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Temporal evaluation of the Conservation Priority Index for medicinal plants

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ABSTRACT

We investigated, through a temporal comparison, the extraction of non-timber forest resources by quantitatively analyzing the Conservation Priority Index (CPI). The study focused on the Fulni-ô Indigenous Territory, in the municipality of Águas Belas, PE (Northeast Brazil), which is characterized by caatinga vegetation (seasonal dry forest). Information on the availability of the exploited resources and the reported use of the species were obtained from vegetation sampling and semi-structured interviews, respectively. Our results demonstrated a reduction in species richness overtime, which may be due to continued resource extraction in the area, and that some species with low densities were even more affected. The species reported as being at high risk in the current study apparently did not differ from their status in the previous study, which supports the idea that these species are most evident in this situation more for their high potential of use than for their high densities. When we associate these events together with the disappearance of some rare species, we can conclude that the CPI was not efficient in predicting changes, and that the combination of variables used with the biological variables of the species needs to be adjusted.

Keywords: biodiversity conservation, Conservation Priority Index, ethnobotany, ethnoecology, traditional ecological knowledge

Introduction

Traditional populations throughout the world appropriate of a vast diversity of plant resources to meet different demands, and they develop practices for the management and use of these resources (Whitton & Rajakaruna 2001; Albuquerque *et al*. 2009; Ferreira Júnior *et al*. 2011). The extractive activities associated with the use of such plant resources have the potential to modify the population dynamics of species. In this context, adequate planning regarding their use is necessary in order to contribute to the conservation of natural stocks, as well as to ensure the persistence of these species for future generations (Hamilton 2004), especially for those that directly depend on them.

Several studies have attempted to explain variation in population dynamics of plant species managed by local communities, and use that information to develop methods of measuring local impact (Marinho *et al*. 2016; Reddy *et al*. 2016). The use of these methods has become more and more common in studies evaluating the impact caused by anthropic actions on vegetation (Dhar *et al*. 2000; Kala 2000; Dzerefos & Witkowski 2001; Badola & Pal 2003; Dalle & Potvin 2004; Kala *et al*. 2004; Oliveira *et al*. 2007; Brehm

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et al. 2010; Albuquerque *et al*. 2011a; b; Idohou *et al*. 2012; Lucena *et al*. 2013). Janni & Bastien (2000), for example, recognized conservation priorities using the index of relative importance based on the proposal of Bennet & Prance (2000) to evaluate plants that have cultural use. Badola & Pal (2003) aimed to highlight the available information on rare, sensitive and endangered medicinal plant species based on surveys in different scientific publications. Such impact indicators have emerged as useful tools, especially when the goal is to develop management and conservation plans for species that are of human interest, although they can possess weaknesses that compromise their reliability. For example, Albuquerque *et al*. (2011b) pointed out that the Conservation Priority Index, one of the tools used to measure impacts on medicinal plant populations, does not consider summed impacts when a species has multiple uses. In addition, when using such indicators, few studies assess their accuracy on a temporal scale.

Considering the limitations shown by some indicators of impact, as well as the need to verify their relevance on temporal scale, the present study proposes a temporal characterization for a period of seven years, using the Conservation Priority Index (CPI) as a quantitative analysis tool for assessing endangered species. The main goal of this study was to determine whether the temporal period from 2007 (Albuquerque *et al*. 2011b) to 2014 was sufficient to detect changes in the population dynamics of medicinal species. For this investigation, we assumed that the environment experiences events of intense extraction of plant resources and that no, or almost no, conservation effort occurred during the time period.

Studies involving population dynamics report that several factors can influence the development of ecosystems, including changes to their current regeneration status leading plant populations into unknown patterns of dynamics (Silveira & Silva 2010; O'Brien *et al*. 2012). The most commonly reported of these factors in the literature are climatic fluctuations and anthropic actions, the latter also including chronic anthropogenic disturbances (Singh 1998; Silveira & Silva 2010; Martorell & Peters 2005; O'Brien *et al*. 2012), which can have a direct influence on forest cycles and altering the response time of plant communities (Feeley *et al*. 2011). Chronic anthropogenic disturbances are continuous human actions of biomass removal from forest resources that have deleterious effects at population, community and ecosystem levels, but do not result in abrupt and complete environmental changes (Singh 1998; Martorell & Peters 2005). These disturbances, in turn, do not represent an immediate risk to plant populations, but they have the capacity to cause changes in the biology of species, altering reproduction rates and making it difficult to re-establish plant cover (Ribeiro *et al*. 2015; Ribeiro-Neto *et al*. 2016). Assuming that the studied environment is subjected to the direct influence of anthropic action and was totally devoid of conservation efforts over time, this study aims to infer the current conservation status of species considered as conservation priorities in the first study. Given this scenario, we assume that species considered as priorities for conservation in the first period study will remain at risk, with the possible occurrence of changes in population dynamics, or even local extinction, if the extraction of plant resources continues without an appropriate management plan.

