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Non-Timber Forest Products: An Overview

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ABSTRACT

This article will present an overview of different approaches related to the use of non-timber forest products (NTFP), focusing on the ecological and social domain of their exploitation. We also discuss the role of ethnobotany in the study of these resources.

Keywords: biodiversity conservation, plant extractivism, plant population, rural development

CONTENTS

INTRODUCTION

This paper is not intend to be an in-depth theoretical and conceptual revision because it would be almost impossible to fully cover the debates related to the ecological, social, and economic spheres of the processes linked to the use of Non-timber Forest Products. In addition, there are articles which are already available on this topic. These articles, such as by Ticktin (2004), Shaanker *et al.* (2004), and Neumman and Hirsh (2000) already expose some of these aspects. Here we intend to discuss the Non-Timber Forest Products (NTFP) concept, the research methods and the ecological implications of the different biological organizational realms (the individual, population, and the community), as well as some of the social aspects of their use. We also propose to explain the importance of studies related to NTFP use that are not solely sustained by the conservationist discourse. We also want to debate how ethnobotany can contribute to these investigations. Finally, we will present a definition of the term "Non-Timber Forest Products" that encompasses all of the issues explained here. In our proposal, ethnobotany arises as an approach that can connect several of the domains related to NTFP (the ecological, cultural, and economic domains).

In this sense, an important aspect of people-plant interrelations that has been covered in recent ethnobotanical investigations is related to the use of plant resources. Since the over-exploitation of species is seen as one of the greatest causes of biodiversity loss, the number of studies on this theme is growing. Thus, discourse regarding conservation has become almost commonplace, and special attention has been given to a special group of resources known as NTFP. This attention has arisen due to special characteristics of this set of plants, such as their high monetary return by unit of area, the promotion of local development, and the potential conservation of biological richness (see, for example, Ticktin 2004). Consequently, for some authors, the use of NTFP is one of the "present-day conservation paradigms", especially because its exploitation is very similar to the proposals that seek to attain "sustainable development" (see Ticktin 2004). However, in this article, we wish to put into perspective the idea that automatically associates NTFP with conservation and sustainability.

THE CONCEPTS

"Non-timber forest products" (NTFP) is a highly disseminated term internationally and was initially used for a wide variety of differentiated forest products (**Fig. 1**). Presently, NTFP are defined as plant or animal products – that exclude wood (for different purposes) or firewood – coming from natural or managed plant formations. In a way, it can be said that the concept of NTFP was coined in order to group this set of resources that are supposedly not well-known ecologically, and to value the environmental products or services offered by tropical forest formations as an alternative to using wood or firewood (Vantomme 2001). Other terms are also used, yet they are not as clear and they are applied in a variety of situations – often permeated with value judgments – such as: "smaller products," "special

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Invited Review

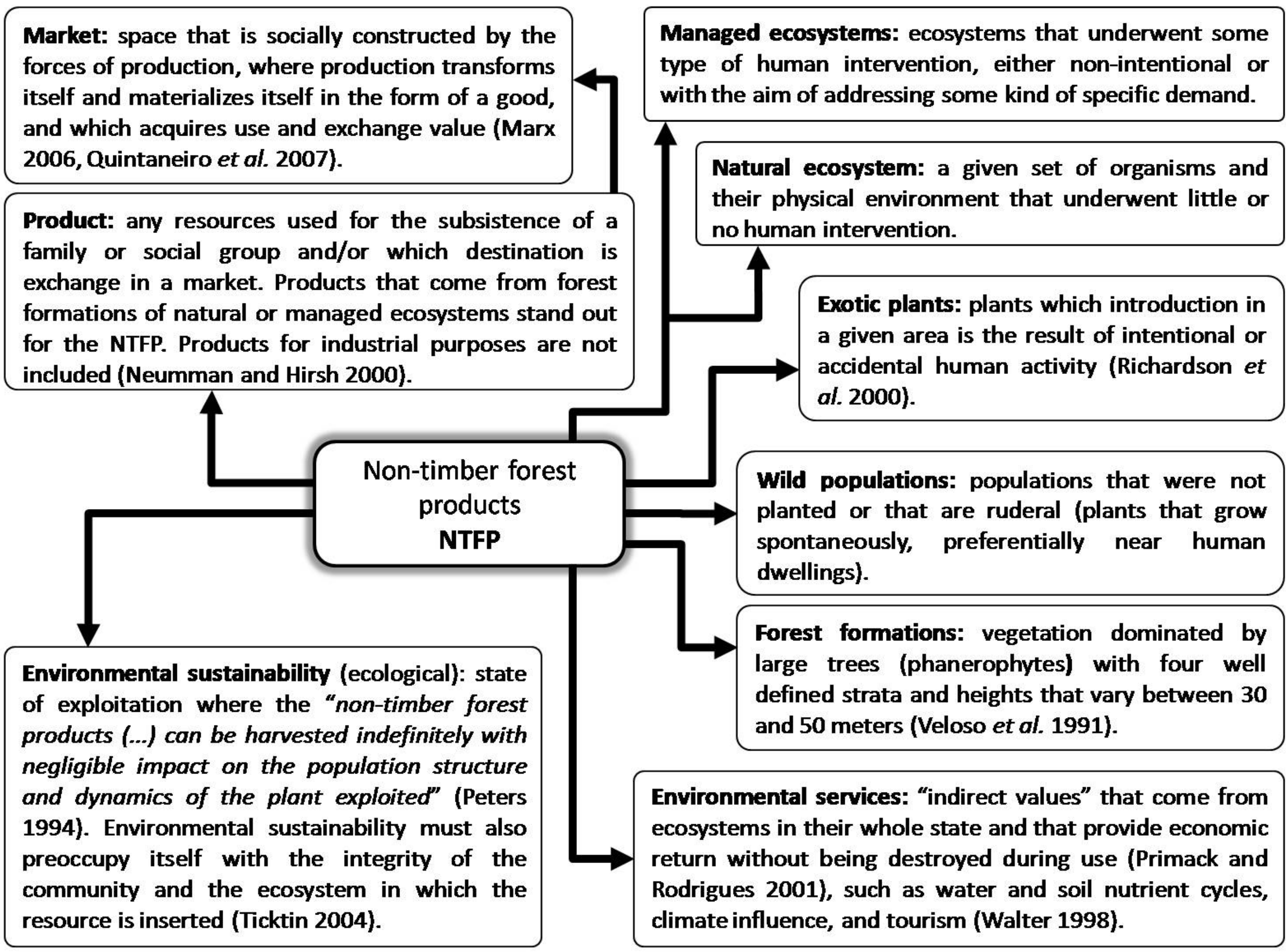

Fig. 1 Some key elements and their definitions associated with the concept of Non-Timber Forest Products.

products," and "secondary forest products" (Vantomme 2001).

