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Prioritization of useful medicinal tree species for conservation in Wari-Maro Forest Reserve in Benin: A multivariate analysis approach

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Prioritization of medicinal plant species in conservation schemes is critically important in low income countries. This paper aimed at developing a multivariate prioritization approach to guide conservation of medicinal tree species of Wari-Maro Forest Reserve in central Benin. Ethnobotany surveys were conducted in communities surrounding the forest, using individual semi-structured interviews with 149 people. Additionally, 42 plots were established in the forest to assess the availability of reported species, using mensuration of ecological indicators. Ethnobotanical indices, harvesting risk index, economic importance, threat status, adaptability to climate variations and ecological indicators were computed and pulled into principal components for each species, to yield a compound priority value. Overall, 73 medicinal tree species were reported for 94 traditional medicinal uses. Using our approach, twelve species emerged as priority species for conservation. The most important priority species were *Afzelia africana*, *Khaya senegalensis*, *Milicia excelsa* and *Pterocarpus erinaceus*. Local perceptions on the availability of three of these species were perfectly congruent with ecological indicators. Enrichment planting and assisted rejuvenation were suggested as urgent conservation actions to be taken.

1. Introduction

Plants represent a fundamental basis for life on Earth (Schatz, 2009). They constitute one of the main sources of medicinal compounds, on which humans depend for their health (Whitton, 2013). Despite the development of modern medicine, many local communities around the world are using various plant species in traditional medicine (van Andel et al., 2012; Whitton, 2013). Unlike South American pharmacopeia where herbs are prominent (Albuquerque et al., 2007; van Andel et al., 2007), trees and shrubs play a greater role in African traditional medicine (van Andel et al., 2012). Nearly all the organs of trees and shrubs (leaves, barks, roots, stem, serf and flower) are used to cure a wide range of illnesses/pains. In a recent past, the exploitation of trees for non-timber purposes such as medicinal and food uses was more sustainable than timber uses. However, the shift from subsistence harvesting to extraction for commercial purpose has resulted in a decline of native populations of many medicinal plant species (Cunningham, 1993; Delvaux et al., 2009; Veldman et al., 2014; van Andel et al., 2015). This trend is likely to be exacerbated by the current demographic boom in African developing countries (Alamu and Agbeja, 2011).

In this context of degradation of natural resources, developing conservation strategies for the exploited plant species is urgently needed. Such conservation planning can contribute to an unconditional restoration or sustainable use of useful medicinal tree species (Hamilton, 2004), in order to ensure the persistence of those species for future generations. Unfortunately, due to the limited resources available in developing countries, it is not always possible to consider all species in conservation plans. In fact, species prioritization is becoming important for conservation decision and management (Hamilton, 2004).

Over the world, many ethnobotanical studies on local conservation priorities of plants have been carried out (Kala et al., 2004; de Oliveira et al., 2007; de Melo et al., 2009; Brehm et al., 2010; Idohou et al., 2012). Research approaches vary considerably (Hamilton, 2004) and many parameters have been taken into account, depending on the characteristic of each region and targeted useful plant species. In Brazil for example, local knowledge on the plant species, harvesting strategy, plant availability and economic importance were considered (de Oliveira et al., 2007; de Melo et al., 2009). In Sierra Leone, medicinal plants have been ranked using their importance in urban markets, habitat type, abundance and harvesting techniques (Jusu and Sanchez,

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2013, 2014). Elsewhere, other aspects related to distribution of plant species and current threats have been considered for prioritizing crop wild relatives (Brehm et al., 2010; Idohou et al., 2012).

Although it seems important to consider several criteria, it should be noted that some of these criteria such as ethnobotanical indices and ecological indicators might be correlated and therefore, collinearity effects should be carefully considered. Moreover, in the process of prioritization, some authors have mechanically pooled such criteria in an ordinal decisive parameter (de Oliveira et al., 2007; de Melo et al., 2009). Some recent works (Brehm et al., 2010; Idohou et al., 2012) have combined four different methods of ordinal classification for the prioritization of crop wild relatives. In these cases, the priority species were identified as those species most encountered at top positions of the different lists. However, any approach based just on one method of ordinal classification will most likely contribute to subjective results. Next to that, ranking methods are marred by biases associated with converting some quantitative data into ordinal data. Here we propose an alternative strategy for prioritization. To improve accuracy of the prioritization process without using several methods of ordinal classification or ranking, we performed multivariate analysis on multiple criteria in order to obtain a reliable statistical result.

We expect a multivariate analysis approach applied to yield efficient priority setting of over-exploited biodiversity. Here we use this approach to assess the conservation priorities of medicinal tree species of Wari-Maro Forest Reserve (W-MFR) in Benin. W-MFR is one of the biodiversity hotspots in Benin's Sudanian zone, where tree species are highly threatened by anthropogenic pressure such as agriculture, pastoralism, logging and extraction of firewood and plant organs for medicinal and food uses (Adomou et al., 2011). The Sudanian zone is a center of plant endemism sensu White (1983).

This study addressed the following research questions (i) how important is W-MFR plant species for local communities' medicine? (ii) Which of these species should be prioritized conservation? And, (iii) are local perceptions of species' abundance and ecology congruent with field observations?

2. Material and methods

2.1. Study area

W-MFR is located in central Benin (8°80′–9°10′ N and 1°55′–2°25′ E; Fig. 1) in the Sudan phytochoria (White, 1983). Covering an area of about 120,686 ha, this forest is part of the Mont Koufé region protected area network. The prominent vegetation types are *Isoberlinia* spp. woodland (50,057 ha) and savannah (56,088 ha) (Glèlè Kakaï and Sinsin, 2009). Soils are ferruginous with lateric concretions developed on granites and gneisses (Faure, 1977). Climate in the region is subhumid dry with a unimodal rainfall regime and a dry season lasting five months (November to March). Annual rainfall varies from 900 mm to 1200 mm with a peak in August (267.5 mm) (Gnanglè et al., 2011). Temperature ranges from 21 °C (December–January) to 40 °C (February–April) with an average of 32 °C. From December to February, the north-east wind called "*harmattan*" coming from the Sahara desert affects the climate making it dry and cold. The vicinities of this forest are inhabited by two main socio-linguistic groups: the Nagot and the Bariba, both being farmers and hunters. As a result of shifting cultivation as well as tree logging for timber extraction and construction, the forest has suffered drastic degradation as in many cases in Benin.

2.2. Data collection

Data were collected between November, 2013 and January 2014. Prior to the survey, a meeting was held with local leaders to provide details about the survey and to secure informed consent. Ethnobotanical surveys were conducted using individual semi-structured interviews with the traditionally most prominent authorities of local households (generally men). If he was not available, his wife or another member of the household was surveyed. Because of reluctance of some respondents, informants were selected depending on their willingness and interest in participating in the study. Overall, 149 people including 35 women were interviewed across ten different villages (Alafiarou, Agramarou, Koko, Banigri, Beterou, Sinahou, Ouberou, Wari-Maro, Wannou, and Igbere) located around the W-MFR. Informants' ages ranged from 18 to 87 years, with an average age of 48.23 ± 15.41. People were interviewed with a questionnaire in local languages with the help of local translators. The questionnaire focused on the tree species used for the treatment of human diseases, the different medicinal uses attributed, the plant parts used, the other non-medicinal uses, and the local perceptions on availability of the species (Supplementary File 1). Three categorical levels of availability (rare, common or abundant) were defined. The plants' names given by informants in local languages (Nagot, Bariba, Peuhl, Fon) were matched with their scientific names using plant catalogues (de Souza, 2008) and Benin's flora (Akoègninou et al., 2006). Informants were also accompanied in the field to identify and collect the plant cited during the ethnobotanical surveys.