Materials and methods

Study area

The study was conducted in the Fulni-ô Indigenous Territory, located in the municipality of Águas Belas, state of Pernambuco, Northeast Brazil (9°06'45"S, 37°07'15"W), approximately 315 km from the state capital Recife (CONDEPE/FIDEM 2006; IBGE 2015) (Fig. 1). The territory of the Fulni-ô comprises three villages: the main village, which is approximately 500 m from the town, and the Ouricurí and Xixiakhlá villages, which have approximately 3,657 inhabitants and occupy a total area of approximately 11,500 ha (FUNASA 2007; Silveira *et al*. 2011; CONDEPE 1981). According to the climatic classification of Köppen-Geiger, the climate is semi-arid (BSh) and hot and humid, with an average temperature of 25 °C and annual precipitation of around 600 mm. The local vegetation is hyperxerophytic caatinga (dry forest).

The research group's relationship with the Fulni-ô people started with the "Study Project of the Environmental and Cultural Sustainability of the Fulni-ô Medical System", which began in July 2007 and concluded in December 2008. This project was executed by the *Associação Mista Cacique Procópio Sarapó* (AMCPS) in partnership with the *Área de Medicina Tradicional Indígena* (AMTI), Project Visigus II, and with the *Distrito Sanitário Especial Indígena de Pernambuco* (DSEI-PE), National Health Foundation, and had as its main objectives: the development of proposals for interaction between the Fulni-ô medical system and the Subsystem of Attention to the Health of the Indigenous Peoples; identification of community and traditional strategies for the sustainability of Fulni-ô traditional medicine and presenting a Manipulation of Medicinal Plants Workshop; and valuing and strengthening the knowledge, practices and practitioners of traditional Fulni-ô medicine, among others. Through this relationship, the Fulni-ô group itself recognized a need to pursue research on environmental and cultural sustainability of their ethnicity. Given this situation, the research group resumed studies in 2014, with the purpose of continuing to develop research aimed at preserving Fulni-ô medicinal practices.

Fulni-ô ethnicity

The Fulni-ô are indigenous people who lived on the banks of the Ipanema River, which borders their indigenous