Due to the high diversity and complexity of the NTFP and their definition, for Neumman and Hirsh (2000), they are "inexact and disturbing, as they are determined not by what they are, but by what they are not." Walter (1998) states that the definition used depends on the "question" that needs to be answered. However, "regardless of the term used, its scope and range should be elucidated very well." (Vantomme 2001). NTFP are characterized by their economic versatility, the variation in their final usage, the differences among the production basis, and resource richness (Santos *et al.* 2003). Some examples of NTFP are cashews, almonds, nuts, fruit, herbs, spices, colorings, oils, resins, fibers, barks, and aromatic, medicinal, and ornamental plants.

For Neumman and Hirsh (2000), in addition to the inherent diversification idea, NTFP stand out due to the supposition that the forest that is the source of the products will remain structured, and more or less unharmed. Thus, there is a widespread argument that comes with the NTFP concept: that their use is easier to manage and has less impact on plant communities than traditional forest exploitation (Ticktin 2004). Nevertheless, Peters (1994) argues that this statement is superficial and dangerous, and that there is no fixed, direct relationship between NTFP use and the sustainability of the plant extraction.

In addition to this practical conflict, there are some conceptual impasses to defining NTFP. Some authors, for example, do not recognize exotic plants as non-timber forest products because they believe that these are elements that are external to the system, meaning that they were not part of the original forest formation (Castellani 2002). Villalobos and Ocampo (1997) point out that an strong characteristic of the NTFP is their collection from wild populations of forest formations, which excludes products from highly modified landscapes such as pastures and plantations. Their argument is that the latter cases already fit into domestication processes. Thus, this idea associates the notion of "wildness" with the concept of NTFP (see Diegues 2000), which, in our view, is limiting.

Two other issues that deserve to be considered are the resources' origin solely from the forest formations, and the duality between the so-called "natural" and "managed" ecosystems. We prefer, in principle, to adopt Vantomme's (2001) definition because of its greater ability to encompass different ideas without identity loss. His definition is: "*any biological material (other than wood itself for industrial use and sawed wood by-products such as signs and panels) that can be extracted from natural ecosystems, managed plantations, etc., and that are used for subsistence or commercialization, or that have some type of social, cultural, or religious value*." We also consider environmental services as NTFP, even though they are not recognized as such in many studies (Walter 1998).

IMPORTANCE OF NON-TIMBER FOREST PRODUCTS (NTFP)

Almost all arguments that emphasize the importance of the use of NTFP are related to the biodiversity conservation discourse and/or to some proposal regarding sustainable development. This might be the result of the present global scenario, in which a biological crisis related to biodiversity loss is widely discussed in most domains (Layragues 1998).

The main argument is that NTFP perfectly fulfill proposals that integrate the conservation of biological richness and local development, especially in poor communities. The supposition is that communities and their members will conserve and protect forests and forest services if they re-

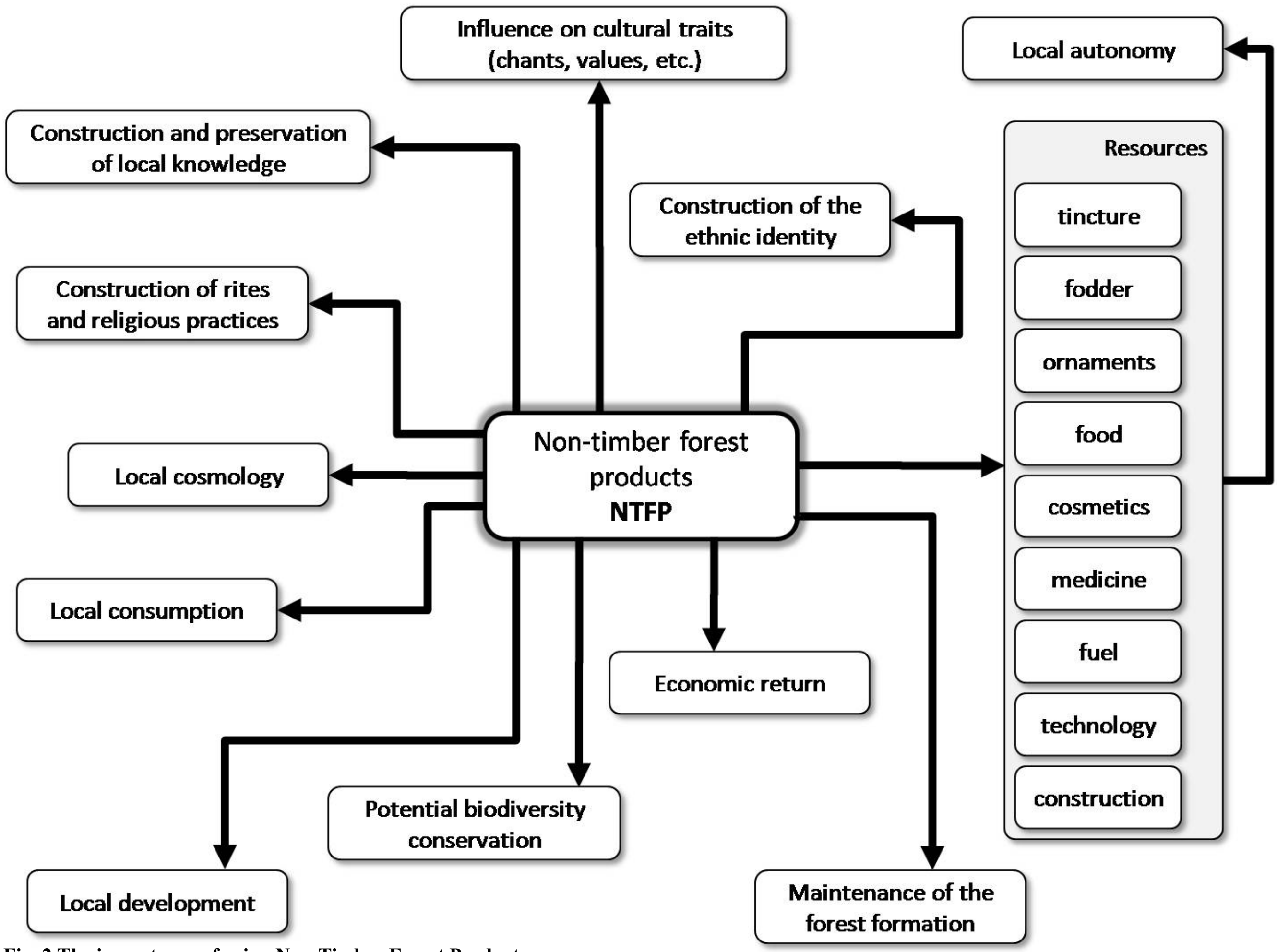

Fig. 2 The importance of using Non-Timber Forest Products.

ceive some sort of economic return (Lawrence *et al*. 1995; Neumman and Hirsh 2000). Some authors believe that immediatism is one of the most important reasons for devastation (Castellani 2002), and that the economic return from sustainable exploitation is the only alternative, or the only incentive capable of making local communities feel the need to conserve forest formations (Kremen *et al*. 1998; Ndangalasia *et al*. 2007). Another common argument is that the profitability of NTFP exploitation practices by unit of area is greater in the long-run than deforesting these areas or converting them into pastures or areas of cultivation (Neumman and Hirsh 2000). Nevertheless, it is important to take into consideration that the use of NTFP can be highly unsustainable if unorganized collection prevails and people do not respect the resources' ecology. The importance of a resource for a community – with or without economic incentives – is not an absolute guarantee for protection and/or conservation of the forest's resources. The local value systems, knowledge, and beliefs that are associated with these resources must also be considered.

