Estimating the Local Value of Non-Timber Forest Products to Pendjari Biosphere Reserve Dwellers in Benin[1]

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Estimating the Local Value of Non-Timber Forest Products to Pendjari Biosphere Reserve Dwellers in Benin. This paper uses an indices method based on participant ranking of species to quantify use–values of Non-Timber Forest Products (NTFPs) and the socio-economic factors that influence these values for people living around the Pendjari Biosphere Reserve in Benin. There were 76 species identified that had a high index value to people. The 10 most valued species were *Parkia biglobosa*, *Adansonia digitata*, *Vitellaria paradoxa*, *Tamarindus indica*, *Lannea microcarpa*, *Vitex doniana*, *Hibiscus asper*, *Melochia corchorifolia*, *Khaya senegalensis*, and *Diospyros mespiliformis*. Species values were influenced by the vegetative form of the species as well as by the gender of a participant and his/her affiliation to the ethnic group. The study also illustrates that women had a preference for NTFP species with high commercial and nutritional values, while men preferred plants that provide construction material and medicine. Moreover, the ethnic group that historically had more contact and interaction with the vegetation valued NTFPs more than any other group. The difference in value attributed to species by people was also driven by the vertical transmission of ethnobotanical knowledge in the study area. For long-term biodiversity conservation, it will be useful to involve the needs of all of the local communities in the design of a management plan and focus attention on the most important species.

Key Words: Local values, non-timber forest products, Pendjari biosphere reserve, Benin.

Introduction

In Africa, Non-Timber Forest Products (NTFPs) represent direct inputs to satisfy different household needs for food, medicine, and materials for construction. Often they are the only means for forest dwellers to enter the cash economy (Avocèvou-Ayisso et al. 2009; Camou-Guerrero et al. 2008; Delvaux et al. 2009; Hermans et al. 2004). However, we still have a poor understanding of the factors that determine or influence the value of these resources and the extent to which rural people depend on them (Lawrence et al. 2005; Shanley and Rosa 2004). Indeed, people in any given community do not use and value all plant species equally and, consequently, some researchers have argued that identifying the more relevant groups of species for local people may help in defining and implementing priorities for conservation and sustainable management strategies (Camou-Guerrero et al. 2008; Dalle and Potvin 2004; Kvist et al. 2001).

According to previous studies, socio-cultural factors such as age, gender, the location of dwellings, and their distance from markets affect how people are linked with plant species. Age and gender determine intra-cultural variations in traditional knowledge and perception of plant species (Camou-Guerrero et al. 2008; Hanazaki et al. 2000; Müller-Schwarze 2006). Learning about useful plants begins at an early age and continues through adulthood; thus, older people in general possess more detailed knowledge of

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plants than younger generations (Camou-Guerrero et al. 2008; Müller-Schwarze, 2006). From a gender perspective, various authors have reported that preferences for useful plant species, as well as general interest in forest resources, can differ among men and women (Camou-Guerrero et al. 2008; Case et al. 2005; Gemedo-Dalle et al. 2005). These differences have been partly explained as a consequence of the sexual division of labor in traditional societies and because learning is culturally conditioned (Müller-Schwarze 2006).

Another gender aspect related to the differentiation in preferences for useful plant species relates to plant life form. Comparing male and female indigenous knowledge in Ethiopia, women were found to be especially knowledgeable about grasses and forb species used for forage (Gemedo-Dalle et al. 2005). Women in the Madre de Dios region of Peru tend to value fruit species more highly than timber, while the reverse is true for the men (Lawrence et al. 2005). Plant life form is thus an important factor affecting values ascribed to species. This is particularly relevant in a savanna habitat where tree species' products are available throughout the year, but forbs are not. Research conducted in Cinzana, near Ségou (Mali), found the contribution of herbaceous species to the NTFPs used and harvested during the dry season to be negligible (Gustad et al. 2004). Of the species reported, all but one was woody, pointing to the importance of tree species to the local communities in a region with a long seasonal dry period.

The location of dwellings and their distance from markets have also been identified as key factors that influence the value assigned to species by a population (Lawrence et al. 2005). Indeed, previous findings assumed that sustainable development linked to forest conservation depends on the existence of markets, particularly for NTFPs (Richards 1993; Vadez et al. 2004). The logic is that markets increase locally perceived values and, consequently, harvesters' motivation to manage their more valued species sustainably.

When developing management plans for natural resources, it is vital to understand these relationships while integrating the needs of local populations. This is especially important in the case of biosphere reserves, which encourage sustainable development that is adapted to the local context (IUCN 2002).

The present study was conducted in Benin, West Africa, where there is still limited understanding of the factors that determine the value of species in traditional communities and the socio-economic factors influencing the extent to which people depend on forest resources. This study may be the first to report plant diversity in relation to the socio-economic and cultural factors that influence the values ascribed to them by people in the Pendjari Biosphere Reserve in northern Benin.

Following insights from previous research showing that in traditional societies gender is a significant factor that influences the use of wild plants, we hypothesized that in the Pendjari Biosphere Reserve, men and women would value NTFPs differently (Camou-Guerrero et al. 2008; Gemedo-Dalle et al. 2005; Lawrence et al. 2005). Based on preliminary results and knowledge of cultural differences among ethnic groups in the area, we also hypothesized that value accorded to species varies among different ethnic groups (Case et al. 2005; Lawrence et al. 2005). We hypothesized further that people differentially value forbs and woody species (Gustad et al. 2004). We also tested whether the species values are a function of distance from village to market (Lawrence et al. 2005). The objectives of this study are: (1) to identify by means of quantitative methods the most important species used by people around the Pendjari Biosphere Reserve to satisfy their subsistence needs, (2) to determine whether men and women or separate ethnic groups value NTFPs differently, (3) to assess the effect of plant life form on its perceived value, and (4) to analyze the impact of markets on the value ascribed to species by local people.

Study Area

The study was conducted in the Pendjari Biosphere Reserve located in the northwestern area of the Republic of Benin (10°30′ to 11°30′ N; 0°50′ to 2°00′ E) (Fig. 1). With the exception of the Atakora chain (400–513 meters [m] above sea level), the region mostly lies between 150–200 m above sea level (Heinrich and Moldenhauer 2002).

Pendjari Biosphere Reserve was declared a Game Reserve in 1954, upgraded to a National Park in 1961, and became a Biosphere Reserve in 1986 (IUCN 2002). The current regime attempts to give local populations more control over the management of the peripheral areas. The reserve is divided into three areas, two of which (the core and hunting areas) prohibit timber logging and the conversion of protected lands for agriculture. However, bordering communities are allowed to gather forest products such as NTFPs in the controlled access and hunting zones (CENAGREF 2005).

