Sociodemographic factors influencing environmental perception and local ecological knowledge in forests of different ages in Northeastern Brazil

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Research

Abstract

Background: Local ecological knowledge (LEK) has been a great ally in developing conservation strategies that are more attuned to the local reality. However, since this knowledge is dynamic, it is necessary to conduct studies that understand how cultural, sociodemographic and ecological factors can affect it. In this regard, the present study to assess the knowledge of farmers from different communities regarding plant species in forests of varying ages, as well as the sociodemographic and environmental perception factors that may influence them.

Methods: The study was conducted in two rural communities in the municipality of José de Freitas, Piauí, Brazil. The research involved farmers who possess knowledge about forests of different ages, selected through the snowball sampling technique. Data were collected through semi-structured interviews and guided tours for species collection. A total of 36 farmers participated in the study, including nine women and 27 men.

Results: : Our study unveiled distinct plant species knowledge in rural communities for forests of varying ages, often tied to cultural contexts. Sociodemographic and environmental factors analysis revealed age and perceived forest regeneration time influenced early-stage plant knowledge. For late-stage plant knowledge, factors included fragment visits, perception of regeneration time, and their interaction. While communities had differing knowledge on early and late-stage plants, common explanatory factors emerged.

Conclusions: The study suggests that in the studied communities, it's important to consider both age and current environmental experiences of farmers in LEK studies. This highlights the valuable contributions of both older and younger farmers in understanding changes in forest fragments of varying ages.

Keywords: Ethnobotany, dynamics of ecological knowledge, biodiversity conservation, natural regeneration.

Background

The resulting interaction between nature and culture has reshaped our environment to form landscapes that reflect the history, sociocultural identity, and socioeconomic status of human populations, proving beneficial for their survival (Albuquerque et al. 2019). Local Ecological Knowledge (LEK) is the result of human populations' coexistence and interaction with the environment in which they live (Albuquerque et al. 2019, Berkes et al. 2000). It is based on shared experiences and practices and can be adaptive (Berkes et al. 2000, Joa et al. 2018). In this regard, LEK is not static and is susceptible to change due to various factors, such as cultural, environmental, and socioeconomic influences (Oliveira et al. 2019; Turner & Turner 2008).

Studies indicate that the surrounding landscape influences the knowledge of human populations. For example, living in proximity to and interacting with plants increase the number of species used for food and timber known to local populations (Silva et al. 2017, Toledo & Salick 2006). Other research has suggested that anthropogenic activities in the landscape can decrease the diversity and abundance of known plant species (DeClerck et al. 2010, Tarrasón et al. 2010). Considering that human populations use forest resources and landscapes in their daily lives, it is expected that they have more knowledge about the ecological characteristics of locally distributed species, which farmers often encounter in their agricultural activities (de Freitas Lins Neto et al. 2013, Ochoa & Ladio 2014). In addition to the importance of investigating LEK, it is believed that the interaction of this knowledge with ecological studies and environmental factors influencing succession in secondary forest fragments is of great significance (Chazdon et al. 2020, Reyes-García et al. 2019).

Some studies suggest that local populations possess substantial knowledge about plants in nearby forest fragments, including morphological, ecophysiological, and phenological aspects of useful species (Campos et al. 2018, de Freitas Lins Neto et al. 2013, Sobral et al. 2017), contributing to conservation efforts (Ochoa & Ladio 2014). This knowledge can efficiently inform the regeneration of secondary forest fragments. Human populations tend to select resource acquisition areas based on fragment successional states, favoring early plants for medicinal purposes and late-stage plants for timber resources (Toledo & Salick 2006). Understanding the human-resource relationship is crucial for comprehending plant succession responses (Toledo & Salick 2006), as community management practices can alter environmental conditions, impacting fragment regeneration timelines (Chazdon et al. 2020). In our study, we classify early colonizing species as those appearing in initial succession stages, primarily comprising seed bank plants dispersed by animals and wind, as well as those capable of resprouting. Late colonizing plants emerge at more advanced succession stages (Arroyo-Rodríguez et al. 2017, Chadzon 2012, Lopes et al. 2012).

