REPORT

Human perceptions of landscape change: The case of a monodominant forest of *Attalea speciosa* Mart ex. Spreng (Northeast Brazil)

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Abstract From the perception of human populations, we can assess the changes occurring in certain landscapes and the factors that cause those changes. Such studies have proven helpful in increasing the knowledge of the history of a landscape, recognizing past formations and projecting its future. Our research objective was to determine how a landscape dominated by the palm tree *Attalea speciosa*, a species of ecological, economic, and cultural importance, has been changing over time by synthesizing and comparing historical documents and local perceptions. This study was conducted in Araripe Environmental Protection Area, Northeast Region, Brazil. To understand local landscape change, we interviewed active harvesters in four communities in which *A. speciosa* use has been documented. Historical documents were evaluated as a complement to the interview data. According to local informants, areas previously used for cultivation and animal husbandry that were abandoned or decimated by droughts in the region may have fostered the expansion of a monodominant *A. speciosa* forest. Furthermore, other forms of landscape management resulting from human population growth may also have affected the current and past distribution of this forest.

Keywords Ethnobiology · Ethnoecology · Environmental Perception · Landscape Ecology · Local Ecological Knowledge

INTRODUCTION

The relationship between human populations and the environment can be studied using a variety of scientific approaches. In landscape ecology, the relationship between humans and the natural environment has been addressed to

understand the consequences of these interactions in ecological, economic, and socio-cultural contexts (Vitte 2007; Nucci 2007). However, studies of this topic usually do not consider the historical contact that has occurred between human populations and landscapes. Accordingly, investigations of historical ecology are quite relevant because they seek to understand the relationship between people and landscapes by reconstructing the historical process of landscape change over time (Balée and Erickson 2006).

Land-use and management practices by human populations are drivers of landscape modifications (Bürgi et al. 2004). Activities such as agriculture, agroforestry, and cattle raising are examples of changes in the landscape driven by humans. Casas et al. (1997) believe that the current configuration of the landscape in several regions of the world is the result of modifications resulting from the domestication process, which human groups have performed for thousands of years. Landscape domestication is considered a process in which human manipulation causes changes in landscape ecology to transform the original ecosystems into a more productive landscape (Clement 1999). The degree of change in the landscape may vary from “promoted,” a landscape in which desirable plant populations are protected, to “domesticated,” a category that involves the complete transformation of the biotic landscape to favor the growth of one or a few selected food species (Clement 1999). Access to resources can be influenced by socioeconomic and political processes, leading to landscape changes.

Parallel to the process of landscape domestication, human populations have developed knowledge related to the places where they live (Berkes et al. 2000). This knowledge may assist investigations of landscape change because local or traditional human populations generally have a life story connected to the land (Bell 2001). This life

history allows them to develop a unique perspective of the world, building a perception of reality that is influenced by their values and ecological, economic, and cultural references (Lykke 2000; Xu et al. 2006). Using local knowledge and perception, it is possible to evaluate changes that have occurred in certain landscapes and their causal factors (Xu et al. 2006). Additionally, research on local human knowledge and perception enables collection of valuable ethnobotanical information that is central to the development of management strategies and the sustainable use of environmental resources, especially when considering human populations in protected areas (Lykke 2000; Cavalcanti et al. 2015).

Our research objective was to assess historical landscape change as perceived by human populations. We focused on a monodominant forest of *Attalea speciosa* Mart ex. Spreng (*A. speciosa*) in the Araripe Environmental Protection Area (APA-Araripe), Northeast Brazil, that is geographically isolated from other populations of this species. The APA-Araripe is a sustainable use conservation unit and has traditional communities within and outside its boundary (IBAMA 2004). In this area, many traditional peoples' activities of daily life are linked to the extraction of plant products such as babassu (IBAMA 2004).