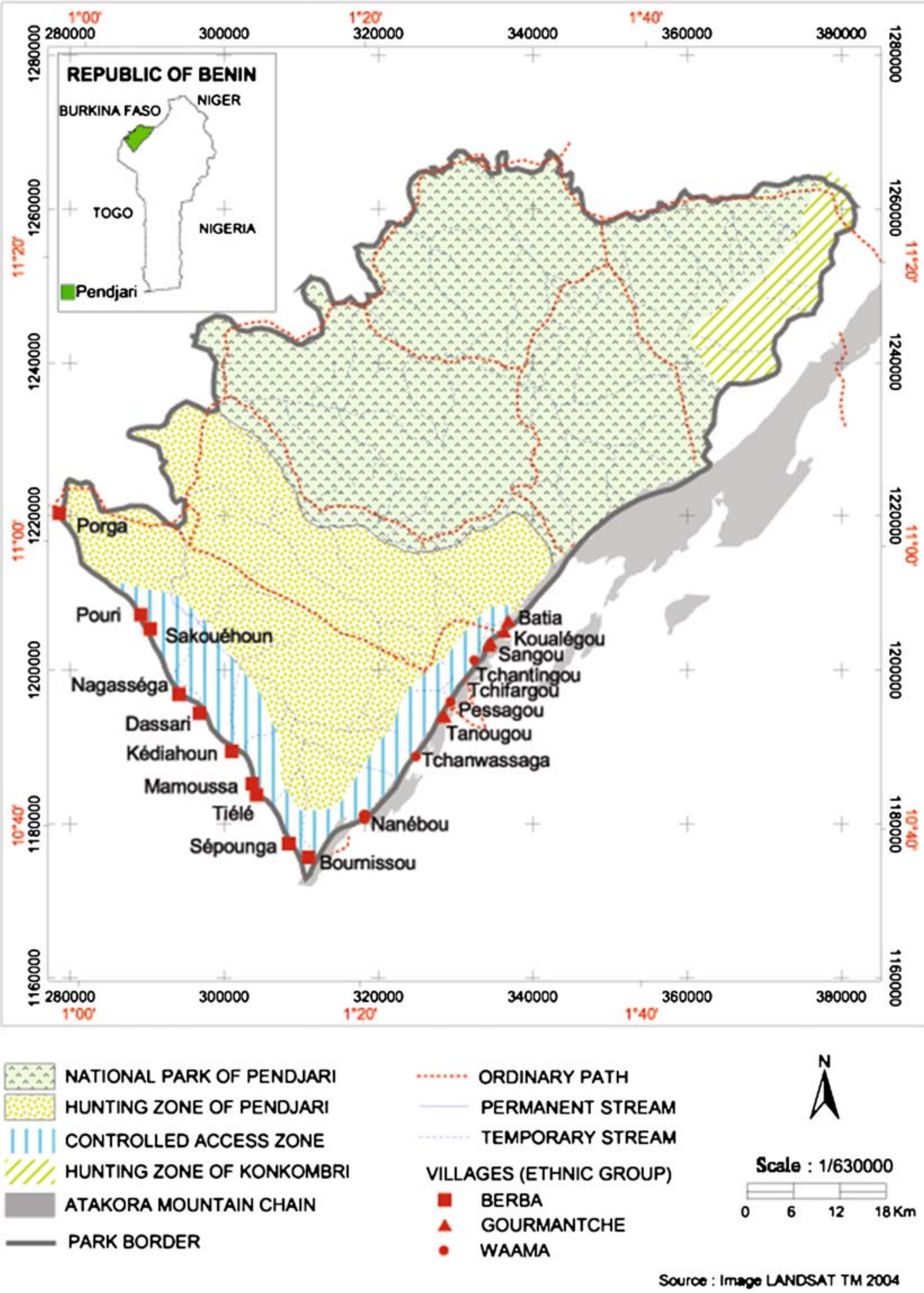

Fig. 1. Map of Pendjari Biosphere Reserve. Map of Pendjari Biosphere Reserve in the northern part of Benin (West Africa), illustrating the location of surrounding villages and different zones as suggested by the biosphere reserve concept.

Around the periphery of the reserve, fields and fallows dominate the landscape. The main soil type occurring in the Pendjari Biosphere Reserve is tropical ferruginous soil. The soil of the Atakora chain, which occupies the southern part of the reserve, is stony and unfit for agriculture. Except for the land around rivers and temporary and permanent streams, the soil is generally not very fertile. The climate is Sudanian with a seven-month dry period; peak rainfall occurs between late May and early October and the mean annual rainfall is 1,000 millimeters (mm) (Sinsin et al. 2002). The mean annual temperature is 27° centigrade (C). The vegetation is composed mostly of open shrub and tree savannas, and in some places, dry or gallery forests.

The population in the study area, which is estimated to be 30,000 inhabitants, is composed of three main ethnic groups: Berba, Gourmantche, and Waama. Moved from the inside of the park where they lived initially to the park periphery between 1958 and 1961, the population is spread across 20 villages (Djossa et al. 2008) that are installed in the controlled access zone along two axis roads between the hunting zone and the park border. According to local common belief, this was done to create the Pendjari National Park; however, according to authorities, the aim of these transfers was to concentrate sufficient populations on specifically identified sites in order to connect them with socio-economic infrastructure such as roads, health centers, and schools (Kiansi 2008). The Berba group dominates the area along Tanguieta-Porga Road, while the Waama and Gourmantche groups are situated along Tanguieta-Batia Road between the Atakora chain and the Pendjari National Park. A limited number of people from Peulh or Fulani, Dendi, and Bariba ethnic groups populate the study area as well. The three main ethnic groups settled in the area during the early 19th century (Kiansi 2008). Historically, they were hunters and fisherman, but due to the establishment of the park and its restrictions, they were converted into farmers. People of the Gourmantche ethnic group are specialists in geomancy, which is a form of divination based on the interpretation of objects such as pebbles thrown to the ground. People of this ethnic group are believed to have the ability to predict the future, a talent that, combined with their considerable knowledge of the virtues of plants, is associated with their practice of prescribing natural plant recipes to treat various health problems (Kiansi 2008).

The most important livelihood activity is subsistence agriculture. Cultivated crops include yams, maize, sorghum, cowpea, groundnuts, and rice (CENAGREF 2005). The savanna in the buffer zone is also used for cattle grazing and intensive collection of firewood (Sinsin et al. 2002). The people surrounding the reserve still retain much of their traditional lifestyle and have extensive knowledge of the wildlife resources of the area (Djossa et al. 2008). They harvest useful species for their nourishment, primary healthcare, and to supplement agricultural incomes.

There are five main weekly markets where local people trade their products. The most important of these is the Tanguiéta market where collectors periodically come to exchange their goods.

Methods

Sampling Technique

The research sample was constituted using demographic data from the study area (CENAGREF 2005). We interviewed 185 participants (105 men and 80 women) at home and in their local languages. Each ethnic group was represented in proportion to their occurrence in the overall Pendjari Biosphere Reserve population: 80 people from the Berba group, 51 from the Gourmantche, 49 from the Waama, and 5 from minority ethnic groups (Peulh, Bariba, Dendi). Participants were selected within a given age group and based on the individuals' willingness to be involved as unpaid volunteers. We established contact by introducing ourselves to each interviewee while presenting the objectives of the study. The ages of the participants ranged from 16 to 90 years. We chose 16 years of age as the youngest limit because people in the study area tend to have obtained considerable knowledge about vegetable use by this age (IUCN 2002).