Effective strategies for establishing sustainable management of forest fragments require prior understanding of local realities, including the factors that influence ecological knowledge, which can vary due to multiple local economic and cultural realities associated with high biodiversity (Saynes-Vásquez et al. 2016). In this regard, the role of sociodemographic variables and perception of landscape change that can influence local ecological knowledge is highlighted. Empirical studies indicate that older peasants tend to possess more local ecological knowledge due to their greater life experience, contributing to the accumulation of knowledge not experienced by younger people, such as knowledge of medicinal plants (Almeida et al. 2012, Corroto et al. 2022) and timber plants (de Arruda et al. 2019). However, other studies suggest that younger people may have different knowledge due to increased current contact (Alencar et al. 2014). Additionally, it is believed that greater work frequency in forest areas or contact with forest resources used can favor the accumulation of knowledge, as observed in LEK studies related to timber plants (Ramos et al. 2008) and medicinal plants (Alencar et al. 2014).

The objective of this research was to evaluate the relationship between sociodemographic factors and environmental perception in the knowledge of farmers from different communities regarding early and late colonizing species in secondary forest fragments. Thus, the following questions were addressed: 1. Do the Segurança II and São Domingos communities have distinct knowledge about plants in forests of different regeneration ages? 2. Do the communities distinguish between plants in forests of different regeneration ages (early and late plants) and do they show consensus among informants? 3. What sociodemographic factors and environmental perception (age of informants, frequency of visits, time in fragment regeneration) influence the number of known early and late colonizing plants in forests of different ages in these communities? Based on the questions above, the following hypothesis were formulated: 1. There are differences in the

known species across forests of different ages, between early and late-stage plants. 2. Differences exist in the knowledge held by farmers within the studied communities. 3. The age of the farmers, the number of visits to fragments, and the perception of regeneration time positively influence the knowledge of plants in forests of varying ages. For these hypothesis, we have formulated the following predictions: 1. The composition of known species by farmers among forests of different ages will be distinct due to the distinct stages of the forests. 2. The composition of known species by farmers among rural communities will differ, considering the distinct social configurations of these communities. 3. Older farmers, who regularly visit forest fragments during the week and perceive a longer regeneration time in the fragments, will possess broader knowledge of both early and late-stage species. With this study, we aim to emphasize the importance of involving local populations in strategies for restoring forest fragments and conserving the surrounding environment.

Materials and Methods

Study area

The study was conducted with farmers residing in the Segurança II (4°48'50.02"S and 42°35'57.10"W) and São Domingos Settlement (4°48'50.02"S and 42°37'42.74"W) communities, both located in the municipality of José de Freitas, Piauí (4°47'57.8"S and 42°36'49.0"W) (Fig. 1). The municipality is situated in an ecotone region where cerrado and caatinga biomes overlap. In the studied communities, the predominant phytogeographic domain is cerrado, with a mosaic of caatinga vegetation. The climate is hot semi-arid tropical, with distinct dry and rainy seasons (Carvalho & Avelino 2010).

The study was conducted in both communities due to the residents' long history of providing services to Nazareth farm and the extensive communication among residents. The Segurança II community originated from the division of land among family members, who continue to reside there without migrating to urban areas and consists of 21 households. São Domingos Settlement was established through agrarian reform, with the demarcation of occupied land, and was created on 15/12/2000. It comprises 53 households, but due to a significant population outflow from rural communities to urban areas, only 43 households are currently occupied. Approximately 189 individuals aged 18 or older reside in the studied communities. Both communities are located near PI-113, with a distance of 4 km between them and approximately 9 km from the urban perimeter of José de Freitas, which is 48 km away from the capital, Teresina.

