement in restoration strategies, but also to achieve the desired ecological integrity. Recent studies point to an increase in tree planting initiatives in recent decades, but with low floristic heterogeneity and more focus on useful species (Martin et al. 2021). Participatory ethnobiological research contributes to this practical application of restoration, involving people and promoting a transcultural character to the processes (Lyver et al. 2015; Allen et al. 2010). Indeed, the biocultural approach to restoration has also become a tool for resistance in territories, by ensuring environmental and sociocultural well-being, and the reproduction of biocultural memory (Toledo and Barrera-Bassols 2008). Species of biocultural value can vary over time within a community; what defines their importance is their cultural significance in a given space-time (Garibaldi 2009). Therefore, we affirm that the species cited in this study can be considered bioculturally valuable to the studied communities. Given that the Caru Indigenous Territories, where the Awa Guajá community lives, is one of the last forest remnants of the Maranhão Amazon, it is a Cultural Keystone Place or a Biocultural Refuge (Cuerrier et al. 2015; Barthel et al. 2013), an indispensable reference for restoration strategies. The list of tree species with biocultural value for forest restoration presented in this study must be complemented by species lists from conventional ecological surveys of conserved reference forest areas. We reiterate that, according to Sena et al. (2021), recognizing how local knowledge efficiently indicates species and core lineages that provide high amounts of services and goods to local communities may augment the success of restoration initiatives and the ecologic functions of habitats.

CONCLUSION

We have documented species of biocultural value to indigenous, traditional, and rural communities that can contribute to the restoration of forest landscapes socially connected in the eastern Amazon. We have identified a list of 58 native tree species of biocultural value according to the traditional knowledge of these communities. Most species have a utilitarian value, especially for food, hunting and medicinal uses. Our results showed low species consensus among the studied groups and significant differences in the utilitarian values of species in the three areas. This evidences the different cultural traits and also the environmental specificities of each location (phytophysiognomy, conservation gradient), which must be considered in the planning, implementation and management of restoration projects. Indigenous knowledge is an indispensable source of reference information for restoration strategies. Intangible values that reproduce cultural aspects of societies need to receive more attention and be better elucidated by restoration science, as they can serve as important allies for forest conservation and sustainable use.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: VCL, DC, GXR.
Carried out the experiment: VCL, STA, RTS, FFB, JCB, TAG, MLSE.
Carried out the data analysis: VCL, DC, RVCS, STA, RTS, FFB.
Wrote the first draft of the manuscript: VCL, DC, GXR.
Review and final writing of the manuscript: VCL, DC, RVCS, STA, GXR.
Supervision: DC, GXR.

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