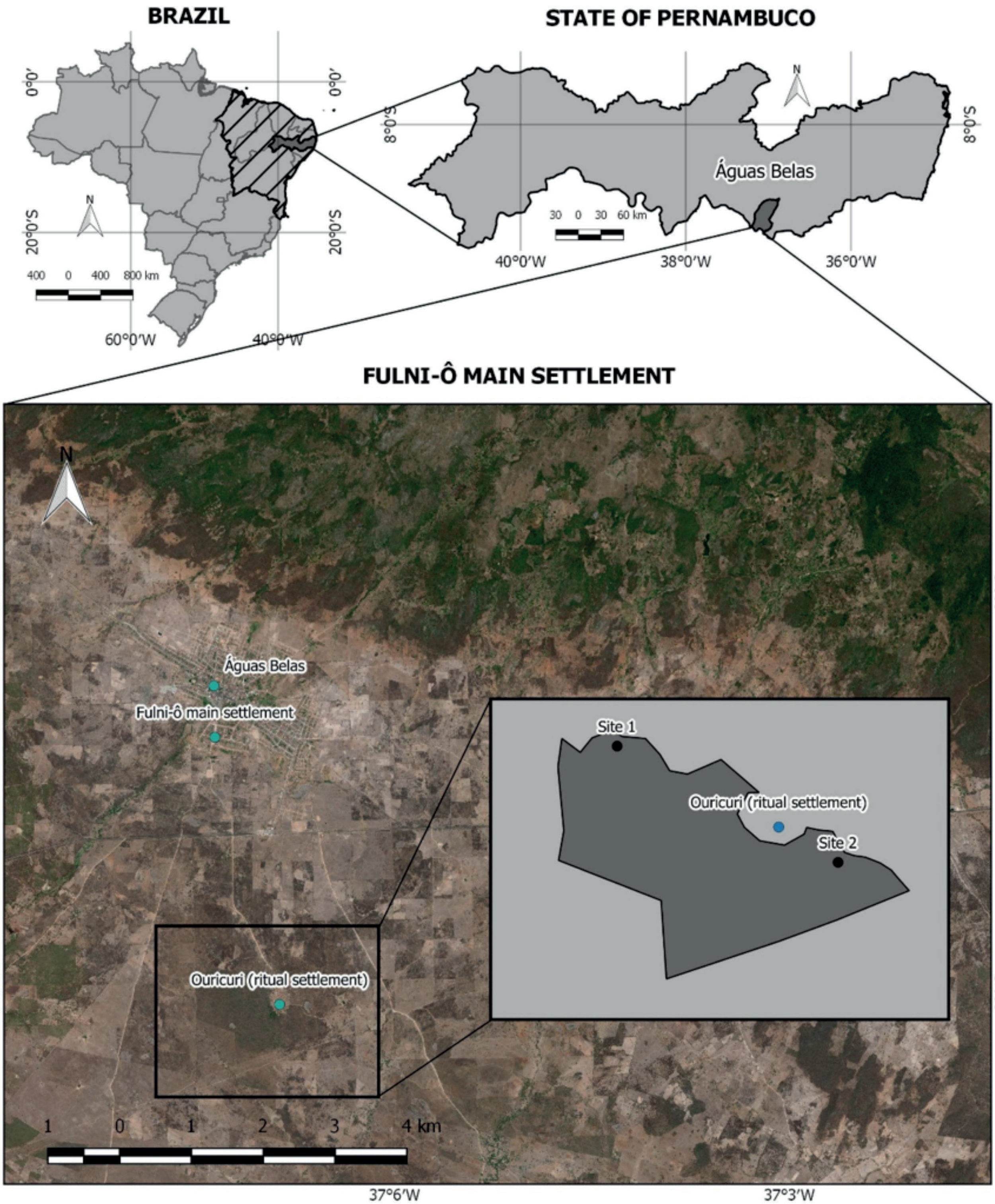

Figure 1. Location of the Fulni-ô community in the semi-arid region of northeastern Brazil (municipality of Águas Belas, state of Pernambuco). Source: Albuquerque *et al*. (2011a).

territory. They were catechized and converted to Catholicism with the arrival of the Capuchins in 1685 (Diaz 1983). They represented one of the only bilingual indigenous peoples of the Northeast Region of Brazil. Their languages are *Yathee*, which belongs to the Macro-Jê linguistic group, and Portuguese. *Yathee* is spoken daily by the community, and especially by the older members (Diaz 1983).

The calendar of the Fulni-ô people is governed by the ritual of Ouricurí that occurs annually between the months of September and December. During this period, the entire population living in the main village and in the Xixiakhlá village move to the Ouricurí village (considered sacred by the Fulni-ô people), and the forest, which has the same name, becomes a main area for resource extraction, especially those resources destined for medicinal uses in rituals and celebrations (Albuquerque *et al*. 2011b). Consequently, the forest is subjected to the direct impact of more than three thousand indigenous natives that transit the area and depend directly on the plant resources that are extracted there. *Yathee* is spoken and taught during this ritual, which represents an important means for the transmission of cosmology, history and traditional knowledge to younger generations. These cultural characteristics are protected by symbolism and secrecy adopted by the Fulni-ô, and it is practically impossible for a non-indigenous person to infer what actually happens during this ritual (Albuquerque *et al*. 2011b; c).

Agriculture and small livestock breeds comprise the subsistence activities of the Fulni-ô people. Landowners generally do not use these areas for cultivation, preferring to lease them to a third party. As a result, only the most arid lands remain available for Fulni-ô subsistence agriculture. Several factors, such as unfavorable climatic conditions and rudimentary techniques, led to the idleness of a large part of the indigenous lands, and leading the Fulni-ô to other activities, such as handcrafts (Silveira *et al*. 2011).

The Fulni-ô medical system

The Fulni-ô medical system consists of a set of knowledge and practices used for health maintenance and the prevention and treatment of diseases, according to indigenous methods (Soldati & Albuquerque 2012). Such knowledge can be found widely among the family circle, in which it is shared collectively, or remain only under the domain of traditional knowledge holders (Souza 2006; Soldati & Albuquerque 2012). When a symptom or malaise is identified, the family circle is where the first care takes place, with diagnosis and the establishment of a therapy to cure the disease. Specialists and holders of traditional knowledge are summoned only in cases that are more complex and/or to cure diseases of their specialty. The milder diseases are usually treated with home remedies or "pharmacy remedies", but if the disease is considered severe and no success is observed in the first attempts of treatment, the indigenous people are taken to nearby cities that provide structure for more specialized treatment (Souza 2006). According to Souza (2006) the Fulni-ô medical system is essentially shamanic. This is explained by the fact that its explanatory practices and models are directly related to the religion and ritual of the Ouricurí.

Legal aspects

A prior authorization by the Fulni-ô was necessary for the collection of data on their use of natural resources. For this, a Prior Informed Consent was issued, which was read and signed by the *Pajé* of the tribe. The research project was submitted and accepted by all institutions required by Brazilian law: National System of Ethics in Research (SISNEP, No. 50629015.9.0000.5207), National Historical and Artistic Patrimony Institute (IPHAN, No. 02000.003064/2013-11), National Research Council (CNPq, No. 84616/13), Biodiversity Information and Authorization System (SISBIO, No. 42874-1), and National Indian Foundation (FUNAI, No. 08620.031129/2014-88).