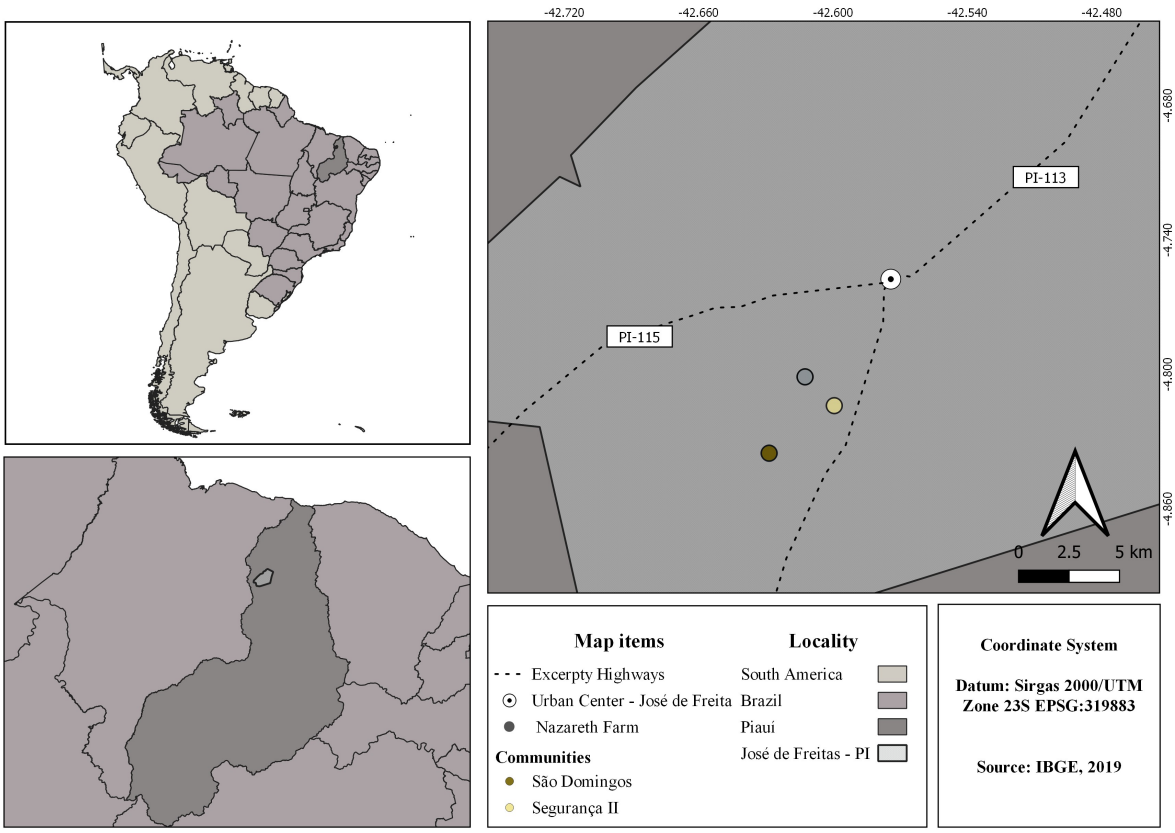

Figure 1. Map with the location of the studied communities, José de Freitas, Piauí, Northeast Brazil

Data Collection

The information was collected between August 2019 and February 2020. Participant selection was based on identifying residents engaged in agriculture and managing their lands near Nazareth Farm, possessing knowledge about forest fragments and abandoned areas within the study area. The sample universe was defined using the snowball sampling technique (Albuquerque et al. 2014a). Thirty-six farmers were interviewed using this sampling technique, chosen to obtain a representative sample of individuals in the communities holding information, among residents aged 18 or older. The research was approved by the Ethics Committee on Human Research (CEP) of the Federal University of Piauí, Campus Ministro Petrônio Portella (Opinion No. 3.563.801), and in the National System for Managing Genetic Heritage and Associated Traditional Knowledge (SISGEN), with registration number AAA321B.

Data were collected through semi-structured interviews. The interviews were conducted at the informant's residence, and at the end of each interview, the informant was invited to recommend another local expert, using the snowball technique (Albuquerque et al. 2014b). The questions in the survey covered key points, such as sociodemographic aspects (age, gender, education, agricultural activities, and the frequency of visits to forest fragments for agricultural purposes on a weekly basis), as well as aspects related to the Local Ecological Knowledge (LEK) of the farmers. To determine the early and late colonizing plant species known to the communities, informants were asked to list the plants freely. Subsequently, based on this list, they were questioned about each mentioned plant, whether they observed them in areas in the initial regeneration process or areas with forests in more advanced successional stages. To obtain information on the regeneration time from the farmers' observations, they were asked how long it took for the forest fragments to become similar to or resemble forests that had never undergone clear-cutting. The interviews were conducted by a single researcher to minimize the potential for biases during data collection.

Plant specimens were collected for taxonomic species identification to prevent potential errors in extrapolating the richness of early and late colonizing species mentioned in the interviews. Collections were made during guided tours (Albuquerque et al. 2014b). The areas selected for collecting species mentioned by farmers were those indicated by informants with the most knowledge. Subsequently, the specimens were herborized and identified through comparison with exsiccatae in reliable digital herbaria, with the assistance of specialized literature and taxonomists familiar with the seasonally dry tropical forests in the ecotonal region of the Middle Parnaíba, the species list was compiled following the APG IV (Group 2016). The identified material is incorporated into the collection of the Graziela Barroso Herbarium (TEPB) at the Federal University of Piauí.