Vegetation surveys were conducted along ten 2000 m transects from the edge to the core area of the W-MFR based on the spatial location of the 10 surrounding villages. A total of 42 rectangular plots (30 m × 50 m) were established on the 10 line transects. Diameters at breast height (dbh) of all trees (dbh ≥ 10 cm) were measured within each plot. Regeneration (seedlings and saplings with dbh < 10 cm) was counted in four subplots of 10 m × 10 m installed in the corners of each plot. Herbarium samples of plants not identified in the field were constituted and later identified at the National Herbarium of University of Abomey Calavi. All scientific plant names, authors and families were checked according to the latest taxonomic nomenclature (www.theplantlist.org).

2.3. Data analysis

The number of species, genus and families were used as ecological indicators for medicinal tree species richness. Medicinal uses attributed to those trees were grouped in medicinal use categories according to International Classification of Diseases of the World Health Organization (WHO, 1999).

For each medicinal use attributed to a given plant, the frequency of citation (FC) was calculated (Phillips and Gentry, 1993; Gómez-Beloz, 2002) as well as the informant consensus factor (ICF) (Trotter and Logan, 1986), which determine the agreement between informants according to the plants commonly used for a particular application.

In order to establish priorities for conservation of medicinal tree species, the medicinal (cultural) importance, harvesting risk, economic importance, threat status, adaptability to climate variations and ecological importances of trees were considered and combined as follows.

As far as *cultural or medicinal importance* is concerned, eight quantitative indices were originally considered: relative importance (RI) (Bennett and Prance, 2000), cultural importance (*CI*), relative frequency of citation (*RFC*), cultural value (*CV*), frequency of citation (*FC*), number of use-reports (*UR*), number of uses (*NU*) and use value (*UV*) (see Tardío and Pardo-de-Santayana, 2008 for computational details of these indices). These indices are more objective for evaluating relative importance of useful plants (Tardío and Pardo-de-Santayana, 2008). The list of ethnobotanical indices was further shortened to account for least correlated ones ($r < 0.7$). The two least correlated ethnobotanical indices were finally retained, namely relative importance (*RI*) and cultural value (*CV*) (Table 1).

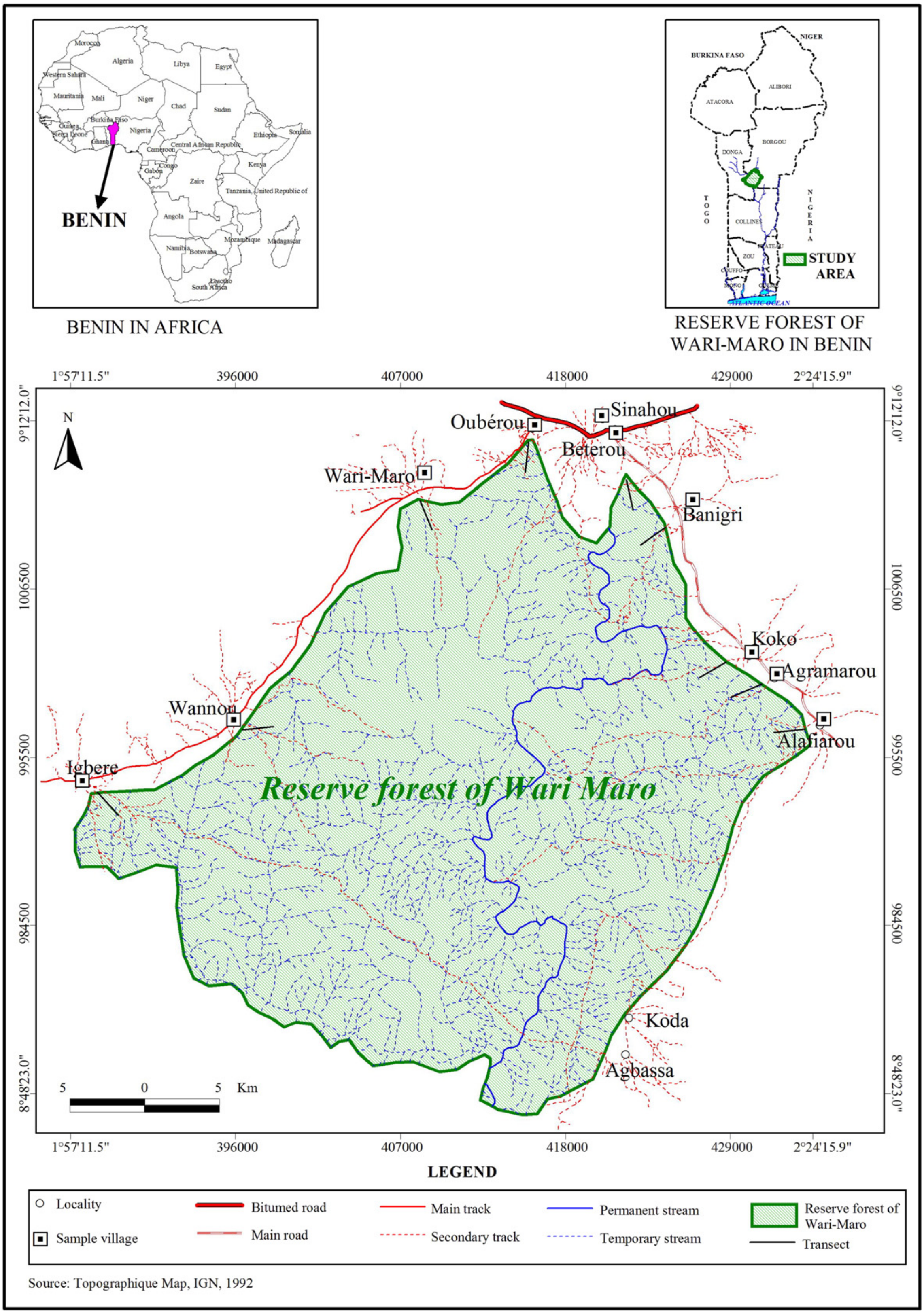

Fig. 1. Location of Wari-Maro Forest Reserve and surveyed villages.

The *harvesting risk index (HR)* was calculated using the risk related to the plant part harvested and the number of medicinal uses (NU_i) attributed to each part of a given tree species. This is important to guide conservation actions of medicinal tree species. The risk of harvesting was scored and a score (H_i) was attributed to each part of a given tree species according to criteria adapted from Dzerefos and Witkowski (2001) and de Oliveira et al. (2007) (Table 2). Thus, the harvesting risk index (HR) was computed as follows:

$$HR = \sum NU_i \times \log(H_i)$$

Table 1
Pairwise correlation between the ethnobotanical indices.

	UR	FC	NU	RFC	UV	CI	CV
FC	0.99						
NU	0.82	0.81					
RFC	0.99	0.99	0.81				
UV	0.82	0.82	0.99	0.81			
CI	0.99	0.99	0.82	0.99	0.82		
CV	0.91	0.92	0.57	0.92	0.58	0.91	
RI	0.74	0.73	0.98	0.73	0.98	0.73	0.47

RI = relative importance, CI = cultural importance, RFC = relative frequency of citation, CV = cultural value, FC = frequency of citation, UR = number of use-reports, NU = number of uses and UV = use value.