Based on the high rate of deforestation in the tropics and the need for solutions that integrate conservation and local development, many conservationists present extractivist reserves (Pinedo-Vasquez *et al*. 1990) and integrated conservation and development programs (Kremen *et al*. 1998) as ways to reconcile forest use and preservation. However, Lawrence *et al*. (1995), while evaluating the possibility of installing extractivist reserves based on local NTFP exploration patterns, concluded that these alternatives are not viable. These authors found that the managed areas that are the source of NTFP allow for a greater quantity of collected resources, and that – despite their importance for local subsistence – resources that come from primary formations are not sold. In other words, the central problem is that the managed forests and buffer zones are more valuable than the primary forests. Since the argument for extractivist reserves is based on economic incentives for preservation, there are no incentives for the conservation of primary physiognomies. Lastly, there is a lot of pressure to convert forests into managed zones. This shows that, in the tropics, the relationship between local communities and protected areas is uncertain (Lawrence *et al*. 1995).

Studies related to NTFP are not only justified by a conservationist perspective (**Fig. 2**). The wild plants collected are the sources of medicine, food, fodder, and even economic incomes, especially for the poorest populations. NTFP significantly contribute to the maintenance and autonomy of local populations throughout the world (Godoy and Bawa 1993; Santos *et al*. 2003). According to Ndangalasia *et al*. (2007), most products that sustain the daily activities of these communities are NTFP. In-depth studies about the role of NTFP in constructing the autonomy of local communities – food and medical autonomy, for example – are essential in order to designate strategies and public policies for local development.

Nevertheless, in some social realities, most of this knowledge – which guarantees a certain autonomy to social groups and contributes to the construction of cultural identity – is threatened due to contact with the dominant occidental society (Diegues 2002). For example, Estomba *et al*. (2006) document that the traditional knowledge of the Mapuche from Argentina, which is strongly rooted in their culture, is threatened because of complications in the transmission of knowledge to future generations. Soldati (2005) recorded that the destruction of some traditional values, in this case pressured by environmental legislation, negatively affects the transmission of knowledge to future generations. In this sense, studies about the use of NTFP by local communities are justified but also by the argument of biodiversity conservation. Thus, these investigations are important from an ethical standpoint that recognizes the role of the NTFP and respects and legitimizes the way of life of these societies.

In some social realities, the non-timber forest products are fundamental in more specific cultural processes, such as identity construction, the strengthening of social memory, food, and spiritual practices (**Fig. 2**). In these situations, the NTFP carry out such important roles in the cohesion and maintenance of certain societies throughout the world that their absence would strongly modify the group's characteristics and "cultural resilience" (Garibaldi and Turner 2004; Albuquerque and Oliveira 2007). Without any doubt, this is the case of the "*jurema*" plant (*Mimosa tenuiflora* (Willd.) Poir.) for some indigenous groups of the Brazilian northeast (Souza *et al*. 2008).

The Atikum-Umã is an example of the above mentioned. They are one of the seven indigenous ethnicities legally recognized in the state of Pernambuco (NE Brazil), which has some of the cultural traits that are highly connected to the use of local plants, such as the *jurema*. According to Grünewald (2004), the *jurema*, which is used in secret rituals, is one of the traditions of the Atikum. It is a distinctive mark in relation to the dominant society. The *jurema* is sung in verses that strengthen the group's identity and is still used to explain the differences in phenotype inside the group. Three types are recognized: "black *jurema*", "red *jurema*" and "white *jurema.*" In addition to the *toré* (a sacred dance), all of these characteristics (which are essentially related to the use of a NTFP) are seen as diacritical signs to establish the Atikum ethnicity. This became a political instrument to guarantee access to a basic resource – land – and has promoted this indigenous group's perpetuation.

Based on the understanding of the different roles that the NTFP carry out for social groups and practices related to their use, numerous opportunities appear regarding our relationship with natural resources. This kind of knowledge has the potential of promoting thoughts such as: what values rule our relationship with nature? Lastly, we need to understand that all knowledge systems are valid (not only the scientific system) (Albuquerque and Andrade 2002). Investigations on NTFP can show us other ways of dealing with the world, including different cultures. As Estomba *et al*. (2006) note, the use of natural resources is intimately tied to a group's culture and reflects its perceptions and beliefs. In this sense, studying this special group of resources elucidates specific processes, such as plant domestication. This strongly contributes to a better understanding of the historical construction of our own society, especially regarding its relationship with plants.

ECOLOGICAL IMPLICATIONS OF "NTFP" USE

Sustainable extraction requires planning and monitoring (Dzerefos and Witkowski 2001). The lack of reliable information about species, that are seen as resources, such as their productivity and state of conservation, complicates the progress of planning and management, and also complicates the delineation of conservation priorities, and the definition of exploration rates. In this way, scientific studies can contribute substantially to the search for sustainable alternatives (Dzerefos and Witkowski 2001), especially in the case of NTFP.

Sustainable extraction can be understood in the following way: "*in ecological terms, extraction is considered sustainable if it doesn't imply any long term deleterious effects in the reproduction and regeneration of the population targeted when compared to an equivalent, unexploited population. In addition, sustainable exploitation must not have adverse effects on the community's other species or on the ecosystem's structure and function*" (Hall and Bawa 1993). It is thus necessary that the rate of exploitation is smaller than the resource's regeneration rate and that the production of any type of residues is compatible with the system's assimilation capacity. Therefore, it is necessary to construct methods that are able of safely evaluating and validating these processes.