Data Collection

Data collection was carried out using a quantitative and qualitative ethnographic method as described by Lawrence et al. (2005). At the beginning of data collection (January 2007), we organized six focus group discussions (two for each ethnic group) during which we invited participants to list all plant species that they personally used as NTFPs. Twenty men and women ranging from 15 to 50 years of age participated in each focus group discussion. In the majority of cases, men were more numerous than women and the discussion lasted approximately two hours. Participants listed the names of all useful plants with which they were acquainted as well as the specific use of each. From the list, we identified six categories of use: food, medicine, construction, ceremony, firewood, and other.

We collected detailed information using questionnaire surveys during a period of six months (April, June, September, December 2007, and January, February 2008). We chose this frequency of data collection to reduce the contextual impact on value attributed to species. We felt that recent events such as disease, food shortage, or the availability of certain NTFPs during data collection periods could influence the value attributed to species by participants. Therefore, we concentrated the data collection period on products extracted during one rainy season, assuming that disease and food shortage events would most likely be constant during this period. The questionnaire survey took about two hours per participant and consisted of two parts. In the first section, we asked participants to list and rank by importance the 10 most significant species that he/she had harvested from the reserve over the last five years. For each species listed, participants gave information on the uses that made that species important to him/her. We limited the harvest period to five years based on the recall ability of participants. Part two focused on collecting information on participants' age, gender, and ethnic group affiliation. Questionnaires were written in French, but we conducted the interviews entirely in the participant's local language. One month before beginning data collection, we performed a trial run of the questionnaire and trained the interviewers (secondary school students) on how to administer the questions. The use of enumerators from the study villages facilitates data collection and increase participants' trust in the information that they are given.

During the interviews, participants listed species by their local names, which were later identified taxonomically. During the interviews, we used a field herbarium, an illustrated reference book of Arbonnier, and the Benin Analytic Flora to identify plants species (Akoègninou et al. 2006; Arbonnier 2000). We collected samples of the species that we could not identify directly in the field and conducted their taxonomic identification at the National Herbarium of Benin, which is at the University of Abomey-Calavi. This is where all plant species known to be native to Benin are conserved as voucher specimens.

Data Analysis

The ranking done by participants was first converted into a score. We attributed the score of 10 to the first species cited by a participant; the second species received a score of 9, and so on. If, instead of 10 species, a participant listed 5, the species that were not mentioned scored zero.

We used a general linear mixed model on the log-transformed score as the dependent variable, and tested the effect of participants' gender, life form of species cited, ethnic groups and the interaction among them (species life form*gender, species life form*ethnic groups) as (fixed) independent variables, and the participant as a random variable (using the procedure described by Verbeke and Molenberghs [1998]). Data on species life form were not collected directly from participants; rather, they were obtained during species identification. The significance of the fixed effects as predictors of score was assessed by Wald statistics. We used the Statistical Package for the Social Sciences model 16.0 for data analysis.

When the general linear mixed model revealed a significant effect of an independent variable on the value accorded to a species, we computed the values of species as described by participants under this variable. The average value of each species was calculated as described by Lawrence et al. (2005). For example, for one species (S), we defined its index value (V_{Smg}) attributed by men (m) in a given ethnic group (g) as: (1) $V_{smg} = \sum \frac{S_{mg}}{n_{mg}}$ (with S_m score attributed to species S by each man and n_m the number of men in the research sample). If we interviewed five men and four ranked species (S) as first, third, sixth, and tenth, the scores (S_m) would be respectively 10, 8, 5, and 1. The species would receive a score of 0 for the man who did not mention it. The species value for men in this community (V_{Smg}) would be $(10 + 8 + 5 + 1 + 0)/5 = 4.8$. The same process was used for women.

We defined species index value (V_{Sg}) attributed by men (m) and women (w) combined in a given ethnic group (g) as: (2) $V_{Sg} = \frac{1}{2}\left(\sum \frac{S_{mg}}{n_{mg}} + \sum \frac{S_{wg}}{n_{wg}}\right)$. Considering the examples above, species' index value (V_{Sg}) for men and women in a community (g) would be $\frac{1}{2}$ $[(10 + 8 + 5 + 1)/4 + (6 + 3 + 9 + 2 + 8 + 0)/6] = 5.33$.

We obtained the species index value attributed by all Pendjari Biosphere Reserve communities (V_{sr}) as: (3) $V_{Sr} = \sum_{g=1}^{g=4} \frac{V_{Sg}}{4}$ (g varies from 1 to 4 due to the existence in the study area of 4 ethnic groups).

To test the possibility that the value of species are more strongly determined by commercialization when the participants' village is closer to a market, we compared the values of species in two villages populated by the Gourmantche: one located closer to a market (Tanongou market, located in the village) and one farther away (Batia, 13 kilometers [km] from Tanongou market).

In addition to the frequency analysis above and in order to identify the most culturally important species' ranking by participant considering their ethnic group affiliation and gender, we computed the average order in which each species is mentioned by adding together the order in which each participant mentioned the species and dividing by the total number of participants (Martin 1995). This was done in order to clearly understand the ethnic group affiliation and gender effect on species index values.

Assessment of the Methodology

The main difficulty of our methodology lies in the impossibility of attributing a "distance" measure to differences between numerical values given to ranks. For example, while two participants give higher rank for species *a* than *b*, the reality may be that the first participant thought *a* was only slightly better than *b* while the second thought *a* was considerably better than *b*. Moreover, our methodology did not integrate the frequency with which people effectively use the species that were ranked. Therefore, the hierarchy of plants found here did not exactly equal the frequency of use of each species by informants.

Results

Most Important Species Used

Participants in the focus group discussion listed 97 plant species and associated them with 201 different uses. A total of 76 species with 171 total uses were reported by participants during the individual questionnaire interviews. A total of 118 species were identified as useful in the area.

The majority of plants listed by participants (80%) were multiuse species. However, people around the Pendjari Biosphere Reserve highly valued medicinal and/or food plant species. In total, participants listed 60 medicinal plants and 48 food species as important (Table 1).

The index values (V*sr*) of the 76 species listed in the top 10 by participants ranged from 0.005 to 7.54. We classified them into three groups of index value and have presented them in the Appendix. About 51% of the species listed fell into a category of low value (from 0.005 to 0.097), 29% had an intermediate value (from 0.1 to 0.449), and 20% had a high value (from 0.5 to 7.54). The three most important species used by inhabitants in the study area were *Parkia biglobosa* (V*sr*=7.54), *Adansonia digitata* (V*sr*=7.18), and *Vitellaria paradoxa* (V*sr*=6.79) (Fig. 2). The seeds and pulp of *Parkia biglobosa* are used in the daily diet of the local people. They also use the bark for medicine, the leaves in religious ceremonies, and the pod of the fruit as cement to construct house walls (Fig. 3). Young fresh leaves of *Adansonia digitata* are most frequently harvested to make sauce, the pulp of the fruit and the seeds are used to make juice, and the bark is used in medicine and house construction. The seeds harvested from *Vitellaria paradoxa* are processed to make shea butter and locally used as oil in food preparation and cosmetics (Fig. 3). Another useful product is the bark, which is used in traditional medicine.