Data Analysis

Firstly, the sociodemographic characteristics of the interviewees were described to profile the participants. Data were subjected to exploratory analysis following Zuur et al. (2010) approach. To check if the number of species mentioned for each knowledge is close to the estimated richness for each knowledge, the Jackknife I estimator with 999 permutations was used. To assess the similarity of knowledge regarding species in regenerating areas, early colonizing plants, and late colonizing plants between communities, the Jaccard coefficient was employed, and the results were presented in a Venn diagram. Non-parametric Multidimensional Scaling (NMDS) analysis (Gotelli & Ellison 2012) was used to ordinate community informants, assuming differences in knowledge of plants in regenerating areas between communities and that informants from different communities had differing knowledge of early and late colonizing plants. Two presence-absence matrices were created, one for early colonizing species knowledge and the other for late colonizing species. These matrices were used to calculate a distance matrix using the Jaccard index. The representativeness of the ordination in portraying the actual species distribution was verified using PERMANOVA with 999 permutations (Anderson 2001).

Cultural consensus analysis, derived from the free-list data, was conducted to meet the following objectives for using these concepts: 1) the degree of agreement among informants regarding the cultural knowledge domain; 2) culturally correct information about the cultural domain and common responses from informants; 3) counting for each informant, representing the knowledge domain. In cultural consensus analysis, the first factor (cultural consensus items) should be at least three times larger than the second factor to attribute consensus among informants (Borgatti 1990). For this purpose, the Anthropac 4.0 program was used.

To examine the influence of informant age, frequency of visits to fragments, and fragment regeneration time on the number of known early and late colonizing species by informants from both communities, Generalized Linear Models (GLM) analysis was used. Two models were tested, with the response variable in the first model being the richness of known early colonizing species, and in the second model, the number of known late colonizing species by informants. In both models, the predictor

variables were informant age, frequency of visits to fragments, and fragment regeneration time. The GLMs proposed were adjusted for the Poisson family and simplified by Stepwise, with the model selected based on the AIC value. For this, the "MASS" package was used. The representativeness of the selected model was verified using the "rsq" package. The analyses were conducted in R 4.0 software (R Core Team 2023), and a significance level of $p<0.05$ was used for all analyses.

Results

Description of the group interviewed

A total of 36 farmers participated in this study (19 residents from the Segurança II community and 17 from the São Domingos Settlement), ranging in age from 33 to 82 years (43.4 ± 11.80 years) and with residency times in the studied communities ranging from 3 to 82 years (41.11 ± 25.15 years). Overall, local experts in both communities exhibited low levels of education, defined as either illiteracy or dropping out in the early years of schooling. Only five interviewees had completed secondary education, and one had a university degree. In addition to their roles as farmers, these individuals also pursued other professional activities. Agricultural production for most of the experts is currently considered for subsistence, given the low productivity associated with family farming (Table 1). Farming activities were performed by both men and women. The majority reported that their primary occupation is agriculture (86.11%), while the remaining 13.89% had other occupations such as teaching, domestic work, driving, and trading.

Table 1. Socioeconomic profile of farmers interviewed in the municipality of José de Freitas, PI, Brazil. In number (N) and percentage (%)

Socioeconomic Data		**Segurança II**		**São Domingos**	
		N	**%**	**N**	**%**
Gender	Male	14	38.89	13	36.11
	Female	5	13.89	4	11.11
Age Range	18-59	6	16.67	7	19.44
	≤60	13	36.11	10	27.78
Education	Very low (Not educated)	4	41.67	10	27.78
	Low (Incomplete and complete elementary school)	8	22.22	4	11.11
	Secondary (Complete high school)	2	5.56	3	8.33
	High (Higher Education)	1	2.78	0	0.0
Agricultural Practice	Rarely	7	19.44	3	8.33
	Ever	12	33.33	14	38.89
Length of Residency in the Community	03-39	6	16.67	9	25.00
	40≥	13	36.11	8	22.22
Frequency of mobility	1-3 days weekly	8	22.22	4	11.11
	4-7 days weekly	11	30.56	13	36.11
Economic Occupation	Farmers	15	41.67	15	41.67
	Others	4	11.11	2	5.55
Income from Agricultural Practice	Nonexistent	2	5.56	0	0.0
	Own consumption	13	36.11	15	41.67
	Exclusively for sale	4	11.11	2	5.56

Regarding the frequency of visits to forest fragments, both men and women visit their fields weekly, primarily for activities like weeding, which is more commonly performed by men. Men engaged in activities in the forest fragments mentioned that they were more involved in secondary activities such as weeding, wood removal for fences, charcoal production, among others. On the other hand, women balanced agricultural activities with household chores, resulting in a lower frequency of visits.