The babassu palm, *A. speciosa*, is a species with recognized cultural and economic importance, and the extraction of products from this palm is considered an essential practice for diverse human populations (Andrade 2007; Campos et al. 2015). It is believed that the establishment of the *A. speciosa* forest at this location occurred

because of management activities undertaken by human populations and because it is common throughout Latin America to observe almost pure stands of palm species, including babassu, where presumably a multispecies primary forest once existed (see Kass and Somarriba 1999). The origin of such “oligarchic forests” (Peters et al. 1989) is controversial, but they are usually considered “anthropogenic forests.”

Many palm forests in the Amazon are considered anthropogenic (Balee 1988), but the role of human populations in the establishment of palm forest in dry areas is still understudied. Therefore, the present study sought to determine how the *A. speciosa* forest landscape in a Brazilian seasonally dry forest was established and modified over time by synthesizing and comparing historical documents with the local harvesters' perceptions of changes in a forest's extent (i.e., expansion/reduction).

MATERIALS AND METHODS

Study area

The study was conducted in Chapada do Araripe, Northeastern Brazil, in the Araripe Environmental Protection Area (Área de Proteção Ambiental do Araripe—APA-Araripe), a sustainable use conservation unit of approximately 1063 000 hectares created by the Brazilian government in 1997 (IBAMA 2004) (Fig. 1). The APA-Araripe covers the states of Ceará, Pernambuco, and Piauí

Fig. 1 Images of *Attalea speciosa* forest in the Araripe Environmental Protection Area (APA_Araripe), Northeastern Brazil. Photos: Juliana Campos and Timóteo Silva

and the Araripe National Forest (“Floresta Nacional do Araripe”), which is located in the state of Ceará (IBAMA 2004) (Fig. 1). The region’s soils are the oxisol yellow and oxisol red-yellow type, considered very deep and well drained, but acid and with low fertility (IBAMA 2004). According to the Gaussen classification, the weather is “hot tropical medium dry” (IBAMA 2004).

According to the Brazilian Ministry of the Environment (“Ministério do Meio Ambiente”—MMA) (MMA 2012), this protected area includes seven phytoecological units: wet forest, dry forest, tall savanna woodland (“cerradão”), woody savanna (“caatinga arbórea”), riverine forest, montane deciduous shrub vegetation (“carrasco”), and savanna (“cerrado”). Inserted between these units is a forest of the palm *A. speciosa* (Fig. 1), which has been historically exploited by local human communities. Among the towns located within the APA-Araripe is Barbalha (Brandão et al. 2012) (Fig. 2) in Ceará State; the local population is approximately 55 323, with 38 022 in urban areas and 17 301 in rural areas (IBGE 2011). The city of

Barbalha is part of the Cariri Metropolitan Region (State Complementary Law 78/09, 2009), which is an important commercial center in the Brazilian Northeast. Several rural communities in the city engage in resource management and extraction in the local *A. speciosa* forest. The local residents use different parts of the forest located near their communities.

Ethnobiological data

Selection of communities and informants

For the selection of the local communities, a survey was conducted in search of communities in the region that include residents who have developed extractive activities for *A. speciosa* because these people tend to have a greater knowledge of the species in the forest region. The first contact was made with the leaders of neighborhood associations in each surveyed community. The free list technique (Bernard 2006) was applied, in which the

Fig. 2 Location of the study area in the city of Barbalha, Ceará State, Araripe Environmental Protection Area (APA_Araripe), Northeastern Brazil

representatives were asked to list all of the communities in the city of Barbalha with residents who conduct extractive activities with *A. speciosa*. To this end, the Macaúba community was selected as a starting point because it is recognized by the Brazilian Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis—IBAMA) (IBAMA 2004) as possessing a strong history connected to the extraction of this species.

Residents of 17 communities were initially surveyed, and four communities were selected: Macaúba, Tabocas, Boa Esperança, and Barro Branco. These communities contained more than ten persons working with *A. speciosa*, which would allow participatory workshops. In addition to extractive activities related to *A. speciosa* and other plant species in the region, the sources of income for the residents of these communities are primarily smallholder agriculture, livestock, and government aid (School Supplement [Bolsa escolar], Family Supplement [Bolsa família], and Crop Insurance [Seguro Safra]).