Gender, Ethnic Group, Plant Life Form, Market Effects, and Species Values

The values given by participants to each species were significantly affected by the plant life form, as well as participants' gender and ethnic group ($Z=23.066$; $p<0.0001$). Species marketability was also important in assigning index value. The correlation between ln (species index values) and

Table 1. Total value of species used per category of use.

Category of Uses	Total Value of All Species	Number of Species Used
Medicine	44.07	67
Food	43.66	52
Construction	29.44	30
Firewood	37.41	29
Ceremony	28.17	8
Other uses	24.68	7

Values presented here represent the sum of individual values (Vsr) assigned to species in each category of use by participant.

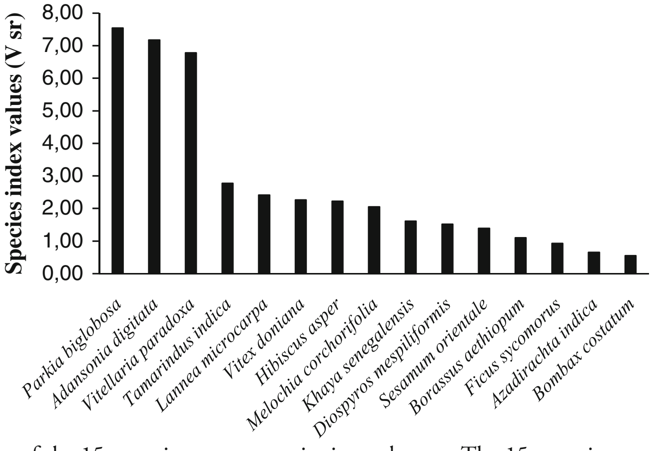

Fig. 2. Index values of the 15 most important species in study area. The 15 most important species are species whose value (*Vsr*) is ≥ 0.5.

ln (frequency of mention of commercial influence) for the 15 most important species is significant (Pearson's correlation coefficient: 0.784, $P < 0.001$).

Variation of Species Index Value Between Genders

Men and women valued useful species differently ($F = 1.95$; $p < 0.001$). Species such as *Diospyros mespiliformis*, *Khaya senegalensis*, and *Lannea microcarpa* were preferred for use in house construction and medicine, activities performed mainly by men. Accordingly, these species were valued significantly higher by men than by women. Those species given higher index value by women, including trees like *Bombax costatum*, and forbs such as *Hibiscus asper*, *Melochia corchorifolia*, and *Sesamum radiatum*, find their chief uses as food and in cooking. Women commonly use the leaves and flowers of the aforementioned species to make sauces.

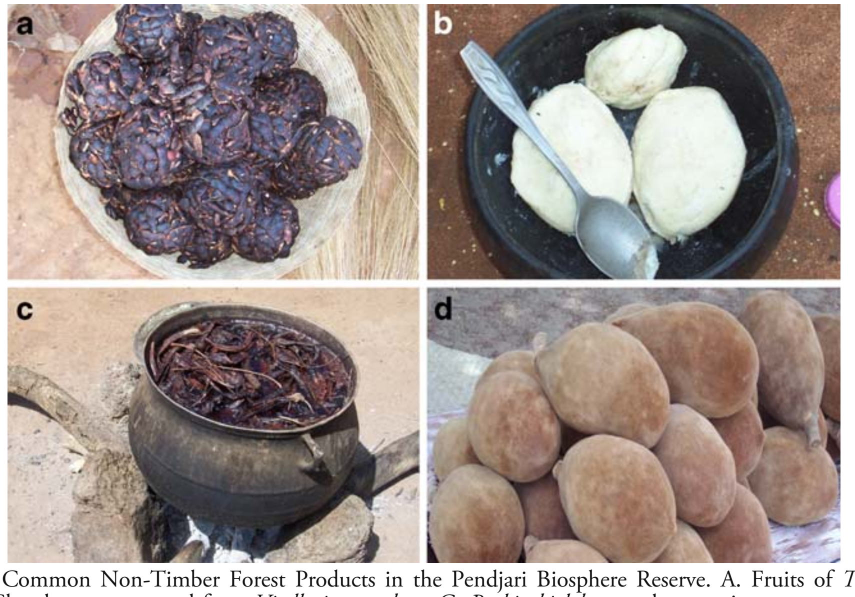

Fig. 3. Common Non-Timber Forest Products in the Pendjari Biosphere Reserve. A. Fruits of *Tamarindus indica*; B. Shea butter processed from *Vitellaria paradoxa*; C. *Parkia biglobosa* pod processing to cement walls*;* D. Fruits of *Adansonia digitata.*

Parkia biglobosa was the most valued species and was a source of food and income. However, there was no significant difference in its index value between men and women. The species is culturally important for both genders (Fig. 4a, b).

Variation Between Ethnic Groups

Species index values varied between ethnic groups (F = 4.33; p < 0.001). *Adansonia digitata*, *Ficus sycomorus*, and *Hibiscus asper* were given significantly higher values by Berba people, while *Bombax costatum*, *Khaya senegalensis*, *Parkia biglobosa*, *Tamarindus indica*, and *Vitellaria paradoxa* were highly ranked by the Gourmantche. Waama people ranked *Diospyros mespiliformis* most highly.

Gourmantche people, who are most limited in land access (Fig. 1), gave higher index values to a greater number of species than did the other ethnic groups and listed species market value as one of the main criteria to rank their top 10 species.

Concerning cultural importance, *Parkia biglobosa* is valued as the most important species by the Gourmantche and Waama, *Adansonia digitata* is the most significant for the Berba ethnic group, and *Vitellaria paradoxa* has the highest cultural importance among the minority ethnic groups (Fig. 5a, b, c, d).

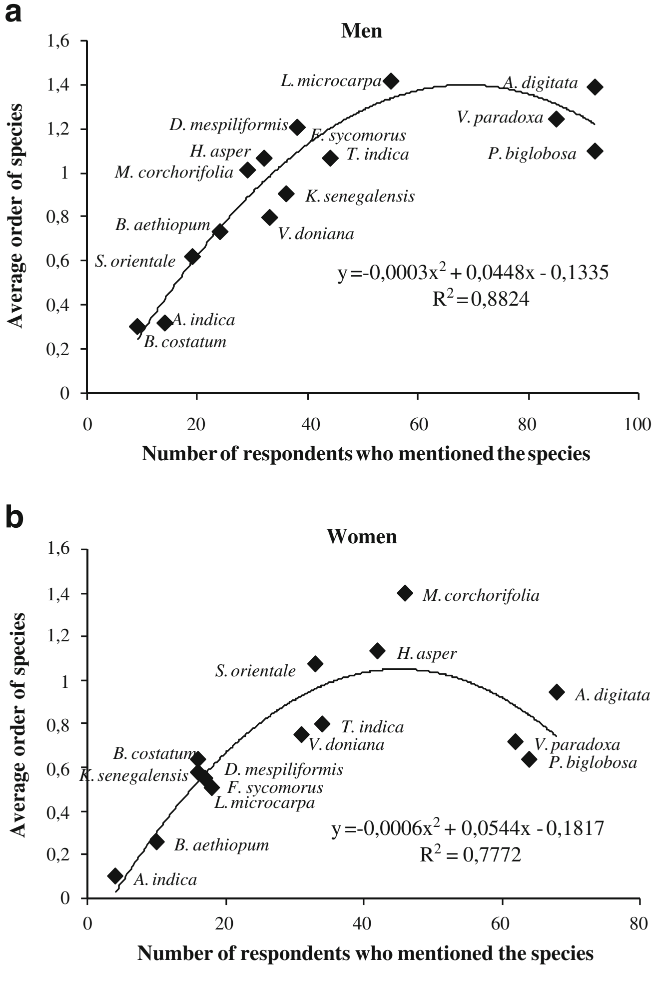

Fig. 4. Graphs A and B present respectively the most culturally important species to men and women in the bottom right of the graphs. *Parkia biglobosa* was found to be the most culturally important species for both men and women.