NU_i = number of medicinal uses attributed to part i of given species. H_i = score of harvesting risk for part i of a given species (Table 2). For a given plant part of a given species, HR_i is a product of two factors NU_i and $\log(H_i)$ where $\log(H_i)$ evaluates the degree of anthropogenic pressure (related to the plant part harvested i) on the species multiplied by the number of medicinal uses attributed to this plant part (NU_i). The logarithm (log) transformation was used to normalize the score (H_i) and neutralize the impact of fruits/seeds harvesting on the species.

For example in the case of *Afzelia africana*, 3, 6, 10, 2 and 7 medicinal uses were respectively attributed to its fruit, leaf, bark, stem and root. Then, the harvesting risk index associated to this species was $HR = 3 \times \log(1) + 6 \times \log(2) + 10 \times \log(3) + 2 \times \log(4) + 7 \times \log(5) = 12.67$.

The *Economic Importance* (*EI*): the economic importance considered in this study concerns especially some species which are sold for medicinal and/or non-medicinal uses. The *EI* was calculated as the average of two values: the value related to plant parts sold for medicinal uses (*MV*) and the value related to other uses (*OV*). The medicinal value (*MV*) was computed as the sum of the scores associated with plant part sold: roots (5), stem (4), bark (3), leaves (2) and seed/fruit (1), according to the degree of sensitivity of the species to harvesting of these organs (Dzerefos and Witkowski, 2001; de Oliveira et al., 2007). The medicinal tree species in which products are sold were retrieved from the list realized by Legba et al. (2012) and Quiroz et al. (2014). Concerning the other use value (*OV*), scores were attributed to five non-medicinal use categories as the following: technology (5), construction (4), food (3); fodder (2) and others — fuel, charcoal, craft … (1). The sum of these scores was pooled to obtain an overall score according to the types of non-medicinal uses of each species. For example, no part of *A. africana* was sold for medicinal use ($MV = 0$) but it is useful for technology, fodder and charcoal production ($OV = 5 + 2 + 1 = 8$). Then the economic importance value (*EI*) for this species was $(0 + 8)/2 = 4$.

The *threat status* (*TS*): two categories of IUCN status on Benin Red List were used and scored as follows: Endangered (10) and Vulnerable (5). The threat score attributed to species which were not endangered or vulnerable is 0. For example *A. africana* is classified as endangered species in Benin (Adomou et al., 2011); then its value for this variable was equal to 10.

Table 2
Harvesting risk score attributed to a given tree species according to harvested plant parts. Adapted from Dzerefos and Witkowski (2001) and de Oliveira et al. (2007)

Harvesting risk	Score (H)
Seed/Fruit: harvesting of the seed or fruit has little effect on reproduction	1
Leaves: harvesting of the leaves reduces the potential production of the whole plant	2
Bark: harvesting of the bark affects the plant by reducing the transmission of serf	3
Stem: harvesting of the stem chops entire branches and finally destructs the whole plant	4
Roots: harvesting of the roots damages the health of the individual plant	5

The *adaptability to climate variations (AC)*: this criterion is relative to species distribution according to chorological characterization sensu White (1983). Three groups were defined and scored as follows: species for which distribution is limited to Sudanian areas — (10), species with continental distribution (5) and species with broader range (global, pantropical, etc.) (0). For example, in the case of *A. africana* which is a Sudanian species, the AC-value was 10.

Data from the vegetation survey were used to compute for each medicinal plant, different ecological indicators according to Mueller-Dombois and Ellenberg (1974). Abundance (A), density (D), frequency (F), relative density (RD) and relative frequency (RF) were calculated by considering trees' counts, size (dbh ≥ 10 cm) and regeneration (dbh < 10 cm). Dominance (Do), relative dominance (RDo) and importance value index (IVI) were also calculated for each species. Overall, 18 ecological indicators were calculated, but only two were retained after checking for multicollinearity ($r < 0.7$): frequency of regeneration and dominance (Table 3).

Finally, the retained ethnobotanical indices, the harvesting risk index, the economic importance, the threat status, the adaptability to climate variations and the ecological indicators were pooled in a data matrix and subjected to Principal Component Analysis (PCA) after a logarithmic transformation. This analysis was performed considering those species that were reported by more than five out of the 149 informants (3.36%). Canonical Correspondence Analysis (CCA) was performed to examine the link between the retained ecological indicators and people perceptions on species availability. For this purpose, local people were asked to assess availability of the tree species by distinguishing the rare, common and abundant species. For all these multivariate analyses, the species names were standardized using the four first letters of both genus and species (i.e., *Tamarindus indica* = "tamaindi"; Supplementary Table 1). All analyses were performed using R software.

3. Results

3.1. Medicinal tree species used by local people around Wari Maro Forest Reserve

Seventy three tree species were reported by informants who participated in the survey (Table 4). Those medicinal tree species were grouped into 61 genera and 27 families. The prominent families were Leguminosae (20 species), Combretaceae (6 species), Moraceae (6 species) and Rubiaceae (5 species). Some other families (overall 17) were represented by only 1 species. The plant parts used were leaves (78%), roots (63%), barks (59%), fruits (11%), stem (10%), serf (4%) and flowers (3%).

The reported medicinal species were used for 94 medicinal purposes classified into 17 categories. The informant consensus factor (ICF) revealed that plants were reported with high consensus for treatment of diseases such as skin diseases (0.77), worm infections (0.73), stomachache (0.72) and malaria (0.62). Other diseases such as dysentery (0.33), headache (0.27), fever (0.27), hernia (0.21) and medico-magic practices (0.21) were also reported. While, certain species were reported to be used for a large range of medicinal uses, many others species were reported for a particular medicinal use only (Table 4).

3.2. Conservation priority of medicinal tree species

The Principal Component Analysis (PCA) performed on all the variables related to ethnobotanical indices, harvesting risk, economic importance, threat status, adaptability to climate variation and ecological indicators explained 62.73% of the observed variation on the first two principal components (Dim 1 and Dim 2). The first component (Dim1) showed a positive link with all variables used (Fig. 2). Variables such as cultural value (CV), relative importance index (RI),

Table 3
Pairwise correlations between the ecological parameters.

Component		Tree & regeneration					Regeneration					Tree						
		F	D	A	RF	RD	F	D	A	RF	RD	F	D	A	Do	RF	RD	RDo
Tree & Regeneration	D	0.80																
	A	0.64	0.89															
	RF	0.99	0.78	0.61														
	RD	0.85	0.87	0.71	0.87													
Regeneration	F	0.89	0.79	0.69	0.84	0.68												
	D	0.80	0.99	0.89	0.77	0.86	0.79											
	A	0.64	0.88	0.99	0.60	0.70	0.68	0.89										
	RF	0.89	0.79	0.69	0.84	0.68	0.99	0.79	0.68									
	RD	0.80	0.99	0.89	0.77	0.86	0.79	0.99	0.89	0.79								
Tree	F	0.87	0.62	0.44	0.92	0.83	0.55	0.61	0.43	0.55	0.61							
	D	0.76	0.66	0.49	0.80	0.94	0.50	0.65	0.48	0.50	0.65	0.85						
	A	0.70	0.59	0.50	0.73	0.86	0.48	0.58	0.49	0.48	0.58	0.77	0.92					
	Do	0.62	0.53	0.42	0.65	0.86	0.40	0.53	0.41	0.40	0.53	0.70	0.95	0.91				
	RF	0.87	0.62	0.44	0.92	0.83	0.55	0.61	0.43	0.55	0.61	0.99	0.85	0.77	0.70			
	RD	0.76	0.66	0.49	0.80	0.94	0.50	0.65	0.48	0.50	0.65	0.85	0.99	0.92	0.95	0.85		
	RDo	0.62	0.53	0.42	0.65	0.86	0.40	0.53	0.41	0.40	0.53	0.70	0.95	0.91	0.99	0.70	0.95	
	IVI	0.76	0.62	0.47	0.80	0.93	0.49	0.62	0.46	0.49	0.62	0.86	0.99	0.93	0.96	0.86	0.99	0.96