Rigorous evaluations of the sustainability of extractivist practices depend on the community's floristic composition (Peters 1994), the knowledge of the resource's ecological characteristics (such as life history, reproduction rate, recruitment, growth, density, and production) (Lawrence *et al*. 1995), and on external characteristics such as the utilization risk, nature, and intensity of harvesting (Peters 1994; Dzerefos and Witkowski 2001). Gaoue and Ticktin (2007) state that other characteristics, such as the multiple use of species and space and time variations, can also influence collection patterns and their impacts. This is especially important in contexts with anthropic or natural disturbances, such as fire and tree plantations. For example, from a cultural and economic point of view, NTFP from the *caatinga* (plant ecosystem of the NE Brazil) are very valuable to the communities that inhabit this region (Araújo *et al*. 2007). So have noticed that the NTFP of this region have multiple uses and include a very diverse number of extractivist options (timber or non-timber) and collection events (see Lucena *et al*. 2007a, 2007b; Albuquerque and Oliveira 2007; Lucena *et al*. 2008).

Thus, as Gaoue and Ticktin (2007) argue, there is a need to understand as much as possible about local collection patterns and what variables influence extraction behavior (or foraging, in ecological terms). Oliveira *et al*. (2007) note that the medicinal plants explored by the rural community are also used for other purposes. The plant species' multiple uses are widespread, yet a limited approach could uncharacterize the total impacts, since they can be much greater when combined with the extraction events (Gaoue and Ticktin 2007).

However, some inherent characteristics of plant communities can make it more difficult to evaluate and establish the sustainable extraction of NTFP. These characteristics are: 1) high diversity and low population density; 2) irregular flowering and fruiting events; 3) high importance and dependence on pollinators and dispersion agents; 4) high mortality levels and low levels of recruitment in the initial phases of the life cycle; and 5) the population's sensitivity to natural changes and disturbances (Peters 1994). The fact is that few studies combine all of the information necessary to safely and sustainably evaluate the use of these resources.

The practices' evaluation methods and the proposals of management alternatives must be as close as possible to the reality of the geographical area where the harvesting is happening. The approach must consider the different extraction dimensions, including the effects of the economic market. Being close to the market, which includes greater ease throughout the production cycle, is interpreted as a factor that increases resource extraction, worsening the damage caused to populations and natural systems (Clement 2006). Uniyal *et al*. (2002) state that the restructuring of the medicinal plant market in India placed additional pressure on forests, where 90% of the plants used in the medicine industry are extracted from wild populations. Dzerefos and Witkowski (2001) recorded a similar situation in South Africa, where the great demand for medicinal plants in local and regional markets unstructured traditional exploitation practices, which were based on greater knowledge of the resources' ecology. In this sense, by analyzing the indigenous populations of the Brazilian Amazon, Albert (2000) argues that the ways of obtaining resources depend on the "variety of social-political options offered for its communication with the so-called 'involving society' (in its regional, national, and international branches)."

METHODOLOGIES USED IN THE STUDIES OF "NTFP" USE

Direct evaluations

Peters (1994) argues that extraction impact depends on the type of plant or tissue explored and presents a classification that is based on the resources' ecological characteristics: 1) fruit and seeds; 2) gums, latex, and resins; and 3) plant parts (e.g. stems, leaves, bulbs, and bark). Nevertheless, also needs to be associated with a categorization of resource "use". Santos *et al*. (2003) compiled different NTFP category systems – most of them in a utilitarian perspective – and argue that selecting a system that comes closest to the reality that is going to be investigated is the beginning of good data collection. The following categories stand out: food, medicine, ornaments, chemical products (resins and oils), fodder, fuel, and structural products (fibers and bamboos). Some classifications encompass the services offered by the forest formations, such as climate regulation, water conservation, soil protection, and recreation.

One of the most important and most often used tools in studies related to extraction is the evaluation of the resource's population structure, meaning, the distribution of a population's individuals in age classes or phases of the life cycle. Harvesting any type of NTFP can produce some kind of measurable response on the collected species' population structure and dynamics. However, this will strongly depend on local usage strategies for the plant that is exploited, as well as on the extraction events. According to Peters (1994), diametric distribution (or age-size distribution) can substitute some long and costly procedures (such as field monitoring over long periods of time) when the aim is to evaluate population sustainability. Distribution into diametric classes furnished information such as recruitment rates, including how many individuals are being included into the population. The higher this rate is, the higher the possibility of the population's survival.

According to Hall and Bawa (1993), evaluating the resource's distribution, abundance, and population structure allows for the identification of preferred habitats for a given species and for the verification of diametric classes that are underrepresented, which suggests that these life stages either respond differently in each habitat or undergo different extraction intensities. The authors argue that if the resource shows restricted distribution in any estimate, including biomass, density, and so forth, it cannot be extrapolated for the entire area unless all of the area coincides with the specific habitat. In these cases, greater sampling efforts would guarantee better estimates for population attributes. Monitoring is an essential activity because what is recorded for populations today can be the result of different factors linked directly to extractive processes.

Fig. 3 presents four idealized diametric distributions, constructed based on three phases: plantules, juveniles, and reproductive adults. According to Hall and Bawa (1993), distribution two characterizes a population where all of the classes are represented. The distribution decreases exponentially, showing the existence of more young individuals in relation to adults. This distribution, also known as the "inverted J," is commonly found in natural stable populations that are capable of auto-regenerating. Line four shows the absence of adults in the population and, consequently, few plantules. If any recruitment occurs at all, it is possible that this population will develop and result in distribution three. According to Peters (1994), line four represents viable populations, in which recruitment events are sporadic and irregular, which in turn generates density peaks. Distribution One reflects a population in which the individuals are almost all the same size and that, for some reason, have limited regeneration rates.

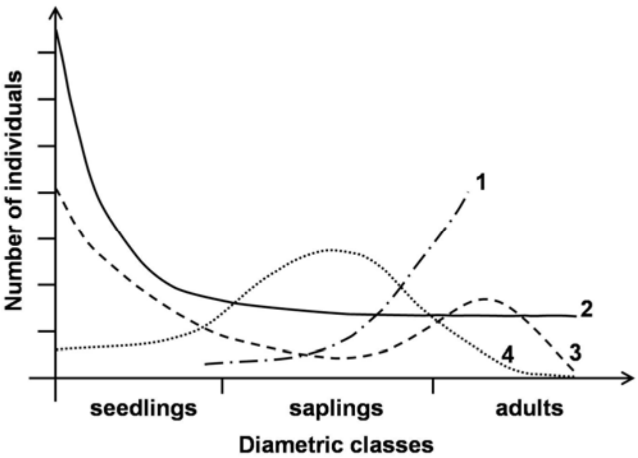

Fig. 3 Hypothetical examples of four diametric distributions in plant populations. Curve 1 indicates a population whit limited regeneration rates; curve 2 corresponds to a population with all size class represented, whit an exponential decline in size class; curve 3 corresponds to a population whit low representation in more than one size class; curve 4 indicates a lack of individuals in the reproductive phase. Modified from Hall and Bawa (1993).

Since populations present specific time and space scales, in an attempt to reduce wrong extrapolations from population evaluations, Hall and Bawa (1993) state that only direct comparisons between harvested and non-harvested populations provide robust data on extraction impacts. However, this kind of comparison is not always possible, especially in highly modified landscapes, or when the region's history is not known.