Local ecological knowledge of forests of different ages among rural communities

Farmers recognized early and late colonizing species in successional forest fragments. Based on the interviews, the richness of species mentioned during the research amounted to 131 ethnobotanical species, both early and late colonizers, of which 126 species were identified, representing 45 families. Fabaceae was the most prominent family (33 species), followed by Bignoniaceae, Combretaceae, Myrtaceae, and Euphorbiaceae. The mentioned species were primarily woody plants (trees and shrubs), followed by herbaceous and liana species. Farmers were familiar with 97.82% of native plants and a small percentage of exotic species, 2.18%. Early colonizers accounted for 32.06%, late colonizers for 25.2%, and species classified as both early and late colonizers for 42.74%.

The most frequently cited species as early and late colonizers among the communities were *Mimosa caesalpiniifolia* Benth. with 97.22% of mentions, *Hymenaea stigonocarpa* Mart. ex Hayne with 72.22% of mentions, *Handroanthus serratifolius* (Vahl) S.O.Grose with 66.67% of mentions, *Astronium urundeuva* (M.Allemão) Engl. with 50% of mentions, *Campomanesia pubescens*(DC.) O. Berg. with 58.33% of mentions, and *Eugenia biflora* (L.) DC. with 41.67% of mentions. As for the most known species in the early colonizing stage, *Combretum duarteanum* Cambess. was mentioned by 36.11% of respondents, while *Vitex flavens* Kunth and *Terminalia fagifolia* Mart. were both mentioned by 16.67% of respondents. For late colonizing plants, the most cited species were *Myrcia multiflora* (Lam.) DC. with 52.78% of mentions, *Byrsonima crassifolia* (L.) Kunth. with 11.11% of mentions, and *Bromelia laciniosa* Mart. with 8.33% of mentions. The results demonstrate a cultural consensus among informants within each community (Table 2) regarding te cultural domain of early and late colonizing species, as the first factor was three times larger than the second factor for both cultural domains.

Table 2. Cultural consensus analysis on knowledge of early and late species for the Segurança II and São Domingos community

Early				Late			
Factor	**Value**	**%**	**Reason**	**Factor**	**Value**	**%**	**Reason**
Segurança II							
1	11.57	88.6	10,743	1	27.57	94.1	25,287
two	1.08	8.2	2,642	two	1.09	3.7	1,736
3	0.41	3.1		3	0.63	2.1	
São Domingos							
1	9.40	85.3	8,490	1	10.00	88.9	12,688
two	1.11	10.0	2,137	two	0.85	7.00	1,698
3	0.58	4.7		3	0.50	4.10	

In Segurança II, early colonizing species numbered 88 with an estimated richness of 120±17.27, while late colonizers comprised 80 species with an estimated richness of 120±13.08. São Domingos recorded 44 early colonizing species with an estimated richness of 60 ±7.82 and 43 late colonizers with an estimated richness of 67±7.93. The Jaccard similarity index showed a 0.21 similarity between early and late colonizing species in Segurança II and a 0.12 similarity in São Domingos. Low similarity between these ecological groups indicates distinct recognition and differentiation by the communities (Figure 2). For early colonizing species cited by farmers across communities, the Jaccard similarity index was 0.20. Late colonizers achieved a similarity index of 0.23 between Segurança II and São Domingos, highlighting differences in community knowledge of early and late colonizing species (Figure 3).

The hypothesis of differences in known species between the communities was also confirmed. NMDS (Figure 4A) showed the separation of informants from the Segurança II and São Domingos communities based on knowledge of early colonizing species (stress=0.11), which was confirmed by the PERMANOVA test (F=6.87; p=0.001). NMDS (Figure 4B) demonstrated the separation of communities based on knowledge of late colonizing species (stress=0.11), also confirmed by PERMANOVA, indicating differences in informant responses (F= 6.25; p=0.001).

Figure 2. Similarity of knowledge of early and late plants for the Segurança II and São Domingos communities