Changes in the *A. speciosa* forest landscape were evaluated from the perspective of local harvesters. After selecting the communities, a meeting was conducted in each community with members of the residents' associations, and the objectives of the research were presented to the participants. From first contact, the people who had worked directly with the palm *A. speciosa* and made use of its resources were identified, and the Snow Ball technique was initiated (Patton 2001). This technique consists of identifying all of the community informants considered "experts" in the subject under investigation who are able to identify additional informants until there is no indication of new informants and the survey sample includes all informants within the target group. The selection of four communities allowed an aggregation and comparison of the representations of human populations, which was used to triangulate data and received data from historical documents.

All of the selected individuals were informed of the objectives of the study and were asked to read and sign the Informed Consent Form ("Termo de Consentimento Livre e Esclarecido") in accordance with the ethical aspects of research involving human subjects (Brazilian National Health Council (Conselho Nacional de Saúde), Resolution No. 466/2012). This study was approved by the Research Ethics Committee of the University of Pernambuco (Universidade de Pernambuco—UPE) N° 527 026, and approval was also obtained from the Biodiversity Authorization and Information System ("Sistema de Autorização e Informação em Biodiversidade"—ICMBIO/SISBIO), which can be confirmed by consulting process permit N° 38063-1.

Participatory methods

To understand the participants' perception of the changes occurring in the *A. speciosa* forest landscape and to have them identify possible causes, participatory workshops were held in each of the four selected communities. In Macaúba, 21 out of a total of 38 invited participants attended (55%), including 16 women and five men, with ages between 24 and 86 years. In Boa Esperança, 14 out of a total of 18 invited participants attended (78%), including eight women and six men, with ages between 32 and 73 years. In Barro Branco, 16 out of a total of 24 invited participants attended (67%), including 13 women and three men, with ages between 19 and 81 years. In Tabocas, four people out of a total of 16 attended (25%), including three women and one man, with ages between 55 and 72 years. The workshops were held between April and August 2013.

Through the timeline technique (Albuquerque et al. 2014a, b), the informants were encouraged to recall aspects of the changes that occurred in the *A. speciosa* forest landscape over time and to indicate possible causes. As a starting point, we used the year of foundation of each of the communities, which was estimated by the informants. In this technique, the informants noted factors that had positive or negative influences on changes to the *A. speciosa* forest, as well as factors perceived not to have had an influence on the forest. As the informants indicated events, a vertical line was drawn on a piece of paper (0.6×1.5 m) to form a timeline with the reported elements recorded in sequence from the oldest to most current.

An historical graph was the second participatory method used (Albuquerque et al. 2014a, b), and it estimated a numerical representation of the abundance of individuals of *A. speciosa* into four distinct periods: 1980s, 1990s, 2000s, and 2013. Using this method, the informants represented their perception of the abundance of *A. speciosa* mentioned in each period by symbols (squares) and indicated possible changes (expansion/reduction) in the extent of the forest in the region and the likely causes. For each decade investigated, the participants could place up to ten symbols, which would represent the maximum abundance of *A. speciosa*. Before defining the number of symbols, the participants were encouraged to discuss their perceptions with the other group members, and the value was presented only after reaching a consensus.

Document analysis

Concurrently with the ethnobiological study, a search was conducted for documents that evaluated issues related to the relationship between human populations and the studied environment. These documents were compared with information from the ethnobiological study and provided

us with complementary data that helped us understand the historical processes leading to the establishment of the babassu forest in APA-Araripe.

First, a survey was conducted of places where historical records of the region were present, using local libraries as a starting point, following the methodology proposed by Medeiros (2014). Then, in each of the locations indicated, people who provided us access to such records were asked about the existence of other repositories that might hold information on the environmental history of Araripe and babassu. The appropriate places were progressively canvassed until all designated locations had been visited. These records were obtained through searches conducted in the Diocese of Crato (“Diocese do Crato”), the Chico Mendes Institute for Biodiversity Conservation (“Instituto Chico Mendes de Conservação da Biodiversidade”—ICMBio), the Casa Grande Foundation (“Fundação Casa Grande”), the Cultural Institute of Crato (“Instituto Cultural do Crato”), Cariri Regional University (“Universidade Regional do Cariri”—URCA), Araripe Geopark, and the Araripe Foundation (“Fundação Araripe”).