After data collection, the population's diametric structure can be adjusted by an equation ($LnY = b_0 + b_1X$) to the "inverted J" model (negative exponential) in order to determine whether the population is viable, meaning that extraction is sustainable. The same regression can define collection rates or specific types of management for the different diametric classes (Filho and Felfili 2003). Peters (1994), in an attempt to construct a methodological guide for NTFP studies, presents a way of constructing management practices from a sustainable standpoint that can be used for dif-

Table 1 Methodology proposed for the sustainable monitoring and management of NTFP in different social realities, modified from Peters (1994).

Step	Characterization
1 Species selection	This is based on essentially social and economic characters, without discarding ecological considerations related to the possibility of sustainable extraction. The following ecological factors are important to observe: phenology, pollination, and dispersion processes, the type of resource offered and its abundance, and diametric distribution.
2 Forest inventory	Given the importance of diametric distribution, forest inventories are necessary in order to access the availability of the resource offered for harvesting.
3 Studies of resource production	Production estimate for the resource in its different size classes or phases of the life cycle. The most viable way to estimate production is to train local collectors to measure, weigh, and count the amount of the resources offered in different situations.
4 Study of species regeneration	This is based on the regular measurement and fluctuation of the initial seedlings and saplings density within the populations being harvested. This data is crossed with the information on population structure in order to provide a more complete scenario. Carrying out this step at five-year intervals is ideal for most species.
5 Evaluation of the rate of exploitation	Visual evaluations of the responses offered by the individuals harvested, such as problems regarding production, regeneration, defense, or growth.
6 Adjusting the extraction to the resource's reality	The previous information sustains the ideal of extraction adjustment. Possibilities are the regulation of the number or size of the individuals subject to harvesting and active management with enrichment or improvement.

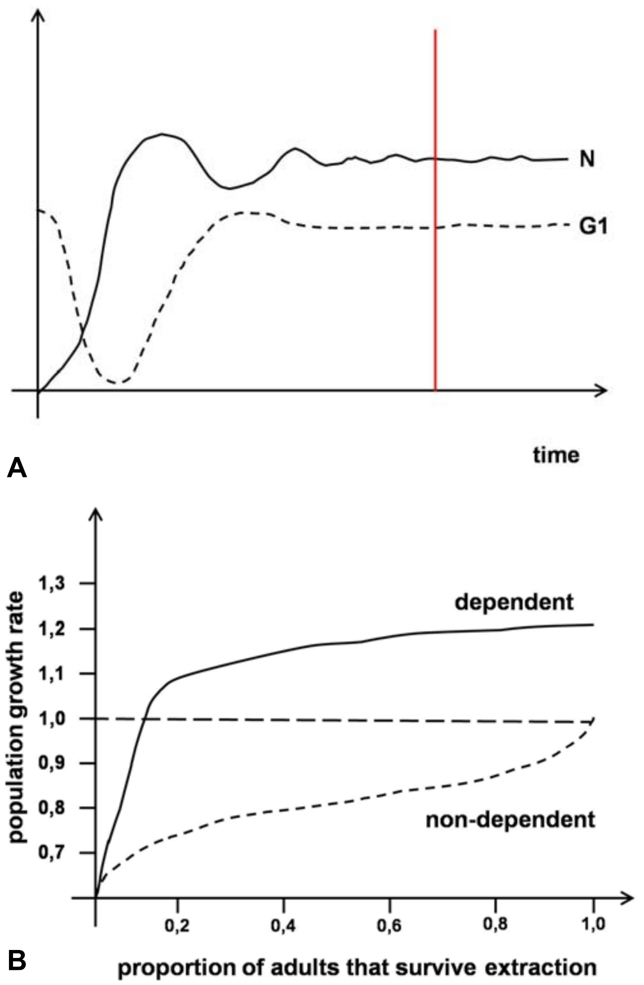

Fig. 4 (**A**) Population size (full line) and logarithm of the probability of recruitment from phase 1 to phase 2 (P_{1-2}) (dotted line) in relation to time in a density-dependent population. The red line indicates the moment when the population gets stable. (**B**) Projection of the population growth rate when density dependence is admitted (solid line) and when density dependence is not considered (dotted line). Modified from Freckleton *et al*. (2003).

ferent realities. The six steps suggested are presented in **Table 1**.

An extremely useful method to evaluate the rate of exploitation of stem barks of medicinal plants, for example, can be found in Cunningham (1993). The author presents seven categories of extraction based on the percentage of bark removed up to two meters high. The greater the amount of bark removed, the more points it will receive, according to the following reasoning: zero when there is no damage; one when the damage is over 10%; two when there is between 10-25% removal; three for 26-50%; four for 51-75%; five for ringbarked; and six when all of the bark as been removed. This method is also useful to test hypotheses related to usage patterns and the extraction of natural resources by different social groups.

One of the most commonly used methods to estimate the long-term impacts of extraction are population models, especially those of the "population matrix" (Boot and Gullison 1995). The basic parameters for the construction of these models are the initial abundance, recruitment probability, and the rates of birth, death, and fecundity. They have the advantage of allowing extraction modeling to consider different variables and view distinct situations such as: the dependence on density, extraction practices, and management systems. According to Freckleton *et al*. (2003), most models used in the approaches related to the NTFP assume that: 1) the population parameters do not vary with time or density; 2) the individuals are independent from their past; and 3) the variables are subject to measuring at a discreet moment in time. However, these assumptions may not fit into the reality of the populations'dynamics and they may offer wrong predictions, since a population's dynamics may be influenced by some variables that are different from the model's assumptions, or that are not taken into consideration, such as dependence on density, competition, lateness, spatial variations, etc. (Gotelli 2007).

Freckleton *et al*. (2003) evaluate the importance of considering less computed variables in population models, such as dependence on density and the time for measuring population parameters (**Fig. 4**). **Fig. 4A** represents a hypothetical population whose dynamics are density-dependent, meaning that the population's per capita birth rate decreases as the population grows, especially due to intra-specific competetion (Ricklefs 2003; Gotelli 2007). In this population, the probability of recruitment between phases one and two of the life cycle (P_{1-2}) was measured when the population was at its equilibrium (red line). A model that wrongly assumes that P_{1-2} is static (not density-dependent) differs considerably from an appropriate model (**Fig. 4B**). According to the same author, small rates of extraction in this situation (the graph represented by the proportion of adults that survive extraction) could be unsustainable. In the dependent model, (**Fig. 4B**, solid line) the population can stand higher rates of exploitation and will only start to decline (growth rate smaller than one) when the adults' survival is less than 0.2. As a result of modeling for *palmito*, Freckleton *et al*. (2003) argue that taking density dependence into consideration is essential for more realistic measures to be carried out, especially regarding sustainable harvesting quotas. Lastly, these authors speculate that many models that have already been created can be used to infer population growth behaviors under an extraction regime, since most report growth rates are close to 1.0 because density dependence is not considered.