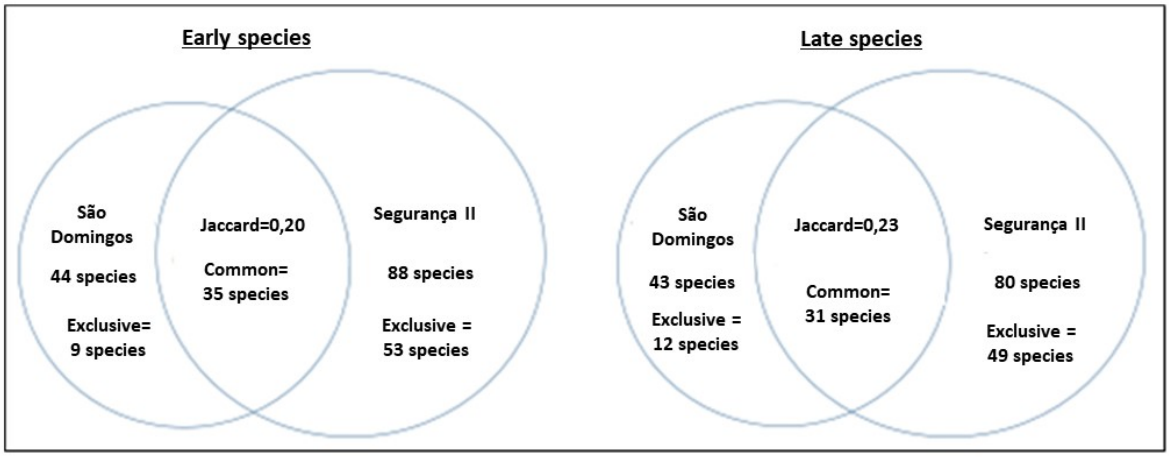

Figure 3. Similarity of knowledge of early and late plants between Segurança II and São Domingos communities

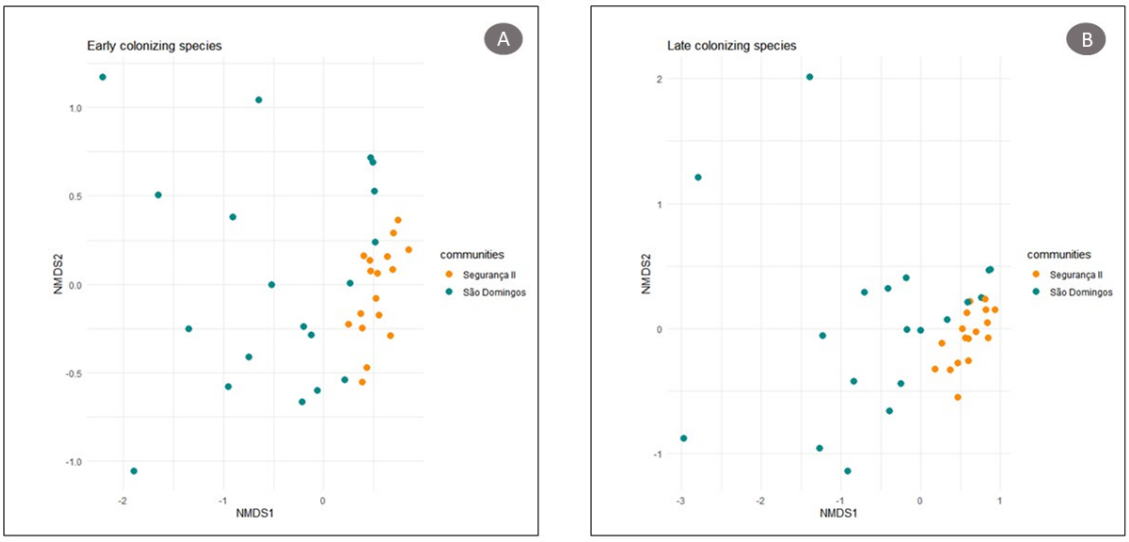

Figure 4. Non-Parametric Multidimensional (NMDS) Scaling Chart for ordering informants based on knowledge of plants among the studied communities. A. plants known as early and B. plants known as late

Factors that influence local ecological knowledge of forests of different ages

Regarding the hypothesis about the influence of age of farmers, the number of visits to fragments, and the perception of regeneration time on knowledge of plants in forests of different ages, we found partial correlations as predicted. In the Segurança II Community (Table 3), age, time, and the interaction between these two variables significantly influenced the richness of known early colonizing species (R^2=0.38). For late colonizers, the frequency of visits to the fragment, regeneration time, and the interaction between these two variables provided a better explanation for the richness of known species (R^2=0.26).

Table 3. Summary of the GLM model for the knowledge of farmers in the Segurança II community on the species richness of regenerating fragments

Early				Late			
	Estimate	Z	P		Estimate	Z	P
Intercept	4,648,109	4,821	<0.001***	Intercept	0.500814	0.805	0.420875
Age	-0.033690	-2,418	0.01559 *	Age	0.008298	1,058	0.290104
Visits	0.059546	1,500	0.13366	Visits	0.242575	3,632	0.000281 ***
Time	-0.263615	-3,012	0.00260 **	Time	0.048739	2006	0.044833 *
Age: time	0.003939	3,180	0.00147 **	Visits:time	-0.008165	-2,096	0.036069 *

In the São Domingos community, according to GLMs (Table 4), it was found that age, time, and the interaction between these two variables also influenced the richness of early colonizing species (R^2= 0.28). For late colonizers, the frequency of visits, regeneration time, and the interaction between these two variables also provided the best explanation for the richness of known species (R^2=0.21).