F = frequency, D = density, A = abundance, RF = relative frequency, RD = relative density, Do = dominance, RDo = relative dominance, IVI = importance value index.

harvesting risk index (HR) and economic importance (EI) were highly correlated with this component (Dim1). This component can be understood as a socio-economic importance gradient of the medicinal tree species. As far as the second component (Dim2) is concerned, it was highly correlated with variables such as threat status (TS) and the two analyzed ecological variables (frequency of regeneration (F_Reg) and dominance of tree (Dom_Tree)). This component represents the scarcity gradient of medicinal tree species. Adaptability to climate variations (AC) was correlated with neither component. Fig. 3 illustrates projection of 31 species (each one reported by more than 5 informants) into a two-dimensional plot (Dim1 × Dim2).

Following the socio-economic importance gradient (Dim1), the most important species were *Khaya senegalensis*, *A. africana*, *Pterocarpus erinaceus*, *Daniellia oliveri*, *Pseudocedrela kotschyi*, *Vitellaria paradoxa* and *Parkia biglobosa*. In terms of scarcity, the most important were *K. senegalensis, A. africana*, *Milicia excelsa*, *Securidaca longipedunculata*, *Kigelia africana*, *Adansonia digitata*, and *T. indica*. The combination of these two groups of species resulted in 12 priority species for conservation. Two species, *K. senegalensis* and *A. africana*, were the most important for conservation as they were simultaneously scarce in the field and had great socio-economic importance.

3.3. Local perceptions of species and field assessment

The Canonical Correspondence Analysis (CCA) analyzed agreement between people perception on availability of species and observed ecological indicators such as dominance of trees (Dom_Tree) and frequency of regeneration (F_Reg) (Fig. 4).

Overall, species considered as abundant by local people were positively correlated with ecological indicators, confirming their availability in the field. Similarly, species recognized as rare by local people were negatively correlated with those ecological indicators, illustrating their observed rarity in the field. Except for *S. longipedunculata* and *T. indica* considered as being fairly available, the scarcity of other priority species such as *A. africana*, *K. senegalensis, M. excelsa*, *A. digitata*, and *K. africana* were acknowledged by local people. However, the informants had a poor perception on the abundance status of *P. erinaceus.*

4. Discussion

4.1. Medicinal uses of tree species

A total of 73 tree species were reported for 94 traditional medicine uses in and around the Wari-Maro Forest Reserve. Species belonging to Leguminosae (Caesalpinioideae, Mimosoideae and Papilionoideae) and Rubiaceae families were the most commonly used in treatment of diseases in the study area. In the Sudanian zone, Leguminosae is an abundant family (Adomou et al., 2006) and it has often been reported as being the most important family in ethnopharmacological surveys all over the world (Stark et al., 2013).

Nine of the 94 medicinal uses were widely reported by informants: skin diseases, worm infections, stomachache, malaria, dysentery, headache, fever, hernia and medico-magic practice. These medicinal uses could be those which are often practiced in the household. It is supposed that the plant products were directly gathered from the natural vegetation for auto-consumption in the household. Among the diseases reported in this study, only malaria has been scientifically investigated in previous studies in Benin (Hermans et al., 2004; Yetein et al., 2013), Togo (Koudouvo et al., 2011), and Ghana (Asase et al., 2005; Asase and Oppong-Mensah, 2009; Asase et al., 2010). The other medicinal uses were commonly reported in some ethnobotany studies (Fandohan et al., 2010; Gouwakinnou et al., 2011). The illnesses such as fever and headache which are associated symptoms of malaria were treated by using the same plants. The most prominent antimalarial species reported by the two ethnic groups (Nagot and Bariba) surveyed were similar to those reported in southern Benin by Fon ethnic group in previous studies (Hermans et al., 2004; Yetein et al., 2013). However, among the most reported species for treatment of malaria in this study, *V. paradoxa* was not previously reported, perhaps because this species is not available in southern Benin or not sold in the markets for medicinal purpose. Species such as *Pavetta crassipes* and *Lophira lanceolata* were reported elsewhere in Benin (Hermans et al., 2004). *K. senegalensis*, *Opilia amentacea*, and *Sarcocephalus latifolius* were reported in Benin (Hermans et al., 2004; Yetein et al., 2013) and other West African countries (Asase et al., 2005; Asase and Oppong-mensah, 2009; Asase et al., 2010; Koudouvo et al., 2011). Antimalarial effects have been assessed and confirmed for some most reported species such as *K. senegalensis* (Adebayo and Krettli, 2011; Soh and Benoit-Vical, 2007); *P. crassipes* (Sanon et al., 2003) *and S. latifolius* (Menan et al., 2006), and *L. lanceolata* (Audu et al., 2007; Onyeto et al., 2014). *O. amentacea* has not yet been screened for such analysis. Consequently, it offers an array for further investigation on antimalarial remedies. Concerning the digestive system diseases, the same species were reported for stomachache, dysentery/diarrhea and for worm infections. These include: *Pteleopsis suberosa*, *S. latifolius*, *K. senegalensis*, *P. kotschyi*, and *P. erinaceus*. This can be explained by the fact that stomachache, dysentery and diarrhea can be caused by worm infections (Dieht et al., 2004).

Table 4
Medicinal tree species of Wari-Maro Forest Reserve and their use.