Establishment of conservation priorities

In order to identify species of conservation priority, we followed the protocol modified by Albuquerque *et al*. (2011b), which takes into account data on the availability of species in the environment together with data on the local uses attributed to each species. The present research considered this study as a starting point for the assessment of conservation priorities from a temporal perspective.

Information regarding the current availability of exploited resources were obtained from vegetation sampling performed between April and May 2014, in the territory belonging to the Fulni-ô indigenous people. The area sampled was exactly the same area inventoried in the initial study, since it is the only area in which non-indigenous people are permitted (see Albuquerque *et al*. 2011b). Due to its proximity to the main village, the forest experiences great pressure from exploitation, especially from September to November when the ritual of Ouricurí occurs. Because it is considered a place of collective appropriation, it suffers from unsustainable collection practices, even though it has limited access for non-indigenous people (Albuquerque *et al*. 2011b).

The vegetation analysis was performed using the same quadrat sampling method used in the first study (see Cottam & Curtis 1956; Felfili *et al*. 2011; Albuquerque *et al*. 2011b). The sites previously delimited by Albuquerque *et al*. (2011b), were demarcated with GPS and with the help of a local guide (one of the authors of Albuquerque *et al*. 2011b), aiming to define with greater precision the area in which the previous analyses were performed. One hundred quadrats were placed at each site for a total of 200 quadrats. The sampling design consisted of the creation of 10 lines of 50 m at each of two defined sites. The lines were installed perpendicular to the trails and the main roads that cross the forest, thus avoiding border areas and areas affected by the development of the city. They were spaced 10m from each other and one point was defined at each 10 m of each sampling line. The area around each point was divided into four quadrants (each with 90º) and for each quadrant, we sampled the diameter at ground level (including individuals with DNS ≥ 3 cm) for the specimen closest to the vertex of the quadrant (Rodal *et al*. 2013). From these data, we calculated the relative density of each species (RD), which is used to compose part of the Conservation Priority Index. In addition, in order to establish the total local diversity, botanical material was collected for species that were not included in the sample in order to include species that were not sampled in the phytosociological inventory. The species sampled were identified by their local names, according to what has already been established by Albuquerque *et al*. (2011b) in the same study area, taxonomically identified and incorporated into the collection of the herbarium Dárdano de Andrade Lima, at the Instituto Agronômico de Pernambuco - IPA (Tab. 1).

Information regarding the reported use of plant species included the data published by Albuquerque *et al*. (2011) from 344 interviews conducted in 2007, representing the first period of study, and data referring from 396 interviews conducted between the years of 2014 and 2015, representing the current sample and the second period of study. This representative sample was divided among the regions of the village, according to the area served by each health agent, in order to include all 14 regions of the indigenous territory. Semi-structured interviews were performed, in which people were asked about plants known for medicinal use, as well as the therapeutic targets that are treated with the use of those plants. All interviews were conducted in the company of an indigenous person to facilitate communication between the researchers and the interviewees, and provide help in translating of some of the plant names that were often known only in the native language of *Yathee*.

For determining conservation priorities of medicinal plants, we used the Conservation Priority Index (CP), which takes into account a biological score (BS) and a risk of use score (RU) for the species. This technique was initially developed by Mander *et al*. (1997), first employed by Dzerefos & Witkowski (2001) and later adapted by Albuquerque *et al*. (2011b). The criteria used in the calculation are explained in Table 2. Conservation priority was calculated based on the formula: $CP = 0.5 (BS) + 0.5 (RU)$.

The Biological Score (BS) was calculated based on the relative density of each taxon: $BS= D \times 10$, where D corresponds to the value obtained based on the relative density of each taxon (DRi) scored according to Table 2. For the calculation of the relative density, undamaged individuals were included as well as those that were partially cut, however, still in condition to offer products.

The highest value between the local importance (L) and the diversity of use (V) determined the value of use (U), which together with the value of the collection risk (H) provided the Risk of Utilization Score (RU) that reaches the maximum value of 100. The Risk of Utilization Score (RU) is calculated by the following formula: $RU = 0.5 (H) + 0.5 (U) \times 10$. The value of the collection risk (H) is based on the biological consequences caused during collection, according to the part of the plant that will be removed (Tab. 2). The value of local importance is determined by the percentage of the number of informants who indicated a particular species as medicinal, and the diversity of use (V) is related to the uses attributed to the species, with scores varying from 1 to 10 (Tab. 2).