Table 4. Summary of the GLM model for the knowledge of farmers in the São Domingos community about the species richness of regenerating fragments

Early				**Late**			
	Estimate	Z	P		Estimate	Z	P
Intercept	4,612,292	3,894	9.86e-05 ***	Intercept	0.180742	0.160	0.8727
Age	-0.047292	-2,177	0.0295 *	Age	-0.006727	-0.735	0.4621
Visits	-0.040384	-0.708	0.4791	Visits	0.305505	1,774	0.0460 *
Time	-0.295851	-2,519	0.0118 *	Time	0.230185	2,131	0.0331 *
Age:time	0.005783	2,487	0.0129 *	Visits:time	-0.038331	-2,083	0.0372 *

Discussion

Factors Explaining the Variation in Plant Knowledge among Local Communities

Local ecological knowledge (LEK) is strongly influenced by social structural factors and the contrasting types of access to the forest and the resources found in these areas. The hypothesis that farmer communities would be able to recognize species at different regeneration stages was supported by this study. Our analyses indicate that the Segurança II and São Domingos communities share consensus knowledge of species, validating the use of free listing for data collection. Despite being neighboring communities, Segurança II and São Domingos showed significant differences in knowledge of species in forests of different ages (early and late colonizing species). Thus, the way people interact with their surrounding environment influences their knowledge of the area in which they live and likely affects its management. In Segurança II, it was observed that knowledge of plant species was greater than that observed in São Domingos. In this community, proximity to the fragments found on the Nazareth farm and interactions with the environment likely facilitate the accumulation of knowledge about the plants in those fragments. Both communities use the forests without restrictions.

It should be noted that over time, the relationship between populations and the environment undergoes changes, leading to a loss of knowledge about plant species. Consequently, some interactions with the environment cease to occur, resulting in reduced use of forest species and products, thus attenuating knowledge of these plants (Gaoue *et al.* 2017). In this regard, even though the communities share the floristic environment, there are cultural differences in their interaction with the environment that affect this knowledge, as observed by Saslis-Lagoudakis *et al.* (2014). In this sense, Segurança II's proximity

to the fragment entrance, combined with the cultural factor of greater interaction with the environment, may explain the higher number of species cited, both early and late colonizers.

In contrast, the São Domingos community is farther from the entrance to the forested areas, which may result in fewer visits to the forest fragment and, consequently, less knowledge of the area. Additionally, the fact that São Domingos is a rural settlement may have influenced the knowledge difference. Considering Brazil's vast territory, government policies for settlements devalue regional differences as well as local knowledge (Araújo & Amorozo 2012).

Furthermore, both communities use the land for family subsistence. It was evident that in the São Domingos settlement, all farmers have their cultivation plots close to each other and far from preserved forest fragments. Since they frequently engage in this activity, it is possible that contact with preserved forest fragments is decreasing. In contrast, in the Segurança II community, farmers plant and carry out their agricultural activities near their own forest fragments. This disparity between communities may also be associated with environmental degradation that can reduce knowledge of both timber and non-timber species (Fernández-Llamazares *et al.* 2015, Castiñeira Latorre *et al*. 2020). Silva *et al.* (2017) observed that with the intense use of useful plants by the local community, the abundance of species in a nearby preserved area decreased, and over time, local knowledge of these species also decreased.

The way farmers use forest fragments in the studied communities allows us to understand how modifications to the environment can alter knowledge. These arguments are discussed in the theory of the tragedy of the commons proposed by Hardin (Hardin 1968), which suggests that under such a regime, people tend to act selfishly and degrade areas more intensively for their benefit, while the resulting damage is shared among all users. This regime directs the practice found in rural settlements, where forest fragments are used jointly, which can contribute to an increase or decrease in the abundance of species and consequently alter the knowledge of local farmers (Lucena *et al.* 2012).

This research suggests that people living in close contact with plant communities are better able to recognize different ecological and eco-physiological events, such as phenology, reproduction, and aspects related to the availability of abiotic resources, which will influence the natural regeneration process in forest fragments near farmers. The use of knowledge is therefore an efficient tool for understanding some eco-physiological aspects (Castillo *et al.* 2020, Sobral *et al.* 2017).