Families/species	Voucher specimen number	Local names	Plant part	Medicinal uses
Anacardiaceae				
Lannea acida A. Rich. s.l.		Aku (n)	Bark	Furuncle (1). Stomachache (1)
Spondias mombin L.		Iyeye (n)	Leaf	Eye pains (1)
Annonaceae				
Annona senegalensis Pers.		Embo (n)	Leaf, root, bark, stem	Fever (2). Digestive disorders (1). Child health care (1). Lumbago (1). Hernia (1). Casting a spell over somebody (1). Medico-magic (1). Oedema (1). Snake bites (1). Headache (1). Wound (1). Skin diseases (1). Stomachache (1)
Hexalobus monopetalus (A. Rich.) Engl. & Diels	AAC202	Tibaka (p)	Leaf, Root	Medico-magic (1). Fever (1)
Uvaria chamae P. Beauv		Tigéra (b)	Leaf, Root	Stiffness (1). Medico-magic (1). Eye pains (1)
Apocynaceae				
Strophanthus hispidus DC.	AAC208	Dina (b)	Root	Hernia (1)
Strophanthus sarmentosus DC.	AAC209	Tcharo (n)	Root	Dysmenorrhea (1)
Araliaceae				
Cussonia arborea Hoehst. ex A. Rich.	AAC193	Sinburu (b)	Leaf, Root, Bark	Bleeding (2). Rheumatism (1). Child health care (1). Worm infections (1)
Arecaceae				
Borassus aethiopum Mart.		Dadoru (b)	Leaf	Malaria (2)
Bignoniaceae				
Kigelia africana (Lam.) Benth.		Kpandoro (n)	Bark, Root, Fruit, Leaf	Hernia (2). Casting a spell over somebody (1). Infections (1). Tonic seizures in children (1). Headache (1). Hemorrhoids (1). Bone diseases (1)
Cannabaceae				
Trema orientalis (L.) Blume	AAC214	Afefe (n)	Leaf	Palpitations (1)
Celastraceae				
Gymnosporia senegalensis (Lam.) Loes.		Féféa (n) Samounou (b)	Leaf, Root	Skin diseases (1). Diarrhea (1)
Loeseneriella africana (Willd.) R. Wilckek	AAC204	Cina (D)	Fruit	Joint sprain (1)
Chrysobalanaceae				
Parinari curatellifolia Planch. ex Benth.		Abo (n), Kpapiku (b)	Root, Leaf, Bark,	Dysentery (2). Lower abdomen pain (1). stomachache (1)
Combretaceae				
Anogeissus leiocarpa (DC.) Guill. & Perr.		Agnin (n), Kakira (b)	Bark, Leaf, Root	Skin diseases (5). Stomachache (3). Malaria (2). Stiff (2). Child health care (2). Fever (1). Tonic seizures in children (1). Digestive disorder (1). Toothache (1). Hemorrhoids (1). Casting a spell over somebody (1)
Combretum Collinum Fresen.	AAC192	Gbodomi (n), Gbagobosa (b)	Bark, Root	Snake bites (1). toothache (1)
Pteleopsis suberosa Engl. & Diels		Okuu (n)	Bark, Leaf, Root, Stem	Skin diseases (3). Dental decay (2). Child health care (2). Worm infections (2). Stomachache (2). Dysentery (1). Dysmenorrhea (1). Malaria (1). Ulcer (1). Scabies (1)
Terminalia avicennioides Guill. & Perr.	AAC211	Bêro (b)	Leaf, Bark, Root	Worm infections (2). Luck (1). Stomachache (1)
Terminalia laxiflora Engl.	AAC212	Bêrokebaru (b)	Bark	Skin diseases (1)
Terminalia sp.		Wawo (n)	Bark	Malaria (4)
Ebenaceae				
Diospyros mespiliformis Hochst. ex A. DC.	AAC195	Igi odu (n), Wimbu (b)	Bark, Fruit, Leaf, Root	Malaria (1). Fatigue (1). Stiffness (1). Casting a spell over somebody (1). Fever (1). Hypotonia in children (1)
Hypericaceae				
Psorospermum febrifugum Spach	AAC206	Gornyêka (b)	Root	Fever in infants (1)
Lamiaceae				
Vitex doniana Sweet		Ognin (n)	Leaf, Bark, Root	Stomachache (2). Stunting (1). Digestive disorders (1)
Vitex madiensis Olïv.	AAC216	Oyiegu (n)	Leaf	Malaria (1)
Leguminosae				
Acacia ataxacantha DC.	AAC186	Sakissoura (b)	Flower, Leaf, Root	Malaria (2). Dentition (1). stomachache (1)
Acacia nilotica (L.) Willd	AAC187	Banyi (b)	Leaf	Urticaria (1)
Acacia sieberiana DC.	AAC188	Sakiburukpika (b)	Leaf, Stem	Stomachache (1). Furuncle (1)
Afzelia africana Sm.		Akpaka (n), Gbébu (b)	Bark, Root, Stem, Leaf, Fruit	Mental disorders (2). Child health care (1). Headache (1). Protection against evil spirits (1). Diarrhea (1). Stillborn (1). Malaria (1). Strength booster (1). Child health care (1). Dysmenorrhea (1). Sprain (1). Skin diseases (1). Stiff (1). Loss of appetite (1). Dysentery (1). Casting a spell over somebody (1). Snake bites (1). Worm infections (1). Malaria (1)
Aganope stuhlmannii (Taub.) Adema	AAC189	Siro (b)	Bark, Leaf, Root	Vertigo (1). Skin diseases (1). Furuncle (1)
Bauhinia rufescens Lam.	AAC190	Klon (f)	Leaf	Malaria (1)
Bauhinia thonningii Schum.		Tibaklé (p)	Leaf, Root, Bark	Cough (1). Fatigue (1). Skin diseases (1). Fever (1). Scorpion bites (1)
Burkea africana Hook.		Atakpa (n), Aiginru (b)	Bark, Leaf, Root	Bleeding (2). Skin diseases (2). Toothache (1). Cough (1). Cholera (1). Worm infections (1). Jaundice (1). Fever in infants (1)

Table 4 (*continued*)