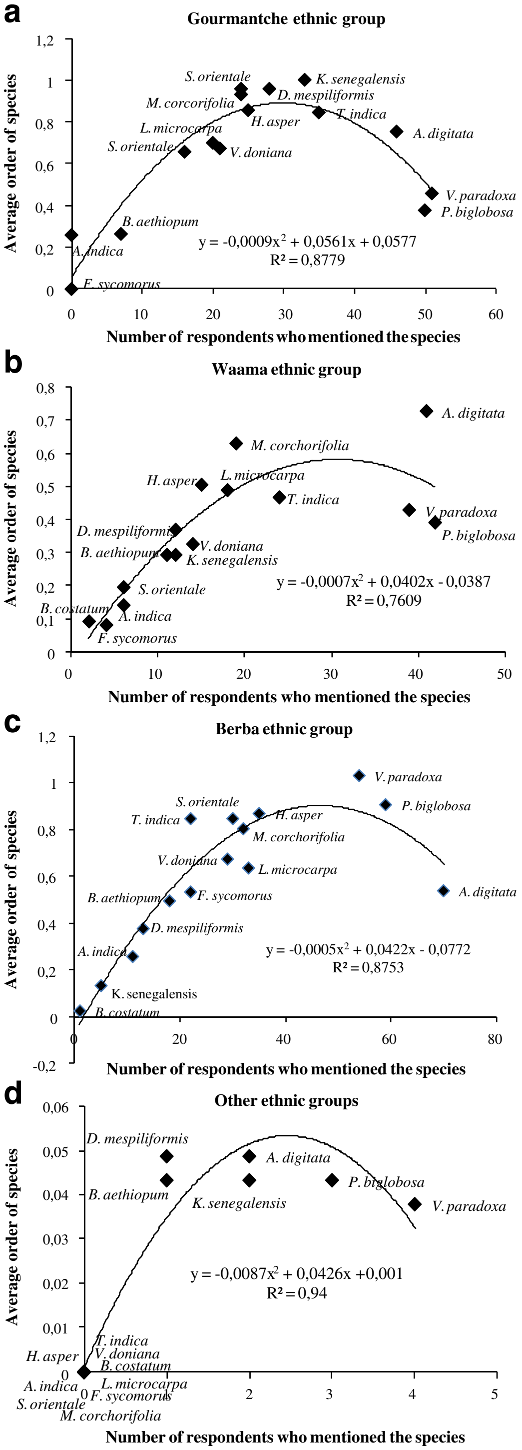

Fig. 5. Graphs A, B, C and D present respectively in the bottom right the most culturally important species to Gourmantche, Waama, Berba, and Other ethnic groups. *Parkia biglobosa* was found to be the most culturally important species to Gourmantche and Waama while *Adansonia digitata*, and *Vitellaria paradoxa* are culturally important to Berba and Other ethnic groups respectively.

Variation in Species Index Values According to Their Plant Life Form

Participants valued trees more than forbs species (Student *t* test, d.f. = 67, $p = 0.001$). Only three forbs species were listed among the top 15 important species (Fig. 2). The most valued forbs species, *Hibiscus asper* (Vsr = 2.23), was ranked seventh. *Hibiscus asper*, which is greatly abundant at the beginning of rainy season, is widely consumed by local people as a vegetable in sauce. These species were collected from parklands including fallows and croplands.

The species index values were also related to the plant family to which they belong. Among the 34 plant families listed by participants, Leguminoseae, Bombacaceae, and Sapotaceae ranked highest. With 145 species, the Leguminoseae family had the highest number of species listed. These families also had the most highly ranked species by participants: *Parkia biglobosa*, *Adansonia digitata*, and *Vitellaria paradoxa*.

Market Proximity and Value of Species

There was a strong relationship between index values attributed to species and the frequency with which participants mentioned marketability as a reason for their ranking (Pearson's correlation coefficient: 0.784, $p < 0.001$). This is reinforced by the fact that the most valued species show positive deviation from the regression of local index value on the frequency of nomination for sale as reason of species importance (Fig. 6). But while marketability of species is one of the factors affecting index values ascribed to species, no relation was found between the market proximity and this value. People closer to markets and those more distant from them ranked species in the same way.

Discussion and Conclusion

The Importance of Non-Timber Forest Products

The inventories of existing NTFP resources and their present uses as reported in this study give a broad view of NTFPs used by people around Pendjari Biosphere Reserve. We found that 76 useful species are identified as important for people living around the reserve. The results helped to identify some useful plant species that should be qualified as priorities for management and conservation purposes. The most significant families in term of species index values are Leguminoseae, Bombacaceae, and Sapotaceae; although, in the study area, the most representative families are Poaceae, Fabaceae, Rubiaceae, Combretaceae, and Euphorbiaceae. Therefore, people do not use species simply because they are abundant. As revealed in previous studies, shared characteristics acquired deep in the evolutionary history of plants have predisposed them to be particularly useful (or not) for humans (Assogbadjo et al. 2008; Lawrence et al. 2005).

Tree species are the most frequently used in the area (80%). Based on the list of species used, people attributed more value to the woody species than to the forbs species. This difference, in accordance with previous studies, can be partly

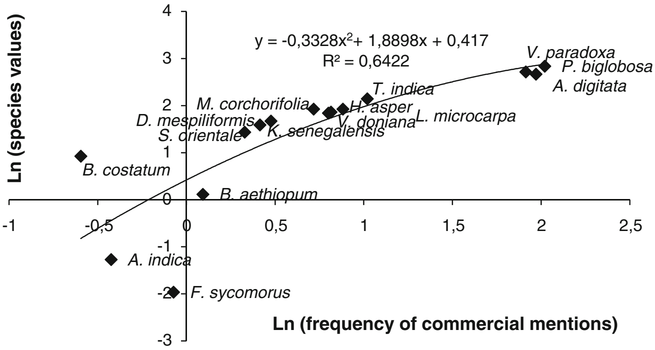

Fig. 6. Relation between the 15 most important species' values and frequency with which participants cited marketability for species as the reason for its importance.

explained by the seasonality observed in forbs species use (Asfaw and Tadesse 2001; Gustad et al. 2004). Forbs species used by participants grow during the rainy season (June–October) and the population has the opportunity to use them only during this period. In contrast, woody species are often multiuse species and their products are available throughout the entire year. Therefore, the more regularly the local people around Pendjari National Park can exploit products from a species, the more important this species becomes to them. This result is consistent with results from other authors who found that people accord high value to multiuse species (Camou-Guerrero et al. 2008; Gemedo-Dalle et al. 2005; Nygren et al. 2006; Pieroni 2001; Ros-Tonen 2000). However, these authors warn that the excessive utilization of these multiuse species may put them at risk. In the present study area, people intensively incorporate these multiuse species into their traditional agroforestry systems. This is an important endogenous conservation strategy that could be improved by conservationists to strengthen sustainable use of these species. Therefore, Pendjari Biosphere Reserve people not only depend on NTFPs for food, medicine, construction materials, and income, but have also developed methods of resource management, which may contribute to their conservation.