In our study, we found that farmers are knowledgeable about early and late colonizing species and that culture between communities likely occurs differently among them, assuming that farmers have knowledge of different species. In this sense, further studies on the LEK of these communities are necessary, as highlighted by other authors, to understand how farmers perceive the influence of the environment and construct knowledge related to ecological succession (Chazdon *et al.* 2020, Reyes-García *et al.* 2019). The results obtained suggest that farmers can provide functional data about species in future research and contribute to discussions within studies related to the plant ecology of seasonally dry forests.

Factors Explaining Local Ecological Knowledge about Plants of Different Forest Ages

Local ecological knowledge (LEK) regarding plant species in regeneration was partially influenced by a combination of predictor variables (age, visits to fragments, and the time of fragment recovery described by farmers). Age influenced the richness of known species in the communities, with older farmers mentioning a greater number of species than the younger ones. This same result has been found in studies on the phenology and conservation status of extractive species (Campos *et al.* 2015a, Campos *et al.* 2018, Sobral *et al.* 2017) in the richness of medicinal plants (Almeida *et al.* 2012, Corroto *et al.* 2022, Santoro *et al.* 2022), edible plants (Campos *et al.* 2015b), and timber species (de Arruda *et al.* 2019).

According to the analysis using Generalized Linear Models (GLM), we observed a weakened association between age and the perception of fragment recovery time for early colonizing species, allowing us to understand that older farmers are more likely to know more about early colonizing species due to the experience gained over the years. It's possible that older farmers are reducing their visits to preserved forest fragments and, as a result, only have contact with species that emerge in their cultivation area, reducing their knowledge of late colonizing species. Studies address these knowledge differences between generations (Fernández-Llamazares *et al.* 2015, Hanazaki *et al.* 2013, Reyes-García *et al.* 2013).

The frequency of visits to the fragment and the recovery time of forest fragments, according to the GLM, were the variables driving knowledge of late colonizing species. This knowledge is possibly determined by the fact that younger farmers visit the forest more frequently and cover greater distances in search of resources, which provides greater observation opportunities. Current contact with the resource, in the case of medicinal plants, is a factor that can affect LEK (Alencar *et*

al. 2014). In our study, these constant observations allowed for a better understanding of ecological processes related to late colonizing plant species. Studies in seasonally dry tropical forest fragments with extractive species corroborate the findings of this study (Campos *et al.* 2018, Sobral *et al.* 2017).

Age directly influenced knowledge of early colonizing species; however, for late colonizing species, the frequency of visits was more significant. Predictor variables acted similarly among farmers in the Segurança II and São Domingos communities, even though the informants had knowledge of different species. The information gathered by these populations can support future research to increase our understanding of ecological succession processes. Both older and younger individuals are capable of providing ecological insights into local species found in the fragments, which are useful for the survival of these populations and the preservation of the natural environment.

Conclusion

The results of this research allow us to suggest that farmers residing near forest fragments and engaged in agricultural activities recognize species in regenerating fragments and their ecological groups. The studied communities exhibit different knowledge levels about local species. These farmers are predominantly male, but knowledge is equivalent in both genders. Older farmers recognize early colonizing species and also relate fragment recovery time to age. Conversely, younger farmers who visit the fragments more frequently possess greater knowledge of late colonizing species. Thus, the experiences and interactions of farmers have contributed to the formation of knowledge regarding the transformations in forest fragment areas.

Therefore, the obtained results contribute to the development of management and restoration strategies for degraded areas. They indicate an approach that ensures an efficient and participatory solution in the formulation of plans and actions for the use and conservation of seasonally dry tropical forests, emphasizing the importance of local communities in decision-making processes. Additionally, the findings of this research provide new data that should enhance our understanding of the successional process in seasonally dry forest fragments in areas with significant land use pressures in emerging economies of tropical countries.

Declarations

List of abbreviations: LEK **-** Local ecological knowledge; TEPB- Graziela Barroso Herbarium; CEP- Ethics Committee on Human Research; SISGEN- National System for Managing Genetic Heritage and Associated Traditional Knowledge
Ethics approval and consent to participate: We have previously informed consent, as detailed in the manuscript.
Consent for publication: Not applicable in this section.
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Author contributions: FIRS, MJLM, RFM and CGRL conceptualization of the study. FIRS, MJLM, RFM and CGRL: writing - original draft preparation. FIRS and CGRL: writing - review and editing.

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