Indirect evaluations

An alternative approach to access extraction and/or usage pressure on forest resources that has been applied in some studies (e.g. Lawrence *et al*. 1995; Kremen *et al*. 1998; Dzerefos and Witkowski 2001) is the use of interviews with the collectors themselves or with community members who interact directly with the resources. The basic premise of this approach is the existence of a relationship between to what extent a plant is known (or the richness of its use) and its usage pressure and the establishment of conservation priorities. This must be seriously put into perspective, since what people cite is not always what is really harvested (Albuquerque *et al*. 2006). Additionally, among the set of species that is locally harvested for the same purpose, there might be a sub-set of preferred species that may inevitably concentrate more collection events (Albuquerque and Oliveira 2007).

From a quantitative perspective, Prance *et al*. (1987) state that the proportion of useful species in a given locality can be used as an indicator of which plants must be a conservation priority. The most preferred species are the focus of this kind of attention. Lawrence *et al*. (1995), however, oppose this method and argue that it is limiting to use only the number of potentially useful species at a locality as indicative of the conservation priorities, since species abundance and distribution (variables that must be taken into consideration) may vary enormously from one place to another. Thus, it is necessary to include quantitative measurements of each resource's availability (Peters 1994). Connecting data on the species' percentage and their availability and distribution makes it possible to compare different areas' extraction potentials and shows the importance of quantitative approaches in the description of extractivist practices (Lawrence *et al*. 1995).

The priority identification method presented by Prance *et al*. (1987) is based on the existence of a direct relationship between a plant species' "local importance" and the use pressure to which it is submitted. Other proposals sus-

Table 2 Variables used to calculate conservation priorities and their possible scores, according to Oliveira *et al.* (2007).

Criteria	Scores
A. Area's relative density (D)	
Not recorded – very low (0-1).	10
Low (1< 3.5).	7
Medium (3.5 < 7).	4
High (≥ 7).	1
B. Collection risk (H)	
Plant's destructive collection or over-exploitation of its roots or bark. Collection represents the removal of the individual.	10
Collection of perennial structures such as bark and roots, and of part of the stem for latex extraction, without causing the individual's death.	7
Collection of permanent aerial structures such as leaves, which can affect the plant's long-term energetic investment, survival, and reproductive success.	4
Collection of transitory aerial structures such as flowers and fruit. The population's regeneration might be altered in the long-run due to collections from its seed bank, but the individual itself is not affected.	1
C. Local importance (L)	
High (listed by >20% of the local collaborators).	10
Moderately high (10 ≤ 20% of the local collaborators).	7
Moderately low (<10% of the local collaborators).	4
D. Use diversity (V)	
One point is added for each use.	1-∞

tain themselves under the same rationale and only differ in the manner in which they determine local importance (Kremen *et al.* 1998). Nevertheless, some considerations must be made about this assumption. Firstly, few studies have tested and shown a clear relationship between a resource's "local importance" and its use pressure (see Albuquerque and Lucena 2005). For example, Oliveira *et al.* (2007) have found a positive relationship between a plant's extraction signals and the number of citations that this resource received during the interviews, which is one of the measurements used to calculate "relative importance." In this case, the extent to which a plant is known by a given community can be used as an indication of use pressure. However, this relationship must not be extrapolated to other social and cultural realities due to each region's cultural and ecological specificities.

Secondly, in an attempt to explain two quantitative techniques used to determine plants' "relative importance," Albuquerque *et al.* (2006) presented some conclusions with strong implications. The authors show that these two techniques do not distinguish a social group's knowledge about a resource from its present use. The techniques analyzed – which are widely used – are related to the potential utility of a plant (i.e., the "local knowledge" related to the resource), not with the resource use itself. Thus, they must not be applied as use pressure measurements (Albuquerque *et al.* 2006). Albuquerque (2006) deepens this discussion of the "discrepancy" between knowledge and use, showing that there are different levels of knowledge around a resource. According to this author, "there is a diversity of plants known as useful in a given culture, including those that are not used frequently." There is also another set of plants that leave this "theoretical" field for a "practical dimension" and are in fact used.

Delineating a group of plants with high utilization potential and multiple uses based on "local importance," for conservation priorities, can result in an ecological error. Species present different distribution and abundance patterns inside a plant community. Thus, some resources might be rare because of their high habitat specificity or because they are from a low-density population, and will consequently have high chances of local extinction (Uniyal *et al.* 2002; Kala 2005). Nevertheless, these highly susceptible resources do not necessarily have high local importance (as it is normally measured). In this case, they would not be considered and would not receive privileged attention, even with a high risk of extinction.

Following the trend of conciliating many variables in biodiversity management and conservation decision-making, such as local culture and each region's specific characteristics (ecological aspects), Oliveira *et al.* (2007) adapted an index from Dzerefos and Witkowski (2001) to propose an identification method for plants that are local conservation priorities. The index suggested, which was initially for medicinal plants, includes the following items in its calculation: 1) a biological component, called the "biological score" (BS), which is defined by the resource's relative density (measured from its availability in the environment); and 2) a cultural component, called the "use risk" (UR), which aggregates aspects such as the potential collection impact, local importance of the resource, and use diversity. The formula proposed is shown below, and the scores of each variable are presented in **Table 2**: CP= (0.5 x BS)+(0.5 x UR), where: BS= D x 10; UR= (0.5 x H)+(0.5 x U); and U is the selection of the greatest value between local importance (L) and use diversity (V).

Nevertheless, the index proposed can have some limitations, as it can considerably value the biological score (species density) at the loss of use risk. In other words, the final list of conservation priorities may privilege low-density species, making culturally important and highly-demanded species stand out less. Thus, this index must be modified in order to better understand local realities in some situations, reducing the weight of resource density in the priority calculations.

Calculating these scores allows for the plants' classification into risk categories: 1) high conservation priority with values higher than or equal to 85; 2) specific collection following pre-determined quotas with values between 60 and 84; 3) not priority with values lower than 59 (Dzerefos and Witkowski 2001). Uniyal *et al.* (2002) present another resource classification proposal according to their conservation state, yet they do not use a real index. The authors base themselves on ecological characters and use pressure to classify the plants (**Table 3**).

Lastly, the success of any method must be constantly monitored. Kremen *et al.* (1998) state that there are no appropriate monitoring methods and propose the use of some

Table 3 Conservation categories, their description, and suggestions for action according to Uniyal *et al.* (2002).