People listed species used as medicine and food earlier and more frequently than other use categories. This supports results from previous studies and could be hypothetically associated with a higher importance of the household's subsistence activities (Gemedo-Dalle et al. 2005; Kala et al. 2004; Lawrence et al. 2005). For instance, in poor rural areas, procurement of food and health constitute crucial activities of daily life and are basic activities for the household's subsistence. This is reinforced by the high degree of poverty in the area. The Atakora province, where we carried out the study, is one of the most disadvantaged areas in Benin and houses the largest number of poor people, or people vulnerable to poverty, in Benin (Adégbidi et al. 1999; FIDA 2006; Martin 2000). Due to difficulties in finding funds for treatment in the modern health center as well as challenges of stocking up foodstuffs to bridge the gap during the dry season, these people rely heavily on NTFPs. This appears to confirm the role of NTFPs in supporting the livelihoods of poor people, a concept largely shown through previous research (Adhikari et al. 2004; Arnold and Ruiz Perez 2001; Fisher and Christopher 2007; Gopalakrishnan et al. 2005; Mahapatra et al. 2005). There is a need for help from conservationists in aiding local people to harvest NTFPs sustainably. Indeed, as the benefits people seek from the NTFPs will change over time, it will become even more necessary to analyze how to make this exploitation sustainable. Again, this study shows the complex role that harvesting NTFPs can play on rural livelihoods and biodiversity conservation.

Factors Affecting Species Index Values

The differences between index values assigned to useful species by men and women are driven by factors such as the type of products obtained from a species and its market value. In general, women valued species used for food more than men, whose interests relate to species used as construction material and medicine. This is consistent with results from other studies that support that differences between men and women concerning value assigned to useful species. These differences may be partly explained by the sexual division of labor in traditional societies (Camou-Guerrero et al. 2008; Müller-Schwarze 2006). In our study, the most likely reason for the differences in values assigned to useful species by men and women may be found in the social organization of household spending. Women are in charge of household nutrition (but receive staple crops from men), while men are responsible for household building. Therefore, women have the responsibility of finding seasonings for cooking food. As stated by women in our research sample, with increasing poverty in the study area, the income given them by men for food is rarely sufficient. Therefore, women have difficulty buying all of the necessary seasonings at the market. NTFPs play an important role in helping them to solve these food issues. This also explains the high frequency with which women ranked marketable species in comparison to men. These results suggest that women have at least as much diversity of knowledge as men. They also show that women are important NTFP stakeholders and merit equal consideration in terms of biodiversity conservation in the reserve.

Our results revealed differences in species index value across the various ethnic groups. The ethnic groups that are hemmed in by the protected area and the mountain chain suffer a lack of land access and, as a result, value NTFPs more highly than other groups. That is the case for the Gourmantche villages (Fig. 1). The conversion of land in the protected area for agriculture is not allowed, while land in the Atakora chain is stony and unfit for agriculture. In this situation, the Gourmantche farmers do not have sufficient land to extend their fields. Therefore, they harvest NTFPs to secure their well-being. This could explain why they cited higher marketability of species as the principal reason motivating them to value a species. This is consistent with previous reports revealing that unavailability of land is one of the most important factors that determine the degree of dependence on forest resources (Adhikari et al. 2004; Murniati et al. 2001). The high level of dependence of the Gourmantche ethnic group on NTFPs may also be explained by their tradition as healers and geomancy science specialists, a practice that equips them with a considerable amount of unique knowledge regarding species' properties. Various authors have suggested that differential species values among similar groups are related to specialized cultural transmission (Case et al. 2005; Gaoué and Ticktin 2009; Gemedo-Dalle et al. 2005; Lozada et al. 2006; Müller-Schwarze 2006). This may lead to greater information heterogeneity and help explain why the various ethnic groups value NTFP species differently within the Pendjari Biosphere Reserve (Adhikari et al. 2004; Murniati et al. 2001). At the same time, the similarity exhibited between the Gourmantche and Waama groups concerning the most culturally valued species may be explained by their geographical proximity; they live relatively close to one another along one of the two access roads that border the Pendjari National Park (Fig. 1). Given these differences in species index values, sustainable resource use and responsible management policy will require the inclusion of the perceptions of all the relevant ethnic groups.

Our results also show that the marketability of species affects their index value; species that are more commercialized are the most valued (for example, *Parkia biglobosa*). This finding explains the strong relationship between frequency of marketing and species index values, and appears to confirm those who report that markets have a positive effect on values accorded to species by people (Gustad et al. 2004; Howell et al. 2008; Lawrence et al. 2005). However, contrary to findings by Lawrence's group in Madre de Dios (Peru), although marketability of species is a determinant in the perceived species value, in the Pendjari Biosphere Reserve, market proximity did not affect the index value of species. The likely explanation is the ease of access to villages. In contrast to the case study in Madre de Dios, all of the villages and local markets in the Pendjari Biosphere Reserve are easily accessible by road. As poverty is one of the main factors determining people's dependence on NTFPs in the study area, growth in the commercialization of marketable species would be helpful for the local poor. This can be done through the development of agroforestry systems that incorporate marketable species.

In conclusion, this study identified the most important useful plant species that should be considered as priorities for management and conservation. Our results show that although people living around the Pendjari Biosphere Reserve have access to a wide range of species, not all are highly valued. NTFPs are used in a wide range of categories, indicating the close links between livelihoods and natural resources in the area. The study also clearly shows that both women and men have extensive knowledge about useful species and merit consideration in reserve biodiversity conservation.

Further studies are necessary to more fully understand the impact of ethnicity on cultural transmission of species knowledge. As seen in our research, some interviewees know certain plants, live near them, and are familiar with their uses, but do not consider them important because their ethnic group did not perceive them to be priority species.

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Literature Cited

Adégbidi, A., M. Ahohounkpanzon, E. Adjovi, V. Houdekon, D. Djoi, and S. Fagnisse. 1999. Profil de pauvreté et d'inégalité au Bénin. Cahier de Recherche No.: 00–01.

Adhikari, B., S. Di Falco, and J. C. Lovett. 2004. Household Characteristic and Forest Dependency: Evidence from Common Property Forest Management in Nepal. Ecological Economics 48:245–257

Akoègninou, A., W. J. van der Burg, and L. J. G. van der Maesen. 2006. Flore analytique du Bénin. Backhuys Publishers, Leiden, The Netherlands.