Families/species	Voucher specimen number	Local names	Plant part	Medicinal uses
Cassia sieberiana DC.	AAC191	Agbélokokpanron (n)	Root	Malaria (1). Poisoning (1)
Daniellia oliveri (Rolfe) Hutch. & Dalz		Wuya (n), Yanburu (b)	Leaf, Bark, Root	Malaria (8). Dysentery (3). Strength boosting (2). Obesity (2). Worm infections (2). Skin diseases (2). Fatigue (2). Casting a spell over somebody (2). Lumbago (1). Joint pains (1). Dysmenorrhea (1). Cough (1). Stunting (1). Stiffness (1). Heart attacks in children (1). Snake bites (1)
Detarium microcarpum Guill. & Perr.	AAC194	Beheru (b)	Root, Leaf, Bark	Stomachache (1). Tonic seizures in children (1). Rib pains (1)
Dialium guineense Willd.		Oyi (n)	Leaf	Malaria (1). hernia (1). Fatigue (1)
Isoberlinia spp.		Êkpa (n)	Bark, Leaf, Root	Skin diseases (2). Strength boosting (1). Protection against evil spirits (1). Diarrhea (1). Anemia (1). Furuncle (1). Stiffness (1). Fever (1). Headache (1). Mental disorders (1). Fatigue (1). Memory disorders (1). Cold (1)
Parkia biglobosa (Jacq.) G. Don.		Ougba (n), Dumbu (b)	Bark, Leaf, Root, Serf, Fruit	Stomachache (3). Burns (2). Hypertension (2). Chance (1). Child health care (1). Lumbago (1). Diabetes (1). Oedema (1). Sprain (1). Malaria (1). Eye pains (1). Cough (1). Jaundice (1). Stiffness (1). Diarrhea (1). Earache (1)
Pericopsis laxiflora (Baker) Meeuwen		Féréku (b)	Bark, Root, Leaf	Stomachache (5). Hernia (1). Hypotonia in children (1). Wound (1). Malaria (1).
Prosopis Africana (Guill. & Perr.) taub.		Akakayi (n), Soba (b)	Leaf, Stem, Bark, Root	Strength boosting (3). Stunting (1). Child health care (1). Hemorrhoids (1). Furuncle (1). Fatigue (1). Hypotonia in children (1). Malaria (1)
Pterocarpus erinaceus Poir.		Aikpé (n), Tonan (b)	Bark, Root	Dysentery (2). Medico-magic (2). Cough (2). Malaria (2). Skin diseases (2). Smelling vaginal discharge/menstruation odors (2). Stomachache (2). Dysmenorrhea (2). Diarrhea (1). Hemorrhoids (1). Worm infections (1). Lumbago (1). Digestive disorders (1). Fever (1)
Swartzia madagascariensis Desv	AAC210	Bokudo (b)	Leaf, Root, Flower	Dysentery (1)
Tamarindus indica L.		Monsoso (n)	Fruit, Leaf	Malaria (2). Stomachache (2). Gonorrhea (1)
Tetrapleura tetraptera (Schum. et Thonn.) Taub	AAC213	Ayidan (n)	Bark	Angina (1)
Loganiaceae				
Strychnos spinosa Lam.		Guroku duabu (b)	Leaf, Bark, Root	Malaria (1). Hernia (1). Ear diseases (1). Stomachache (1). Stunting (1)
Malvaceae				
Adansonia digitata L.		Otché (n), Sona (b)	Leaf, Bark, Root	Strength booster (1). Lumbago (1). Casting a spell over somebody (1). Dysentery (1). Wound (1). Child health care (1)
Sterculia setigera Delile	AAC207	Aleguiloko (n), Korokoru (b)	Leaf, Bark, Root	Tonic seizures in children (3). Casting a spell over somebody (2). Stomachache (1). Child health care (1). Fever in infants (1). Ulcer (1)
Bombax costatum Pellegr. & Vuillet		Kpo kpo (n)	Leaf	Casting a spell over somebody (1). Luck (1)
Ceiba pentandra (L.) Gaertn.		Munoru (b)	Bark	Lumbago (1). Sorcery (1)
Meliaceae				
Khaya senegalensis (Desr.) A. Juss.		Aganwo (n), Kayi (p), Gbira (b)	Bark, Root, Leaf	Stomachache (26). Skin diseases (33). Fever (1). Worm infections (10). Malaria (6). Headache (2). Hernia (2). Lumbago (2). Hypertension (2). Scabies (2). Wound (1). Hemorrhoids (1). Care health (1). Child health care (1). Diarrhea (1). Cholera (1). Fatigue (1). Stunting (1). Dysentery (1). Measles (1).
Pseudocedrela kotschyi (Schweinf.) Harms		Tchaguidi (n), Bisisumbu	Bark, Leaf, Root	Skin diseases (22). Worm infections (12). Stomachache (5). Malaria (2). Headache (2). Lumbago (1). Hernia (1). Joint pains (1). Irregular periods (1). Scabies (1). Stiffness (1). Hypertension (1). Cold (1). Cyst (1)
Trichilia emetica Vahl		Wushioko (n), Gbeku direbu (b)	Root, Bark	Stomachache (3). Fever (1). Stiffness (1). Wound (1). Snake bites (1)
Moraceae				
Ficus abutilifolia (Miq.) Miq	AAC196	Agbèdè odo (n)	Bark	Skin diseases (1). Fever (1). Strength boosting (1)
Ficus glumosa Delile	AAC197	Gakunoku (b)	Leaf	Stunting (1)
Ficus platyphylla Delile	AAC198	Dundehi (p)	Bark	Stomachache (1)
Ficus polita Vahl	AAC199	Okpokpo (n)	Fruit, Leaf, Bark	Malaria (1). Skin diseases (1). Pain (1)
Ficus sp.		Gadu (b)	Bark, Leaf, Root	Tonic seizures in children (1). Hemorrhoids (1). Cough (1)
Milicia excelsa (Welw.) C.C Berg		Iroko (n), Dabaka (b)	Leaf, Serf	Tonic seizures in children (2). Casting a spell over somebody (2). Protection against evil spirits (1). Hernia (1). Childbirth (1). Dysentery (1). Mental disorders (1). Wound (1)
Ochnaceae				
Lophira lanceolata Tiegh. ex Keay		Okpaha (n), Wawura (b)	Leaf, Bark	Malaria (5). Dysentery (2). Headache (2). Skin diseases (1). Digestive disorders (1). Fever (1). Bleeding (1). Stomachache (1).

(continued on next page)

Table 4 (*continued*)

Families/species	Voucher specimen number	Local names	Plant part	Medicinal uses
Olacaceae				
Ximenia americana L.	AAC217	Samnourou (b)	Root, Bark, Leaf	Dysentery (2). Worm infections (1). Cough (1)
Opiliaceae				
Opilia amentacea Roxb.	AAC205	Baso (b), Nendo (n)	Leaf	Malaria (6). Diarrhea (1). Fever (1). Casting a spell over somebody (1).
Phyllanthaceae				
Bridelia ferruginea Benth.		Kpekpela (b), Woman (n)	Bark, Leaf, Root	Malaria (2). Hypotonia in children (1). Vertigo (1). Stomachache (1). Dental decay (1). Cough (1)
Hymenocardia acida Tul.		Ehunkpo (n), Sinman (b)	Leaf, Root	Scorpion bites (1). Diarrhea (1). Sore throat (1). Cough (1)
Uapaca togoensis Pax	AAC215	Faru (b)	Leaf	Headache (1). Malaria (1)
Polygalaceae				
Securidaca longipedunculata Fresen.		Ikpata (n), Sonuan (b)	Root, Leaf	Bone fracture (3). Snake bites (3). Fever (2). Fever in infants (1). Rheumatism (1). Stiffness (1). Oedema (1). Casting a spell over somebody (1). Sprain (2). Scorpion bites (1)
Rubiaceae				
Crossopteryx febrifuga (Afzel. ex G. Don) Benth.		Nyan hili (n)	Root	Hernia (1)
Gardenia erubescens Stapf & Huteh.	AAC200	Dan (b)	Leaf, Bark	Stiffness (1). Nightmares (1)
Gardenia ternifolia Schumach. & Thonn.	AAC201	Kikiba (n), Dahiru (b)	Root, Leaf, Bark, Stem	Strength boosting (1). Diarrhea (1). Stiff (1). Fatigue (1). Casting a spell over somebody (1). Wound (1). Hernia (1). Skin diseases (1). Stunting (1). Jaundice (1). Eyes pains (1)
Pavetta crassipes K. Schum.		Maremura (b)	Leaf	Malaria (10)
Sarcocephalus latifolius (Sm.) E.A. Bruce		Igbessi (n), Monganru (b)	Root, Leaf, Bark, Stem	Skin diseases (4). Stomachache (8). Worm infections (5). Child health care (1). Hernia (2). Dysmenorrhea (1). Malaria (4). Dental decay (1). Eye pains (1). Diarrhea (1)
Sapindaceae				
Blighia sapida K.D. Koenig		Djérébu (b)	Leaf, Root	Toothache (1). Furuncle (1). Malaria (1). Stiffness (1)
Sapotaceae				
Vitellaria paradoxa C.F. Gaertn		Emin (n), Sumbu (n)	Bark, Leaf, Fruit, Root, Serf	Stomachache (14). Malaria (4). Fever (4). Cough (2). Eye pains (2). Dysentery (2). Luck (1). Skin diseases (1). Massage (1). Fatigue (1). Snake bites (1). Headache (1). Hip pains (1). Delayed closure of fontanel in infants (1). Jaundice (1). Furuncle (1). Bone fracture (1). Stunting (1). Ulcer (1)
Ulmaceae				
Holoptelea grandis (Hutch.) Mildbr	AAC203	Sayo (n)	Leaf	Stomachache (1)

Languages: n = nagot, b = bariba, p = peuhl, f = fon.
The numbers in brackets in column of medicinal uses are numbers of citations.