In each of the places visited, a search was performed to identify documents relevant to the study (Medeiros 2014). Local circulation magazines (“Itaytera,” editions from 1958, 1967, 1971, 1984, 1995, “Hyhyté,” edition from 1986), recent editions of ancient manuscripts of naturalists and historians who lived in the nineteenth and twentieth centuries (Irineu Pinheiro, José de Figueiredo Filho, João Brígido, Baptista Siqueira), local newspapers (“A ação,” edition from 1968), and official documents of projects developed in the region (Araripe Project, the National Forest management Plan—Projeto Araripe, Plano de manejo da FLONA) were evaluated. From each document, excerpts were copied that were centered on the research focus, including excerpts that addressed the changes occurring in the regional landscape and the consequences of these changes for the *A. speciosa* forest. The analysis of this material was conducted using standard techniques of content analysis, including cataloging, interpreting, and inferring information based on the contents of the documents (Medeiros 2014). All of this historical research resulted in a register of events related to the management practices conducted by human populations that may have influenced the formation and modification of the *A. speciosa* forest in the region.

RESULTS

Document analysis and local representations of landscape modifications

From the research conducted using historical documents, it was possible to elucidate events related to changes in the

landscape of the *A. speciosa* forest in the study region. The historical documents combined reports, comments, and descriptions of the socio-environmental reality of the landscape of the Cariri region and complemented the data obtained during the construction of the timeline (Table 1). This timeline information was used to identify combinations of factors cited by people that may have influenced the increase or decrease in the regional babassu forest (Table 1).

Local harvesters identify the babassu palm as a species that has been used since the founding of their communities in the eighteenth century, which indicates that babassu would have most likely been among the palm trees used by Cariri Indians, as described in historical documents. However, according to local informants, the palm *A. speciosa* was not widely used by people who were populating the region in the nineteenth century (Table 1). Increased immigration to the Cariri region reflected an economic expansion resulting from the development of sugarcane mills (Table 1).

Historical descriptions of the region demonstrate the important role of sugarcane crops for the Cariri and, more precisely, for the city of Barbalha (Table 1). However, this economic growth, accompanied by population growth in the region, was severely disrupted by severe droughts that occurred in Cariri over several years during the twentieth century (Table 1). According to the local harvesters who attended the workshops, these droughts decimated crops and livestock; according to the historical findings, people emigrated and sought other sources of income (Table 1). These events may be associated with the increased use of products derived from the babassu palm (*A. speciosa*) that was described by the local population; people may have had a need to develop other activities so they would not have to leave their homes. Additionally, it was reported in the workshops that areas previously used for sugarcane plantations were colonized by new individuals of *A. speciosa*, thus promoting the expansion of babassu forest.

Local information obtained from the timeline indicates that with regional population growth since the 1980s, there was an increasingly frequent need to build houses, roads, and power grids (Table 1). According to the informants’ reports, this infrastructure development of the city of Barbalha promoted the deforestation of many areas of *A. speciosa* forest, causing the decline of this forest. The participants reported in the workshops that since 2001, the ban on the felling of *A. speciosa* palms without the permission of the ICMBio has resulted in a reduction in babassu removal and an increase in the babassu population throughout this decade (Table 1).