Category	Description	Suggestions for action
Restricted and high-pressured distribution (RHPD)	Representative populations in their specific habitats, but they undergo high exploitation pressures	Specific conservation areas must be installed and any exploitation of these areas must be banned
Restricted and low-pressured distribution (RLPD)	Restricted distribution, but with low demand from local communities	Use schemes with time and space rotation must be delineated by the local communities themselves
Restricted location and low-pressure (RLLP)	Species are found in one or two locations, but extraction is very limited	More specific studies must be carried out to better understand their distribution and conservation state
Restricted distribution in highly disturbed and pressured areas (RDHDPA)	Resources have restricted distribution, undergo intense exploitation, and are located in disturbed areas such as pastures	-
Wide distribution and high-pressure (WDHP)	Widely distributed and intensely exploited	-
Under cultivation and low-pressure (UCLP)	Species that are being cultivated and that undergo low use pressure	-

plants that are selected based on their biological and cultural characteristics as success indicators for the conservationist practices adopted. The argument is that such plants provide information on ecological (given that human use has considerable impact on wild populations) and social aspects (as these resources contribute greatly to local income) when used as indicators in proposals that are part of local development and conservation, as in the case of the integrated conservation and development plans (ICDP).

ECOLOGICAL IMPACTS OF NTFP EXTRACTION

As in any biological system process, NTFP extraction also brings about ecological effects. According to Ndangalasia *et al*. (2007), although the use of the parts extracted differ among resources, their exploration has some positive and negative impacts on the species. These impacts depend on internal characteristics at the approach level, which includes the species, population, community, ecosystem, and the landscape and also the resilience, elasticity, reproduction rate, mortality, vitality, life form, and the type of growth. In addition, harvesting impacts are intimately linked to external factors, such as the exploitation rate, frequency, and period of collection.

Gaoue and Ticktin (2007) state that the first direct consequences of harvesting are changes in the individual's recruitment, survival, growth, and reproduction rates. These changes consequently affect population structure and dynamics (Ticktin 2004). The ability to recognize, access, and even model extraction impacts depends on understanding the dynamics of how the different spheres of biodiversity organization function – from genes to ecosystems – as extraction potentially affects all of these levels (Hall and Bawa 1993).

The extraction of plant parts has two possible impacts at the individual level: the death of the plant or the regeneration of the organ that was harvested (Peters 1994). For the latter situation, energy relocation is needed for investment in reproduction, as in the case of stem bark use. Due to this kind of relocation, one of the possible individual responses to extraction is the reduction in the growth rate and fruit and seed production, which influences growth rate and population recruitment (Hall and Bawa 1993). Individual impacts depend on which part is harvested, or, more specifically, its amount of nutrients, photosynthesis ability, and regeneration potential (Ticktin 2004).

One of the most important and widely used resources are perennial structures such as barks and roots, especially in semi-arid environments (see Albuquerque 2006; Estomba *et al*. 2006; Oliveira *et al*. 2007). Purohit *et al*. (2001) evaluated the impact of stem bark extraction from a tree traditionally used for tea and verified that the depth and total area extracted influence the species' survival rate. The study made it possible to verify that removing the bark from the stem's entire circumference (ringbark) also affects survival, including growth rates. In some cases, this even causes the individual's death (Gaoue and Ticktin 2007). Finally, Purohit *et al*. (2001) point out an ideal depth for collection so that the effects of extraction are minimal. At first, herbaceous plants tend to tolerate higher rates of extraction given their higher rates of reproduction and growth (Ticktin 2004). Based on the tropics' greater productivity, Ghimire *et al*. (2005) support the hypothesis that plants from these regions have the greatest extraction potential. However, this hypothesis has not been tested yet. In addition, even in the tropics, species' regeneration behavior must be taken into consideration for different ecosystems. Peters (1994) states that extraction – especially of fruit – reduces food availability and alters the composition of the entire fauna. Plant-plant interactions influence community structure, by reducing the harvested species' competitive ability, for example.

Most studies focus on the impacts at the population level, probably because: 1) it is easier to study only one species and 2) there are many robust theories and tools related to the study of populations based on the understanding of communities and ecosystems (Hall and Bawa 1993). Additionally, in principle, the sustainability concept itself focuses on populations, which must support the entire extraction practice (Ticktin 2004). Ndangalasia *et al*. (2007) documented that NTFP density commonly extracted in eastern Africa varies considerably and can be almost five times greater in unaltered areas when compared to exploited areas. Significant differences were found for diametric distribution, even in areas where the practice is banned. The authors justify these differences by over-exploitation, the way extraction is carried out, and the restricted distribution of some resources.

In Benin, Africa, the intense harvesting of barks and leaves causes significant reductions in the density of plantules and juveniles (Gaoue and Ticktin 2007). However, some variations in the density of the resources that were exploited were not related to the extractivist practices, but rather, to different disturbances. For this location, soil type, the presence of parasites, the kind of habitat, and anthropic disturbances are significantly more influential on the harvested species' density than the extraction activity itself. Gaoue and Ticktin (2007) also verified that the extraction's intensity determined the resource's population structure.

CULTURAL AND SOCIAL ASPECTS LINKED TO "NTFP" USE

The impacts of NTFP extraction are highly dependent on the resources' local collection pattern (Ticktin *et al*. 2002). Understanding these patterns, their related variables, and how they behave is important for developing management and conservation plans (Gaoue and Ticktin 2007).

Freckleton *et al*. (2003) compared the impact on the *palmito* population (*Euterpe edulis* Mart.) associated with different forms of extraction, which were: 1) extraction before and after the reproductive period; and 2) extraction with a constant rate of plants (regardless of population density) versus extraction that goes up to a limit that is always constant. They verified that both the timing and the method of extraction alter the population's response.

In a case study on bark extraction by traditional communities, Purohit *et al*. (2001) verified that the number of people in a family influences the amount harvested, which is greater in larger families. The same authors analyzed the influence of purchasing power in collection patterns and found that poorer families depended on collection throughout the year, which does not happen among families who are seen as rich. However, the way extraction is carried out is the same for families of different sizes and levels of purchasing power.

Lawrence *et al*. (1995) aimed to study how the density and abundance of different resources in primary and managed forest formations influenced local collection patterns. Summarizing, the authors show that the three NTFP that were studied are considerably denser in the managed physiognomies – located near the community – than their analogous species in the primary areas. As a result, local collectors extract a lot more resources in the modified areas. The authors conclude that the time for transportation and searching, the better quality, and the greater resource availability (as well as transportation difficulties for collection in the further, primary regions) are the variables that determine the preferential harvesting of the managed resources.

The Fulani, an indigenous group from Sudan who traditionally extract the bark of *Khaya senegalensis* (Ders.) A. Juss., prefer to collect from medium sized and large trees. They show a pattern related to the resource's size (Gaoue and Ticktin 2007). Another local pattern identified is related to leaf extraction, a resource that is also harvested. Most individuals are either not harvested or their leaves are completely removed. According to the authors, climbing the trunk is an extremely dangerous activity that requires a lot of experience. Thus, the Fulani extract the most from each tree in order to maximize the amount of leaves that are collected (Gaoue and Ticktin 2007).