Oliveira *et al*. (2007) suggest that there are limitations in the calculation of conservation priorities, since the formula used does not take into account other uses of medicinal plants that may be potentially more harmful. In order to take into account the observations made by Oliveira *et al*. (2007), Albuquerque *et al*. (2011b) added 10 scores into the variable "associated timber uses" (AT), which takes into account the multiple uses of woody medicinal plants used by the Fulni-ô, resulting in additional pressure on them. The new formula is presented as follows: $PC = 0.5 (BS) + 0.5 (RU) \times 10$, with timber use being included only when the species presents this type of associated use. The data used to calculate the Risk of Utilization Score (RU) and Biological Score (BS), were extracted from the work of Albuquerque *et al*. (2011b).

The Conservation Priority Index was calculated for each of the sampled species. The score allowed the classification of medicinal plants into three categories: Category 1, CP ≥ 80, in which species of high priority for conservation were included, and for which collection should be performed by applying sustainable alternatives; Category 2, < 80 CP > 60, which includes species with potential to be collected according to location and specific quotas; and Category 3, CP ≤ 60, which are species suitable for high impact collection.

Data analysis

In order to test for significant differences among the Conservation Priority Index scores, we used the Wilcoxon test. This statistical analysis was used in order to evaluate the dynamics of the species reported as having some medicinal use, considering the values obtained in the two study periods, without taking into account segregation by categories of risk, as this is implemented in the Conservation Priority Index itself. Using the same type of test, and focusing on the same objective of the previous analysis, we performed an analysis for each risk category (≥ 80; < 80 > 60 and ≤ 60) between the scores of the first (2007) and the second (2014) periods of study.

In order to assess species richness in general, as well as richness of species reported to have medicinal use, we performed a chi-square test on contingency tables. All tests mentioned above were performed using the software

Table 1. Current list of plants collected during the floristic inventory at the Fulni-ô Indigenous Village, Águas Belas (Pernambuco, Northeastern Brazil) with their respective local names. *Species indicated for medicinal use. Species that do not have values for absolute density (AD) and relative density (RD) are those that were not included in the sampling, and inserted in the vegetation listing in order to estimate total local diversity.

Family	Scientific name	Local name	Record No.	No. individuals	AD	RD
Acanthaceae	*Ruellia asperula* (Mart. ExNess) Lindau*	Canela de nambu	90272	4	13.70	0.500
Amaranthaceae	*Pfaffia glomerata* (Spreng.) Pedersen*	Alenta cavalo	90965	1	-	-
Anacardiaceae	*Myracrodruon urundeuva* Allemão*	Aroeira	90266	24	82.23	3.000
	Schinopsis brasiliensis Engl.*	Baraúna	90959	19	65.09	2.375
	Spondias tuberosa Arruda*	Umbuzeiro	90267	1	-	-
Apocynaceae	*Aspidosperma pyrifolium* Mart.*	Pereiro	90274	88	301.51	11.00
Boraginaceae	*Varronia leucocephala* (Moric.) J	Moleque duro	90271	5	17.13	0.625
Burseraceae	*Commiphora leptophloeos* (Mart.) J.B. Gillett*	Imburana branca, Imburana de cambão	90958	51	174.73	6.375
Capparaceae	*Cynophalla hastata* (Jacq.) J. Presl.*	Feijão bravo	91011	3	10.27	0.375
	Capparis jacobinae Moric. Ex Eichler	Cabeça de nego	90275	11	37.68	1.375
Erythroxylaceae	*Erythroxylum suberosum* A.St.-Hil.	-	-	1	3.42	0.125
Celastraceae	*Maytenus rigida* Mart.*	Bom nome	90273	22	75.37	2.750
Euphorbiaceae	*Croton heliotropiifolius* Kunth.*	Velame	90265	1	-	-
	Ditaxis malpighiacea (Ule) Pax&K. Hoffn. *	Sassafrás, Sassafrás fêmea	-	1	-	-
	Jatropha molissima (Pohl) Baill. *	Pinhão, Pinhão bravo	90263	56	191.87	7.000
	Sapium argutum (Mull Arg.) Huber	Burra leiteira	91029	10	34.26	1.250
Leguminosae Caesalpinoidae	*Bauhinia cheilantha* (Bong.) Stud.*	Mororó	90277	101	346.05	12.625
	Poincianella pyramidalis (Tul.) L. P. Queiroz *	Catingueira	90284	192	657.84	24.00
Leguminosae Mimosoidae	*Anadenanthera colubrina* var. *cebil* (Griseb.) Altschul*	Angico de caroço	90282	5	17.131	0.625
	Senegalia bahiensis (Benth) & Ebinger	Espinheiro vermelho	90279	1	1	0.125
	Libidibia férrea (Mart. Ex. Tul.) L. P. Queiroz)	Pau ferro	90993	1	-	-
	Chloroleucon foliolosum (Benth.) C. P. Lewis*	Arapiraca, Espinheiro vermelho, jurema branca	90278	16	54.82	2
	Mimosa tenuiflora (Willd.) Poir. *	Jurema preta	90286	23	78.80	2.875
	Parapiptadenia zehntneri (Harms) M.P. Lima & H.C. Lima*	Angico monjolo	90220	2	6.85	0.250
	Piptadenia stipulacea (Benth.) Ducke*	Angico branco, espinheiro branco	90292	51	174.73	10.50
Bombacaceae	*Ceiba glaziovii* (Kuntze) K. Schum*	Barriguda	91001	1	-	-
Nyctaginaceae	*Guapira noxia* (Netto) Lundell*	Piranha	90270	11	37.68	1.375
Rhamnaceae	*Rhamnidium molle* Reissek	Ameixa	-	3	10.27	0.375
	Ziziphus joazeiro Mart. *	Juazeiro	90269	18	61.67	2.250
Rubiceae	*Coutarea hexandra* (Jacq.) K. Schum.	Canela de veado	-	32	109.64	3.750
	Randia armata (Sw.) DC.		90288	2	6.85	0.250
Sapotaceae	*Syderoxylon obtusifolium* (Roem. & Schult.) T.D. Penn.*	Quixaba	90268	41	140.47	5.125
Verbenaceae	*Lippiagracilis* Schauer*.	Alecrim	90287	5	17.13	0.625
	Lantana camara L.*	Camará	-	1	-	-
	Unidentified 1	-	-	2	6.85	0.250
	Unidentified 2	-	-	1	3.42	0.125