Arbonnier, M. 2000. Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. CIRAD-MNHN, Paris.

Arnold, M. J. E. and M. Ruiz Perez. 2001. Can Non-Timber Forest Products Match Tropical Forest Conservation and Development Objectives? Ecological Economics 39:437–447.

Asfaw, Z. and M. Tadesse. 2001. Prospects for Sustainable Use and Development of Wild Food Plants in Ethiopia. Economic Botany 55 (1):47–62.

Assogbadjo, A. E., R. Glèlè Kakaï, F. J. Chadaré, L. Thomson, T. Kyndt, B. Sinsin, and P. Van Damme. 2008. Folk Classification, Perception, and Preferences of Baobab Products in West Africa: Consequences for Species Conservation and Improvement. Economic Botany 62(1):74–84.

Avocèvou-Ayisso, C., B. Sinsin, A. Adégbidi, G. Dossou, and P. Van Damme. 2009. Sustainable Use of Non-Timber Forest Products: Impact of Fruit Harvesting on *Pentadesma butyracea* Regeneration and Financial Analysis of Its Products Trade in Benin. Forest Ecology and Management (257):1930–1938.

Camou-Guerrero, A., V. Reyes-García, M. Martínez-Ramos, and A. Casas. 2008. Knowledge and Use Value of Plant Species in a Rarámuri Community: A Gender Perspective for Conservation. Human Ecology 36:259–272.

Case, R. J., G. F. Pauli, and D. D. Soejarto. 2005. Factors in Maintaining Indigenous Knowledge among Ethnic Communities of Manus Island. Economic Botany 59:356–365

CENAGREF. 2005. Parc National de la Pendjari, Bénin: Plan d'aménagement participatif et de Gestion 2004–2013. CENAGREF/GTZ, Cotonou, Benin.

Dalle, S. P. and C. Potvin. 2004. Conservation of Useful Plants: An Evaluation of Local Priorities from Two Indigenous Communities in Eastern Panama. Economic Botany 58(1):38–57.

Delvaux, C., B. Sinsin, F. Darchambeau, and P. Van Damme. 2009. Recovery from Bark Harvesting of 12 Medicinal Tree Species in Benin, West Africa. Journal of Applied Ecology 46:703–712.

Djossa, B. A., J. Fahr, E. K. V. Kalko, and B. A. Sinsin. 2008. Fruit Selection and Effects of Seed Handling by Flying Foxes on Germination Rates of Shea Trees, A Key Resource in Northern Benin, West Africa. Ecotropica 14:37–48.

FIDA. 2006. Œuvrer pour que les ruraux pauvres se libèrent de la pauvreté au Bénin. FIDA, Rome.

Fisher, B. and T. Christopher. 2007. Poverty and Biodiversity: Measuring the Overlap of Human Poverty and the Biodiversity Hotspots. Ecological Economics 62:93–101.

Gaoué, G. O. and T. Ticktin. 2009. Fulani Knowledge of the Ecological Impacts of *Khaya senegalensis* (Meliaceae) Foliage Harvest in Benin and Its Implications for Sustainable Harvest. Economic Botany 63(3):256–270.

Gemedo-Dalle, T., B. L. Maass, and J. Isselstein. 2005. Plant Biodiversity and Ethnobotany of Borana Pastoralists in Southern Oromia, Ethiopia. Economic Botany 59:43–65.

Gopalakrishnan, C., W. A. R. Wickramasinghe, H. M. Gunatilake, and P. Illukpitiya. 2005. Estimating the Demand for Non-Timber Forest Products among Rural Communities: A Case Study from the Sinharaja Rain Forest Region, Sri Lanka. Agroforestry Systems 65:13–22.

Gustad, G., S. S. Dhillon, and D. Sidibi. 2004. Local Use and Cultural and Economic Value of Products from Trees in the Parklands of the Municipality of Cinzana, Mali. Economic Botany 58(4):578–587

Hanazaki, N., J. Y. Tamashiro, H. F. Leitão-Filho, and A. Begossi. 2000. Diversity of Plant Uses in Two Caiçara Communities from the Atlantic Forest Coast, Brazil. Biodiversity and Conservation 9(5):597–615.

Heinrich, J. and K. M. Moldenhauer. 2002. Climatic and Anthropogenic Induced Landscape Degradations of West African Dry Savanna Environments during the Later Holocene. Quaternary International 93–94:127–137.

Hermans, M., A. Akoègninou, and L. J. G. van Der Maesen. 2004. Medicinal Plants Used to Treat Malaria in Southern Benin. Economic Botany 58(Supplement):239–252.

Howell, C. J., K. A. Schwabe, and A. H. A. Samah. 2008. Non-Timber Forest Product Dependence among the Jah Hut Subgroup of Peninsular Malaysia's Orang Asli. Environment, Development and Sustainability. Online. Digital Object Identifier doi:10.1007/s10668-008-9176-x.

IUCN. 2002. International Union for Conservation of Nature (IUCN) Evaluation of Nominations of Natural and Mixed Properties to the World Heritage List. Report to the World Heritage Committee Twenty–Sixth Session 24–29 June 2002, Budapest, Hungary. IUCN, Gland, Switzerland, pp. 9–17.

Kala, C. P., N. A. Farooquee, and U. Dhar. 2004. Prioritization of Medicinal Plants on the Basis of Available Knowledge, Existing Practices and Use Value Status in Uttaranchal, India. Biodiversity and Conservation 13:453–469.

Kiansi, Y. 2008. Formation des guides de la Pendjari: Histoire et cultures de la réserve (guidage pratique). Rapport de Formation. CENAGREF, Tanguiéta, Benin.

Kvist, P. L., M. K. Andersen, J. Stagegaard, M. Hesselsoe, and C. Llapapasca. 2001. Extraction from Woody Forest Plants in Flood Plain Communities in Amazonian Peru: Use, Choice, Evaluation and Conservation Status of Resources. Forest Ecology and Management 150:147–174.

Lawrence, A., O. L. Philips, A. R. Ismodes, M. Lopez, S. Rose, D. Wood, and A. J. Farfan. 2005. Local Values for Harvested Forest Plants in Madre de Dios, Peru: Towards a More Contextualised Interpretation of Quantitative Ethnobotanical Data. Biodiversity and Conservation (14):45–79.

Lozada, M., A. Ladio, and M. Weigandt. 2006. Cultural Transmission of Ethnobotanical Knowledge in Rural Community of Northwestern Patagonia, Argentina. Economic Botany (60)4:374–385.

Mahapatra, A. K., A. J. Albers, and E. J. Z. Robinson. 2005. The Impact of NTFP Sales on Rural Households' Cash Income in India's Dry Deciduous Forest. Environmental Management 35(3):258–265.

Martin, G. 2000. Définition, mesure et appréhension globale de la pauvreté : cas du Bénin. Statistique, Développement et Droits de l'Homme, Montreux, Switzerland.

Martin, G. J. 1995. Ethnobotany: A Methods Manual. Earthscan, London.

Müller-Schwarze, N. K. 2006. Antes and Hoy Día: Plant Knowledge and Categorization as Adaptations to Life in Panama in the Twenty-First Century. Economic Botany 60:321–334.