During construction of the timeline, in addition to the events cited by local harvesters that positively or negatively influenced *A. speciosa* forest size, informants also

Table 1 Historical events based on data obtained during the construction of the timeline with informants from the Macaúba, Tabocas, Barro Branco, and Boa Esperança communities and from an evaluation of historical documents; this information was used to determine the factors that may have influenced increases or decreases in the size of the *Attalea speciosa* forest in the APA-Araripe region, city of Barbalha, Ceará State, NE Brazil

Time interval	Information based on informant reports	Historical data
1760	Babassu is native to Cariri and was used by the Indians who inhabited the region (Boa Esperança, Barro Branco, Macaúba)	<p>“Had black hair, lived from hunting and by collecting fruit, mainly coconuts.” (Figueiredo Filho 2010a)</p> <p>“Many household items came from the primitive inhabitants of the jungles [...] The crops of corn and cotton were also known to the Indians. In Cariri, all contributed to an easy and primitive life, with nature providing the macaúba, babassu, piqui, araçá and other wild fruits in abundance.” (Figueiredo Filho 2010b)</p>
1760–1900	The coconut was still rarely used by the people who arrived in the region, and the fertile lands and the increase in sugarcane mills were the highlight of the region (Boa Esperança, Macaúba)	<p>“Even with other crops that are gaining ground, the production of rapadura still dominates the economic life of the Cariri Valley.” (Figueiredo Filho 2010a)</p> <p>“From the foot of the Araripe mountain range sprouts dozens and dozens of perennial fountains spreading fertility in the region.” (Figueiredo Filho 2010a)</p> <p>“[...] September 12, 1758, these people were dismissed under severe penalties, and there was no longer a piece of vacant land in those landscapes... from a small distance, the hills and swamps of Araripe were the most fertile and irrigable lands of Ceará that continued to attract settlers; the planting of sugarcane ensured that immigration was permanent.” (Brigídio 2001)</p> <p>“This year (1765) [...] there were 41 chapels, 972 livestock farms, and 37 mills in Cariri that manufactured honey and rapadura.” (Brigídio 2001)</p>
1901–1970	Drought events occurred, disabling irrigation and damaging crops of sugarcane and other plants and animals. (Macaúba)	<p>“Droughts have always exerted inauspicious action on the Ceará economy since the dawn of our colonization. It is the testimony of history and a chronicle of the time. Even the irrigated and humid soil of Cariri was affected by calamity.” (Figueiredo Filho 2010c)</p> <p>“In this century, we had droughts with quite dire results for the Polígono and even for Ceará, with direct and indirect consequences. The years 1900, 1915, 1919, 1932 and, more recently, 1958 were very tough.” (Figueiredo Filho 2010c)</p> <p>“Almost all agricultural crops and livestock, even in the Valley, suffer from water shortages. [...] There is also an accumulation of adventitious populations seeking the coolest land of Cariri, and they are harassed by the most fearful scourge in the backcountry without water. Big and small cattle also immigrated to the Valley, thereby disrupting the life of the regional rancher.” (Figueiredo Filho 2010c)</p> <p>No relevant reports were found</p>
1971–1980	Growth from using the resource of babassu palm for making sieves (arupemba), mats, fanners, and roofs of houses, resulting in the increase in pressure on the species (Boa Esperança, Tabocas, Macaúba)	
1981–2000	Increase in human population that resulted in the felling of palm trees to build houses, roads, and power grids (Boa Esperança, Tabocas, Macaúba)	From 1991 to 2000, the population of Barbalha city increased from 38 430 to 47 031 inhabitants (IBGE 2010)
2001–present	Ban on felling the babassu palm without authorization of the inspection agency (ICMBio) (Boa Esperança, Tabocas, Macaúba)	Barbalha Municipal bill approved on June 19, 2009

reported events that they believed did not influence its size, including subsistence agriculture by the local population; small herds of animals, such as cattle, goats, and chickens; and drought events in the region. According to the informants, such events and factors did not influence increases or decreases in the *A. speciosa* forest because these events did not lead to the felling of the palms. In addition to these events, the removal of seedlings (to prepare the land for planting) and green palm fruits and leaves (to make oils and handicrafts for sale) was also cited.

Representations of *A. speciosa* abundance

To construct historical charts in each of the communities, representations for the abundance of *A. speciosa* were identified in different decades, and analysis of this variation over time was conducted (Fig. 3).