Table 2. Criteria used for scoring the relative density, collection risks, local importance and diversity of use of medicinal plants (modified by Dzerefos & Witkowski 2001, and Albuquerque *et al*. 2011b).

Criteria	Scores
Relative Density	
None recorded – very low (0-1)	10
Low (1 < 3.5)	7
Medium (3.5 < 7)	4
High (≥ 7)	1
Collection Risk	
Destructive plant collection or over-exploitation of roots or bark. The collection involves the removal of the individual.	10
Aerial structures, such as bark and roots, and removal of part of the stem for extraction of latex, which are collected without causing death to the individual.	7
Permanent aerial structures such as leaves that are removed, potentially affecting plant energy investment, survival and long-term reproductive success.	4
Removal of transient aerial structures, such as flowers and fruits. Regeneration of the population can be altered in the long term by removal from the seed bank, but the individual plant is not affected.	1
Local Importance	
Very high (listed by > 75% of local informants)	10
Moderately high (50-75% of local informants)	7
Moderately low (25-50% of local informants)	4
Very low (< 25% of local informants)	1
Diversity of use	
One point is added for each medicinal use up to the maximum of 10	1-10
Associated Timber Use	
For species with timber use 10 points are added to the formula	10

Bioestat 5.3 (Ayres *et al*. 2007), and $p < 0.05$ were considered significant.

Results

Species richness

The current survey sampled 34 species, of which 19 of were indicated as having medicinal use. Albuquerque *et al*. (2011b) recorded 44 species with 25 of medicinal use. Although the two samples were not significantly different statistically, there was a decrease in total richness and richness of medicinal plants ($x^2 = 0.002$, $p = 0.8835$). Ten species previously cataloged were not present in the current sampling, among which are eight heliophytes, which were already in low densities in the previous study: *Spondias tuberosa*, *Caesalpinia leiostachya*, *Chorisia* sp., *Croton heliotropifolius*, *Ditaxis malpighiacea* with indications of medicinal use, and *Acacia bahiensis*, *Enterolobium contortisiliquum*, *Ptilochaeta bahiensis*, *Ruprechtia laxiflora* and *Cardiospermum* sp. with indications of medicinal. The other two species, *Anemopaegma* sp. and *Capsicum parvifolium,* are ombrophylous, and were also present in low densities in the previous study.

This reduction in species richness, indicating the disappearance of some species, may be the result of the continued extraction of resources in the indigenous territory since no management action has been implemented in the region in recent years.

Conservation Priority Index and risk categories

There were seven species (28 %) in the high-risk category of the previous study and five (26.31 %) in the current study, while 12 species (48 %) were in the medium-risk category in the previous study and nine (47.36 %) in the current study. Only six species (24 %) were in the low-risk category of the previous study and five (26.31 %) in the current study. Three species, *Maytenus rigida*, *Chloroleucon foliolosum* and *Commiphora leptophloeos,* moved to lower risk categories between the two study periods. Since these species did not exhibit pronounced changes in their relative densities, this change is likely due to a reduction in their use. In turn, two species, *Ruellia asperula* and *Piptadenia stipulaceae*, moved to higher risk categories. *Ruellia asperula* experienced an increased CP score due to a decrease in its density, while *Piptadenia stipulaceae* had an increase because of an increase in the number of people who reported it as medicinal, thereby increasing its use value (Tab. 3).