If the medicinal uses of these tree species were limited to auto-consumption in rural areas, there would be little concern about harvest sustainability. However, from the most reported species, the following were said to be highly marketed: *S. latifolius*, *K. senegalensis*, *L. lanceolata*, *Bridelia ferruginea*, *M. excelsa*, *P. kotschyi*, *P. suberosa*, *P. crassipes*, *V. paradoxa*, *P. biglobosa*, *S. longipedunculata*, *P. erinaceus*, *Prosopis africana*, and *K. africana* (Vodouhê et al., 2008; Quiroz et al., 2014). In this regard, it is relevant to improve the capacity of their natural populations to meet the growing market demand through plantations.

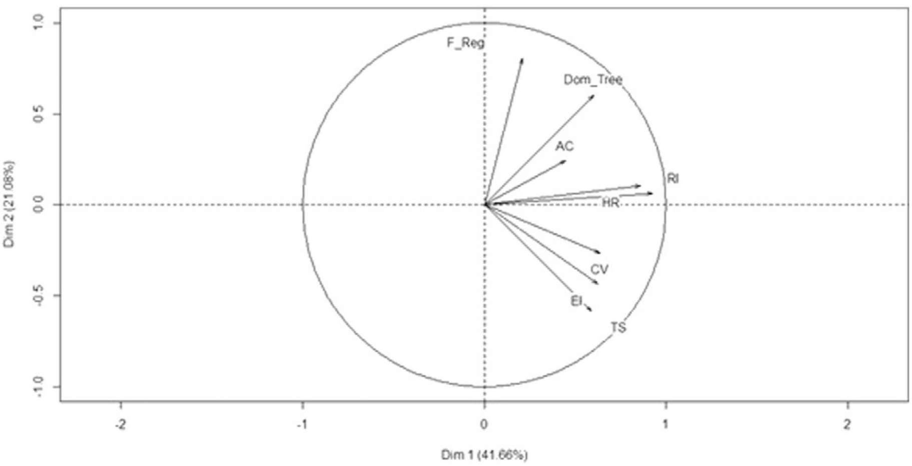

Fig. 2. Graph showing the covariates in a two dimensional plot (Dim 1 × Dim2). CV = cultural value, RI = relative importance index, HR = harvesting risk index, EI = economic importance, TS = threat status, AC = adaptability to climate variations, Dom_Tree = dominance of tree, F_reg = frequency of regeneration.

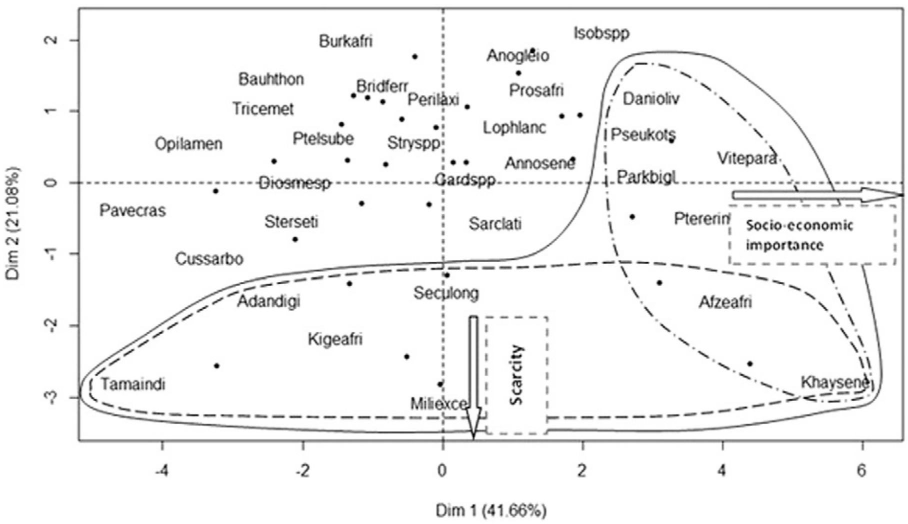

Fig. 3. Visualization of reported species in a two dimensional plot (Dim1 × Dim2).

4.2. Factors driving conservation status of priority medicinal tree species

Overall, 12 medicinal tree species were highlighted as priority for conservation in Wari-Maro Forest Reserve. Among these species, *A. africana*, *K. senegalensis*, *M. excelsa*, *P. erinaceus*, *K. africana* and *A. digitata* were also perceived by informants as being rare. Local perceptions showed congruence with ecological indicators, except for *P. erinaceus*. People perceptions have been suggested to be a good tool to set prioritization for conservation of medicinal tree species (Dalle and Potvin, 2004; Dovie et al., 2008; Tabuti et al., 2011). The ecological data collected during this study permitted to confirm relative rarity of medicinal species in the field. Hence, local communities must be effectively involved in formulating management plans for restoration of degraded forests. With regard to the case of *P. erinaceus*, people perceived this species as being rare while the used ecological indicators revealed that it is actually available in the field. Some reasons may explain this contrast. The used ecological indicators (frequency and abundance) can only assess the relative prevalence of a given medicinal tree species. In the case of *P. erinaceus*, informants did not consider the availability of this species for traditional medicinal uses, but rather its availability for wood utilization which seems to be their preferred use. Seemingly, the perceived rarity of a given species is related to its main or preferred use. Any useful species would be perceived as being rare if the quantity or the quality of the available individuals is not enough to cover people's need. In this specific case, local perception was guided by availability of large trees. As such, local perceptions regarding the threat status of *P. erinaceus* would be congruent with ecological indicators such as diameter size class distributions, basal area and dominance. Indeed, *P. erinaceus* is well known for its timber products and was overexploited in the past and, only undesirable (from a timber value perspective) and small individuals can currently be observed in the forest. In addition, the wood utilization seems to be the main or preferred use of most priority species such as *K. senegalensis*, *A. africana* and *M. excelsa.* Consequently their rarity has probably resulted from their over-exploitation for timber (Ouinsavi et al., 2005; Bonou et al., 2009; Glèlè Kakaï and Sinsin, 2009). That is the case of many medicinal plants in Africa (Tabuti et al., 2011). But in the case of *K. africana*, traditional medicinal use is a single use that puts high pressure on this species (Adomou et al., 2011).

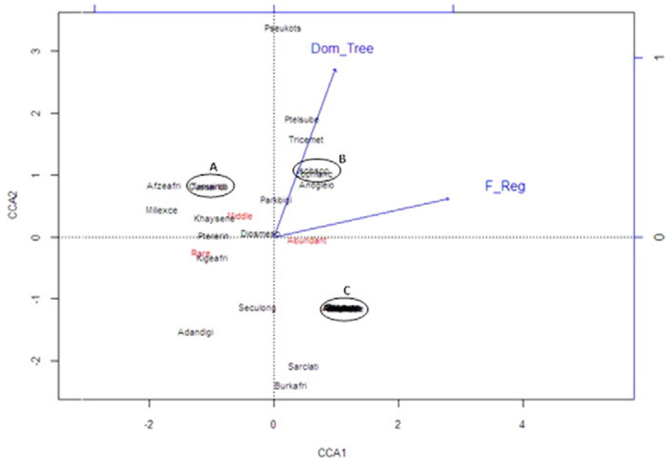

Fig. 4. Canonical Correspondence Analysis (CCA) plot. Dom_Tree = dominance of tree, F_reg = frequency of regeneration. The codes overlap each other in the figure are detailed as following: A: Cussarbo and Tamaindi; B: Isobspp and Lophlanc; C: Annosene, Bauhthon, Bridferr, Danioliv, Gardspp, Opilamen, Pavecras, Perilaxi, Prosafri, Sterseti, Stryspp, and Vitepara.