Analyzing the information in Fig. 3, we observe that the rising and falling patterns of *A. speciosa* abundance representations were similar over time in the communities of Boa Esperança and Macaúba. In these communities, the residents noticed an increase in the abundance of *A. speciosa* since 2000, preceded by a decrease in previous decades. In Barro Branco, informants perceived an increase in the *A. speciosa* population only from 1980 to 1990, with the abundance remaining constant from 1990 to the present. However, the Tabocas informants perceived a decreased abundance of the *A. speciosa* palm during the same time period. With respect to the period between the 1990s and the present, people in the Tabocas community indicated that the *A. speciosa* population remained constant, which was also noted by the Barro Branco informants (Fig. 3).

Fig. 3 Perceived *Attalea speciosa* (babassu) abundance for the 1980s, 1990s, 2000s, and 2010s according to the representations of informants in the communities of Macaúba, Tabocas, Barro Branco, and Boa Esperança, city of Barbalha, Ceará State, Northeastern Brazil

These results reflect differences in the perspective of each individual. For all of the collected information, the informants indicated their reasons for noting increases or decreases in *A. speciosa* abundance. The increased abundance in Barro Branco identified only from 1980 to 1990 was justified as a result of fewer people working with babassu in the 1970s; according to the informants, there were increased amounts of babassu germination and growth in later decades (Fig. 3). From the 1990s to the present, the population of babassu remained constant and was preserved naturally, which was perceived by the residents of Barro Branco (Fig. 3). In Tabocas, people noted a decrease in the palm population from 1980 to 1990, which, according to the informants, was a result of deforestation for the construction of roads and houses and the installation of electrical networks.

In Boa Esperança, the informants perceived a decline in the babassu population only from 1990 to 2000, which was caused by the construction of new roads and houses because of the arrival of immigrants. For the same reason, the people of Macaúba indicated a population decline from 1980 to 2000 (Fig. 3). Since 2000, the inhabitants of Boa Esperança and Macaúba perceived a babassu population increase, attributed by the people of Macaúba to the creation of laws against deforestation in the region that prevented the removal of palm trees without prior permission from the ICMBio.

DISCUSSION

Historical data and local representations of landscape modifications

Data from BiodieselBR (2006) indicated that the use of the babassu palm in Brazil originated with the Indians and occurred before the arrival of European settlers in the country. May et al. (1985) suggested that the current babassu forest in Ceará might have been initiated by indigenous people who planted this palm. However, data obtained in the present study cannot confirm this hypothesis. Nevertheless, the access to historical documents, combined with the participatory methods, revealed landscape changes that may have fostered the babassu forest in the study area.

Among the most significant changes in the landscape has been the replacement of native vegetation by sugarcane plantations, which occurred between the years 1760 and 1970; the communities reported this change, and it was indicated in the document analysis (Table 1). The cultivation of sugarcane causes major changes in the landscape because it requires the use of fire. In addition to the burning of native vegetation to cultivate cane, fire is used to remove

leaves from the cane to facilitate harvesting. Thus, it was likely that replacing several phytoecological units with sugarcane monoculture caused not only “domestication” of the landscape but also changes in the characteristics of the soil and seed bank because of the high temperatures of the fires (Galdos et al. 2009).

However, *A. speciosa* has characteristics that confer resistance to these fires (Mitja and Ferraz 2001). In its early stages of development after germination, the apical meristem has a negative geotropism, allowing the roots to go deeper into the soil and to not be affected during fires (May et al. 1985; Mitja and Ferraz 2001). This characteristic ensures the success of the babassu palm in these areas (May et al. 1985). With the reduced competition from other species caused by the burning, *A. speciosa* individuals may have freely developed, and these areas would have become suitable for the development of true single-species babassu forests (May et al. 1985). Thus, it is believed that the numerous cycles of sugarcane cultivation in the study area gradually eliminated most species and seed banks in the soil, favoring babassu individuals because of their resistance to fire. After the decrease in sugarcane monoculture caused by the successive droughts between the years 1900 and 1970 and the concomitant abandonment of cultivated areas and the migration of human populations (Table 1), the babassu population most likely expanded to form the monodominant studied forest. Anderson (1983) highlighted that babassu palm is especially common on abandoned agricultural land, which corroborates our findings.