Regarding the species that did not exhibit changes in their CP score between the previous study and the current study, we can infer the following: the species considered high-risk remained so because of their reputation as species of wide local use. These species are: *Anadenanthera colubrina*, *Myracrodruon urundeuva*, *Cynophalla hastata* and

Table 3. List of medicinal plants sampled in the Ouricuri Forest, Fulni-ô Indigenous Village, Águas Belas, Pernambuco. T1: corresponds to the first study in the year 2007; T2: corresponds to the second study in the year 2014; NI = number of individuals; RD = relative density; CR = collection risk; LI = local importance; NU = number of medicinal uses; DU = diversity of medicinal uses; VU = value of use; and CP = conservation priority index.

Scientific name	NI T1	NI T2	RD T1	RD T2	CR T1	CR T2	LI T1	LI T2	NU T1	NU T2	DU T1	DU T2	VU T1	VU T2	CP T1	CP T2
Anadenanthera colubrina var. *cebil* (Griseb.) Altschul*	7	1	10	10	7	7	1	1	21	10	10	10	5.5	5.5	91.25	91.25
Myracrodruon urundeuva Allemão*	21	24	7	7	7	7	10	10	74	56	10	10	10	10	87.50	87.50
Parapiptadenia zenhtneri (Harms) M.P. Lima & H.C. Lima*	4	2	10	10	7	7	1	1	5	9	5	9	3	5	85.00	90.00
Cynophalla hastata (Jacq.) J. Presl. *	6	3	10	10	7	7	1	1	3	3	3	3	2	2	82.50	82.50
Lippia gracilis Schauer.	1	5	10	10	4	4	7	7	35	22	10	10	8.5	8.5	81.25	81.25
Maytenus rigida Mart.*	23	22	7	7	7	7	4	1	45	31	10	10	7	5.5	80.00	76.25
Schinopsis brasiliensis Engl.*	15	19	7	7	7	7	1	1	19	16	10	10	5.5	5.5	76.25	76.25
Mimosa tenuiflora (Willd.) Poir. *	13	23	7	7	7	7	1	1	18	21	10	10	5.5	5.5	76.25	76.25
Guapira noxia (Netto) Lundell*	11	11	7	7	7	7	1	1	30	12	10	10	5.5	5.5	76.25	76.25
Ziziphus joazeiro Mart.*	9	18	7	7	7	7	1	1	33	29	10	10	5.5	5.5	76.25	76.25
Chloroleucon foliolosum (Benth.) C.P. Lewis*	7	16	10	10	7	7	1	1	7	9	7	9	4	5	87.50	75.00
Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.*	22	41	7	4	7	7	4	4	28	32	10	10	7	7	80.00	65.00
Ruellia asperula (Mart. Ex Ness) Lindau*	10	4	7	10	4	4	1	1	2	1	2	1	1.5	1	48.75	63.75
Piptadenia stipulacea (Benth.) Ducke*	51	55	4	1	7	7	1	4	18	8	10	8	5.5	6	61.25	62.50
Commiphora leptophloeos (Mart.) J.B. Gillett*	46	52	4	4	7	1	4	1	27	29	10	10	7	5.5	55.00	36.25
Jatropha molissima (Pohl) Baill. *	24	56	7	1	7	1	1	1	15	4	10	4	5.5	2.5	66.25	28.75
Poincianella pyramidalis (Tul.) L.P. Queiroz*	150	192	1	1	7	7	1	1	24	30	10	10	5.5	5.5	46.25	46.25
Bauhinia cheilantha (Bong.) Stud. *	105	101	1	1	7	7	1	1	23	17	10	10	5.5	5.5	46.25	46.25
Aspidosperma pyrifolium Mart.*	114	88	1	1	7	7	1	1	15	12	10	10	5.5	5.5	46.25	46.25

Lippia gracilis. In general, these species are not present in high densities, but have been able to withstand significant impact from collection, because in addition to being used medicinally, they also have associated timber uses. The species of the medium-risk category that remained so (*Schinopsis brasiliensis, Mimosa tenuiflora, Guapira noxia,* and *Ziziphus joazeiro*) exhibited only a small decrease in the number of individuals, as well as the number of attributed uses, although not significantly enough to influence the final value of the CP score. The species of the low-risk category that remained so (*Poincianella pyramidalis, Bauhinia cheilantha* and *Aspidosperma pyrifolium*) exhibited a completely different situation from the species in the other categories that did not change. These species possessed high relative densities along with a high number of specimens in both the previous and current studies, and were also reported as of low local importance, being listed by less than 25 % of the informants.