Lumber species such as *K. senegalensis*, *A. Africana*, and *P. erinaceus* identified as priority species for conservation in this study were reported to be threatened in both open access and protected areas of Pendjari Biosphere Reserve of Benin (Houehanou et al., 2013). Elsewhere, *M. excelsa* has been subjected to people demonization that combined with other exploitation for timber resulted in its critical decline in the 1970s and 1980s nationwide in Benin (Ouinsavi et al., 2005). According to the latter authors, apart from its exploitation for timber, *M. excelsa* individuals were often cut down because they are traditionally believed to host bad spirits and witchcraft activities.

Prioritization of *A. africana*, *K. senegalensis*, *M. excelsa*, *P. erinaceus*, and *K. africana* for conservation as illustrated here is congruent with their national and international status. All these species were previously listed as endangered species in the IUCN Red List for Benin (Adomou et al., 2011) and *M. excelsa*, *K. senegalensis*, and *A. Africana* have vulnerable status on the international IUCN Red List. *P. erinaceus* has not yet been evaluated. However, some species are naturally rare in their native areas (Dominguez Lozano et al., 2003; Pärtel et al., 2005; Gauthier et al., 2010). This could be the case for *A. digitata*, *T. indica*, and *S. longipedunculata*. Indeed, it has been proven that human disturbance is not the sole causal factor driving the decline of *T. indica* and *A. digitata* populations (Fandohan et al., 2010; Bourou et al., 2012; Ouédraogo and Thiombiano, 2012). These species' adult trees are habitually conserved by local people because of their numerous food, medicinal and other uses (Sibibé and Williams, 2002;

Fandohan et al., 2010; Bourou et al., 2012). The most important factors that may have a negative impact on these species are human practices that result in the harvesting of fruits and leaves in combination with climate change (Bourou et al., 2012; Sanou et al., 2014). Concerning *S. longipedunculata*, no other use was reported apart from the medicinal use for which their roots were sold expensively at 140.80 US$/kg with a small bulk offered for sale daily (34 kg) on the market in Southern Benin (Quiroz et al., 2014). In Ghana, where it is also perceived as a rare species (van Andel et al., 2012), *S. longipedunculata*'s roots were offered daily for sale in big bulk (561 kg), and sold at 47.8 US$/kg. Comparing the commercial importance of this species between the two countries, *S. longipedunculata* seems less accessible or scarcer in Benin than Ghana. Other species locally identified as rare species (e.g., *A. digitata*, *T. indica*) may be common elsewhere in Benin and as a result were not reported on the national IUCN Red List of Benin (Adomou et al., 2011). However, any species facing human pressure while not benefiting from sustainable management plans may soon face local extirpation and thus also deserves attention.

Among other socio-economically important species (*D. oliveri*, *P. kotschyi*, *V. paradoxa* and *P. biglobosa*), only *V. paradoxa* has a threatened status in Benin (Adomou et al., 2011). Because of the high medicinal importance combined with the food use of *V. paradoxa* and *P. biglobosa*, it is not surprising that they are facing a great risk of overharvesting (Koura et al., 2011). As for *D. oliveri* and *P. kotschyi*, their abundance in the field put them on the fringes of protection measure at present. But it is prudent to be vigilant concerning future exploitation trends of any useful species.

4.3. Management strategies for priority plant conservation

Scientific findings on conservation priority-setting are useless if they are not converted into management strategies (Wilson et al., 2009). Therefore, in a context of continued degradation of W-MFR, combined with the shortcomings of past projects (e.g., *Projet d'Aménagement des Massifs Forestiers d'Agoua, des Monts Kouffé et de Wari-Maro*, ended since 2007), the current findings should be used more wisely. During the implementation of the aforementioned project, *K. senegalensis* has been widely planted in this forest for its restoration. However, planted young trees were destroyed by the cattle due to poor monitoring. Herders usually introduce their herds in the forest with connivance of forest officials, who get some economic incentive from them. However, the plantation of *K. senegalensis* has succeeded along road sides of major cities yet most of the trees are faced with high debarking pressure for medicinal uses. To avoid similar failures, it would be better to manage the conservation of those species in private lands by associating local people. Indeed, plantation on private land has been used and proved successful to conserve some tree species elsewhere (Langpap and Kerkvliet, 2012; Kamal and Grodzinska-Jurczak, 2014; Trimble and van Aarde, 2014). This form of management can allow conservation and sustainable use of these native tree species. Establishing of private plantations of native species will require that the landowners are convinced of the economic rational of allocation of their land to plantation. They will also need alternative livelihood such as alley cropping while trees are growing. In that case, medicinal use alone will not be sufficient to convince them. Other uses such as wood for joinery or construction will need to be added to medicinal uses, to engage interested private developers. However, all the priority species could be considered for the establishment of a medicinal plant garden. The Beninese government through the forest administration and development partners could encourage such initiative. Owing to the critical importance of these medicinal tree species for human health, any person or entity, private or public, national or international should contribute to their protection. With regard to restoration strategies of the forest reserve, it will be necessary to conduct studies to identify suitable approaches for W-MFR restoration. One aspect to be considered during these investigations is effective application of participative approaches to the management of the reserve.

4.4. Using of multivariate analysis in conservation priority setting

In order to identify priority species for conservation, we used a Principal Component Analysis (PCA) which combined ethnobotanical, harvesting risk, economic, threat, adaptability to climate variation and ecological factors. This is a new approach as compared to previous one using ordinal classification or ranking (de Oliveira et al., 2007; de Melo et al., 2009). It helped identify most important and threatened medicinal species, and is more objective than a single ordinal classification or ranking. Ethnobotanical indices and ecological indicators can be pooled in different ways to yield a compound ordinal decision metric. Various decision metrics can result from a same database. That is for example the case of the methods developed by Brehm et al. (2010): point scoring procedure (PSP), point scoring procedure with weighting (PSPW), compound ranking system, and binomial ranking system (BRS). However, multivariate analysis (e.g. this study) has the advantage to summarize several variables into a limited number of synthetic variables (Jackson, 1991). The PCA approach can be used for any forest reserve, regional or national area. The most important is to pool the different ethnobotanical and ecological variables in data matrix, capable to be analyzed with any statistical software. The researchers who are not skilled to perform such statistical analysis could ask help from local biometricians.

5. Conclusion

People surrounding the Wari-Maro Forest Reserve hold important knowledge, not only on medicinal uses of tree species in their environment but also about their abundance. A total of 94 traditional medicine uses were reported for 73 native tree species. These species were mainly used for skin diseases and worm infections, stomachache, malaria, dysentery, headache, fever, hernia and medico-magic practice. Using Principal Components Analysis (PCA) applied on cultural importance, harvesting risk, economic importance, threat status, adaptability to climate variations and ecological data, 12 medicinal tree species were prioritized for conservation. Valuable species such as *M. excelsa*, *A. africana*, *K. senegalensis* and *P. erinaceus* appeared to be of the highest priority. People perceptions on their rarity were well congruent with ecological indicators. These species should be given upmost importance for future research for their domestication and conservation. Pending critical public actions, we suggest encouraging public and private landowners to prioritize these species in plantation plans. The multivariate approach used here is a quick unsubjective tool for practical conservation priority setting which could potentially be applied in other research areas.

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