In areas such as the Araripe region, fallow lands can be burned during the dry season (Kass and Somarriba 1999). As stated before, burning may enhance palm populations that have pioneering characteristics, such as babassu and the “açai” palms (*Euterpe* spp.), resulting in monospecific or oligarchic forests (Peters et al. 1989). This scenario seems to be the case in the Araripe region.

The local informants indicated that this forest decreased in extent from the mid-1980s to the 2000s because of deforestation processes associated with population growth in the region in recent decades. The factors observed by the people as promoters of changes in the local landscape are also often associated with migrations of human groups, which cause increases/decreases in population density in a given region and have been observed in the history of the Araripe region. According to historical reports in Cariri, emigration induced by major droughts in Cariri motivated the abandonment of areas previously used for cultivation and livestock. According to Rêgo (1999), the movement of human groups can promote the dispersion of native and exotic species, thereby facilitating or preventing the establishment of certain species in the environment. Because the babassu is a species with ecological

characteristics that classify it as a pioneer and dominant species in areas degraded by man (Silva 2008), *A. speciosa* could have been favored in this region by deforestation events and the abandonment of fertile land.

According to Silva (2008), babassu populations were most likely spaced in forested areas of high biodiversity; however, in the current forest formations, extensive babassu patches were observed with continuous growth that was primarily caused by deforestation resulting from human activities and the competitive success of the species compared to plants that are not tolerant to fire. In a study of disturbance gradients in rainforests of northern Chiapas, Mexico, changes were observed in the absolute density and basal area of trees where the disturbance intensity was greater; disturbances in the study areas included forest extraction, grazing, and fire (Ramírez-Marcial et al. 2001). These differences demonstrate the role of human activities in altering forested environments.

Representations of *A. speciosa* abundance

In constructing the historical charts, we observed that the Macaúba and Boa Esperança communities showed greater similarity in the rise and fall of abundance patterns of babassu over time, which may be related to the exploration site used by the inhabitants of these communities. These communities are geographically adjacent, and they make use of common areas to obtain babassu resources. However, the geographic location of Barro Branco is far removed from the others, with the people of this community making use of a separate area to acquire their palm resources. This fact may have influenced the perception of the Barro Branco residents and may have caused its graphical representation of babassu abundance in the region to be the most dissimilar compared with the others. This explanation relies on the work of Fagerholm et al. (2012), who indicated that people best perceive areas that are closest to their homes. These authors note the difficulty of representing people in the space dimension and recommend that variables representing the distance between the place inhabited by the people and resource collection areas should be considered in studies of this nature.

According to Chambers and Mayoux (2003), the use of participatory methods may generate more accurate data compared with the use of conventional methods with regard to studies of cause and effect. However, although the studied communities were from the same city, the observed differences in their perception of the local landscape can also be justified by the multiplicity of factors involved in building individual perceptions. Rao et al. (2003) demonstrated the influence of factors such as age, gender, education, and socioeconomic on the perceptions of local populations.

Limitations

One of the difficulties encountered in the application of participatory methodologies used in our study was observed by Evans et al. (2006). These authors mention the difficulties encountered in pilot studies for participatory methodologies because the costs and availability of people hinder the effectiveness of such methodologies. Therefore, studies such as the one proposed here could be supplemented with other sources of quantitative data, such as the use of satellite images and individual interviews, and could be designed based on the socioeconomic factors of the local population.

CONCLUSION

The role of human populations as drivers of landscape change can be observed in the establishment of the babassu forest in Cariri, Ceará State; this process most likely started before the arrival of European settlers in the region. However, the current monodominant babassu forest probably began to develop after the replacement of the original phytoecological units with sugarcane monocultures, most likely in the nineteenth century. Although the populations of babassu in the study area can be considered “incidentally coevolved” and not the product of conscious human selection, in subsequent decades, the exploitation of the species has represented an important source of income in the region. This observation demonstrates that the relationship between cultures and the natural environment is not simply an interaction of internal and external factors but also a coevolved development of human beings and landscapes in response to their mutual influence.

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