Murniati, D. P. Garrity, and A. Gintings. 2001. The Contribution of Agroforestry Systems to Reducing Farmers' Dependence on the Resources of Adjacent National Parks: A Case Study from Sumatra, Indonesia. Agroforestry Systems 52:171–184.

Nygren, A., C. Lacuna-Richman, K. Keinänen, and L. Alsa, L. 2006. Ecological, Socio-Cultural, Economic and Political Factors Influencing the Contribution of Non-Timber Forest Products to Local Livelihoods: Case Studies from Honduras and the Philippines. Small-Scale Forest Economics, Management and Policy 5(2):249–269.

Pieroni, A. 2001. Evaluation of the Cultural Significance of Wild Food Botanicals Traditionally Consumed in Northwestern Tuscany, Italy. Joumal of Ethnobiology 21(1):89–104.

Richards, M. 1993. The Potential of Non-Timber Forest Products in Sustainable Natural Forest Management in Amazonia. Commonwealth Forestry Review 72:21–27.

Ros-Tonen, M. A. F. 2000. The role of Non-Timber Forest Products in Sustainable Tropical Forest Management. Holz als Roh-und Werkstoff 58:196–201.

Shanley, P. and N. A. Rosa. 2004. Eroding Knowledge: An Ethnobotanical Inventory in Eastern Amazonian's Logging Frontier. Economic Botany 58:135–160.

Sinsin, B., A. C. Tehou, I. Daouda, and A. Saidou. 2002. Abundance and Species Richness of Larger Mammals in Pendjari National Park in Benin. Mammalia 66:369–380.

Vadez, V., V. Reyes-Garcìa, R. A. Godoy, V. L. Apaza, E. Byron, T. Huanca, W. R. Leonard, E. Pérez, and D. Wilkie. 2004. Does Integration to the Market Threaten Agricultural Diversity? Panel and Cross-Sectional Data from a Horticultural-Foraging Society in the Bolivian Amazon. Human Ecology 32(5):635–646.

Verbeke, G. and G. Molenberghs. 1998. Linear Mixed Models for Longitude Data. Springer-Verlag, New York.

Appendix: Species Listed by Participant with Their Family, Major Uses, and Index Values

Species	Family	Preference Group	Use	Index Values
Anacardium occidentale	Anacardiaceae	I	1,2,5	0.05
Ozoroa insignis			1,2	0.04
Uvaria chamae	Annonaceae		1,2,5	0.01
Hyphaene thebaica	Arecaceae		1,4,6	0.08
Gymnema sylvestre	Asclepiadaceae		2	0.03
Leptadenia spp.			1,2	0.04
Crescentia cujete	Bignoniaceae		2	0.01
Ceiba pentandra	Bombacaceae		1,2,4,5	0.09
Cadaba farinosa	Capparaceae		1	0.04
Garcinia livingstonei	Clusiaceae		1,2,5	0.097
Cochlospermum planchoni	Cochlospermaceae		1,2	0.03
Combretum glutinosum	Combretaceae		1	0.02
Euphorbia poissonii	Euphorbiaceae		2	0.02
Jatropha curcas			2	0.02
Acacia gourmaensis	Leguminosae		2,5	0.02
Acacia hockii			2	0.02
Acacia seyal			2,5	0.03
Afzelia africana			2,4,5	0.06
Berlinia grandiflora			2,4	0.02
Cassia sieberiana			2	0.06
Cassia sp.			1,2	0.02
Daniellia oliveri			2,4,5	0.03
Strychnos spinosa	Loganiaceae		1,2	0.04
Ficus lutea	Moraceae		1,2,4,5	0.08
Ficus sur			1,2	0.02
Milicia excelsa			2,5	0.02
Imperata cylindrica	Poaceae		2,4	0.04
Oxytenanthera abyssinica			1,4	0.04
Securidaca longepedunculata	Polygalaceae		2	0.03
Crossopteryx febrifuga	Rubiaceae		2,5	0.005
Gardenia ternifolia			1,2	0.03
Mitragyna inermis			2,4	0.01
Blighia sapida	Sapindaceae		1,2	0.02
Paullinia pinnata			2,4	0.04
Cola laurifolia	Sterculiaceae		2,5	0.03
Dombeya quinqueseta			2	0.01
Sterculia setigera			2,3	0.005
Corchorus olitorus	Tiliaceae		1	0.07
Grewia venusta			1	0.04
Mangifera indica	Anacardiaceae	II	1,2	0.36
Sclerocarya birrea			1,2	0.13
Annona senegalensis	Annonaceae		1,2,4,5	0.40
Calotropis procera	Asclepiadaceae		1,2	0.17
Vernonia spp.	Asteraceae		1,2	0.15
Balanites aegyptiaca	Balanitaceae		1,2	0.11
Anogeissus leiocarpa	Combretaceae		2,3,4,5	0.18
Combretum collinum	Leguminosae		1,2,5	0.14
Burkea Africana			1,2,3,4	0.16
Detarium microcarpum			1,2,3,4,5	0.37
Piliostigma thonningii			1,2,4,5	0.30

Pterocarpus erinaceus			1,2	0.13
Moringa oleifera	Moringaceae		1,2	0.18
Eucalyptus camaldulensis	Myrtaceae		2,4,5	0.19
Ximenia americana	Olacaceae		1,2	0.27
Pennisetum spp.	Poaceae		4	0.45
Gardenia erubescens	Rubiaceae		1,2	0.13
Sarcocephalus latifolius			1,2	0.11
Zanthoxylum zanthoxyloides	Rutaceae		1,2	0.30
Grewia flavescens	Tiliaceae		1	0.15
Cissus populnea	Vitaceae		1,2,4	0.15
Kaempheria spp.	Zingiberaceae		2	0.10
Lannea microcarpa	Anacardiaceae	III	1,2,4,5	2.42
Borassus aethiopum	Arecaceae		1,2,4,5	1.10
Adansonia digitata	Bombacaceae		1,2,3,4,5,6	7.18
Bombax costatum			1,2,4	0.55
Diospyros mespiliformis	Ebenaceae		1,2,3,4,5,6	1.51
Parkia biglobosa	Leguminosae		1,2,3,4,5	7.54
Tamarindus indica			1,2,3,4,5	2.77
Hibiscus asper	Malvaceae		1,2	2.23
Azadirachta indica	Meliaceae		1,2,4,5,6	0.65
Khaya senegalensis			2,4,5	1.61
Ficus sycomorus	Moraceae		1,2,4,5	0.93
Sesamum radiatum	Pedaliaceae		1,2	1.39
Vitellaria paradoxa	Sapotaceae		1,2,4,5,6	6.78
Melochia corchorifolia	Sterculiaceae		1,3,6	2.05
Vitex doniana	Verbenaceae		1,2,4,5,6	2.26

Food (1); Medicinal (2); Ceremony (3); Construction (4); Fire wood (5); Other (6). **I** = Low preference (index values from 0.005 to 0.097); **II** = Intermediate preference (index values from 0.1 to 0.449) and **III** = High preference (index values from 0.5 to 7.54).