The current CP scores of each species in each group (high, medium and low risk) were not significantly different from the previous scores. Thus, for high-risk ($t = 1.3432$, $p>0.05$) and medium-risk ($V=2$, $p>0.05$) and low-risk species ($V=2$, $p>0.05$), the CP scores remained the same. These results show that, in general, changes of little significance occurred over the years, both regarding relative densities and potential uses.

Discussion

Considering that one of the aims of this work was to perform a temporal comparative analysis, it is important to emphasize that the current study followed the same protocols used in the previous study. The results demonstrate a temporal reduction in the number of species, suggesting over-exploitation of the area over the seven year period, and that some species that were already present at low densities were even more affected, perhaps by an increase in use as medicinal plants, or perhaps because of other categories of use. The literature points out that most medicinal plants exploited by local communities in the caatinga also have other associated uses (Albuquerque *et al*. 2011b; Lucena *et al*. 2007). Considering this, it seems that a technique that does not take into account uses other than medicinal uses, tends to underestimate the pressure on these populations, causing error in the measurement of impact. Gaoue & Ticktin (2007) argued that species may be affected by a combination of different exploitive events, or by the level of damage to individuals or to the population. These exploitive events could be occurring in the study area, since there is a variety of reported uses other than just medicinal. This diversity of exploitive events can contribute to increased extractive pressure and cause much more damage when executed simultaneously (Albuquerque *et al*. 2011b).

The species found to be at high-risk in the current study apparently did not experience changes in their CP scores since they are the same species that were high-risk in the previous study. This can be interpreted to be more of a result of their high use potential, than by their densities, which vary from intermediate to high, according to the CP. Thus, it is believed that these populations will persist due to their local abundance, even if the levels of extraction continue to increase beyond the support capacity of the populations. Studies, such as Albuquerque *et al*. (2007; 2011b) and Souza *et al*. (2016), help us understand this scenario, by showing us that some species of the caatinga with relatively high importance, and consequently a high number of indications of therapeutic use, also reach great densities, as is the case of *Myracrodruon urundeuva* and *Sideroxylon obtusifolium*. Nonetheless, it is necessary to immediately develop strategies so that these populations will not become locally extinct in the near future, by proposing means for their sensible use within the capacity of their continued persistence.

Other factors that may influence CP are those that contribute to the distribution of the species, such as genetic and demographic variation, which regulate population size. Albuquerque *et al*. (2011b) suggested that the dynamics of species used in the region need to be carefully studied, since some species tend to be highly valued due to the influence of the weight of some specific variables on the calculation of their CP. For example, *Parapiptadenia zehntneri* and *Cynophalla flexuosa* were considered species of conservation priority, having been allocated to Category 1 (CP ≥ 80). However, these species were observed exist in naturally low relative densities in both the previous and current studies, which increases their CP score to the "rare" category. On the other hand, variables considering use of these species were considerably low, which allows us to assume that these species were listed as priority for conservation due to their normal pattern of distribution in nature.

The strong indications of human presence in the area over the years, accompanied by intense and continuous extractive activity, may have led to the observed decrease in species richness between the two study periods. Ribeiro *et al*. (2015) found that even low-intensity disturbances, known as chronic anthropogenic disturbances, may have the potential to cause marked effects on plant communities by altering their richness. Activities involving the harvesting of leaves, fruits and bark for medicinal purposes usually do not result in abrupt changes of the environment. However, the continuous nature of their exploitation does not seem to allow populations and ecosystems to recover, causing reductions in the density of stems, basal area, species richness and community uniformity, thereby favoring species adapted to disturbances (Sagar *et al*. 2003; Ribeiro *et al*. 2015).

Although the collection of non-timber forest resources appears to be less damaging to ecosystems than the collection of actual timber, there are indications that excessive collection of bark, fruit and leaves may have consequences for plant populations, including, theoretically, a decrease in reproduction rates (Gaoue & Ticktin 2007; Baldauf & Santos 2013; 2014; Baldauf *et al*. 2014; Gaoue *et al*. 2013). This reality is especially noticeable in seasonally dry forests in Brazil, wherein leaves and fruits are not available all year round. Given this situation, rural populations began to collect resources that were always available, such as the bark of the stem and roots (Albuquerque 2006). There are indications that the excessive collection of these resources is causing a decrease in plant richness of some ecosystems, mainly due to the death of some individuals with larger stem diameters that are more frequently subjected to collection (Soldati & Albuquerque 2011; Feitosa *et al*. 2014).

In associating the evidence of excessive collection with the disappearance of some rare species, we can conclude that CP was not effective at predicting changes, thus indicating that the combination of use variables and biological variables needs to be better determined. Based on this evidence, as well as the statistical analyses performed, it can be said that CP has not been reliable at determining species conservation priority. Therefore, it is recommended that a species-by-species level analysis be performed to determine all of the factors involved in measuring impacts on plant populations.

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