While studying a rural community in the *agreste* region of the state of Pernambuco, Brazil, Oliveira *et al.* (2007) concluded that the extraction of medicinal plants is influenced by total abundance (an availability measurement) and by the number of known species cited. Yet, there is no relationship between the number of informants that cite a given plant and the species' distribution pattern. These results suggest that, for the location studied: 1) the availability of the resource influences collection; 2) use pressure does not depend on how much a species is known, but on the richness of its uses, meaning that even a plant that is not cited a lot can have high rates of extraction; and 3) since extraction does not depend on resource distribution, there is a variable that influences collection, such as the resource's quality, for example.

The examples cited above agree with Ladio and Lozada (2004) when they state that use patterns are strongly influenced by the resources' ecological characteristics, such as distribution, distance, and conservation state. These studies also bring forth predictions from some ecological models and hypotheses used to understand human behaviors, such as the "ecological apparency" hypothesis (see Albuquerque and Lucena 2005) and the "Optimal Foraging" model (see MacArthur and Pianka 1966; Pyke *et al.* 1977; Begossi and Richerson 1992; Begossi *et al.* 2005).

Many of the studies cited above show the exploitation of resources from formations that are not necessarily "forests," and the importance of this kind of practice for local communities (see also Purohit *et al.* 2001; Uniyal *et al.* 2002; Ghimire *et al.* 2005; Kala 2005; Schmidt *et al.* 2006). Thus, the phenomenon of non-timber resource use is common to a great diversity of plant formations throughout the world, and shows that there is a widespread, global relationship between humans and highly diverse ecosystems. Additionally, we say that this relationship is, in fact, interdependent, in which the biological and cultural systems are constructed jointly and result in "socio-biodiversity." This phenomenon was mentioned by Posey (1987), when showing that many rich environments in the Amazon that are seen as "natural" are the result of indigenous intervention. In this sense, the same author categorically states that "explicit demarcations between natural and re-managed ecosystems cannot be established.

Finally, many studies have shown that local populations use a considerable richness of exotic plants, and that the role of this diversity is extremely important for subsistence activities (see Bennett and Prance 2000). Estomba *et al.* (2006), when studying the traditional communities of Patagonia, Argentina, verified that the richness of native species used as medicinal plants does not differ from the richness of exotic species. The justification presented is the existence of a process of erosion of the local knowledge. Albuquerque (2006) found similar results for the rural location of the *caatinga*, with no differences between the proportion of native and exotic floras that are known and used. Nevertheless, this author does not see the strong presence of exotic plants in the set of resources as evidence for knowledge loss or erosion, as opposed to other studies. Albuquerque (2006) brings forth the hypothesis that this is the result of a diversification process, opposing the passive notion of culture in which knowledge erosion and acculturation are presented as an explanation for the process. According to this author, including exotic species can be a kind of "flexibilization," an active cultural "strategy" to diversify the set of plants used by adding new elements and allowing for a greater set of useful resources.

THE ROLE OF ETHNOBOTANY

As we have tried to show, the issues related to NTFP studies (concepts, method, etc.) are undergoing a continuous maturation process that can receive valuable collaborations from ethnobotany. Given their essentially multidisciplinary nature in the search for a better comprehension of the different people-plant relationship domains, we understand that ethnobotany has a great potential to contribute to several of the aspects debated in this article.

Presently, ethnobotany contributes substantially to the conservation of biodiversity and local knowledge, investigation of possible collection patterns, management practices that are more adapted to local specificities, and resources' local importance and social role. These investigations certainly allow for a better understanding of the impacts of NTFP exploitation, the resources' ecological responses, and, overall, other various aspects of exploitation that contribute to natural resource preservation. In addition, it is possible to construct different decision-making scenarios that make people use certain resources.

Closer interactions between ethnobotany and other sciences, such as sociology, can promote more in-depth debates on several social aspects that are related to NTFP use, and that, today, lack more meticulous and theory-based evaluations, especially in conservationist texts and articles. What we tried to debate here is illustrated in the argument that poverty is the main force behind natural resource overexploitation and that an economic return is the most viable pathway to biodiversity preservation. We are not arguing that these statements are defective in their essence, but that they function at a very simplistic level. A community's poverty is not simply a local event. It is, in fact, the result of a larger regional and global network, more specifically composed of the social exploitation relationships that rule the enclosing society. In this sense, poverty cannot be solved in the local sphere, but by restructuring our society's values and relationships. When ethnobotany absorbs classical social theories, it can contribute to the diagnosis of the real causes and forces behind the loss and maintenance of biodiversity, and to the understanding of the role of local communities. Thus, the ability to reevaluate some NTFP-related paradigms will be enlarged, such as the idea that only an economic return inherently promotes biodiversity conservation in poor communities.

Another issue that can be explored from this approximation is the social implication of incorporating occidental values or practices into local communities. According to Diegues (2002), distinct cultures "*participate in different economic systems and each one of these systems determines a specific way of exploiting natural resources and using human labor (...). It is not only nature and its geographical-environmental limitations that motivate a specific type of exploitation of the forest's natural resources, but the ways how social relationships are shapes, their intentional rationalities, their material and social production aims.*" In this way, the attempt to include external values into a local culture may cause it to become unstructured and modify its social relationships and, consequently, its relationship with the environment.

Finally, ethnobotany can question the reasons for the rapid rising of the argument that NTFP contribute to biodiversity conservation. Layrargues (1998) studied the green environmental preservation discourse of companies and sustainable development, which was initially rejected by the business world but is presently accepted and publicized. He concluded that large companies do not have a new environmental understanding that is "ecologically correct," but they have an "ideological appropriation" of the environmental discourse and they are in a search of the greater acceptance of their products, market enlargement, and increase in profitability, regardless of the environmental preoccupations. Ideological appropriations occur currently, such as in the case of the Green Revolution (1980's) and the present view of genetically modified organisms (GMOs) as a way of eradicating world poverty (Pinheiro 2003). In this sense, using NTFP as alternatives to conservation can be questioned, since this proposal does not oppose the real cause of biodiversity loss – unbridled consumerism – but only feeds the creation of new economic niches.

FINAL CONSIDERATIONS

Throughout the article we tried to demonstrate that NTFP concepts bring together an extremely varied set of products with ecological and social specificities that are quite distinct even though they share the one main property that names the group: all are resources that are not wood. Their complexity can be seen through the richness of sciences that focus their investigations on the use of these products by different societies. We believe, as Santos *et al*. (2003) state, that the concept of NTFP will be better determined "*when practices and development policies adjusted to forest areas are created in order to give these resources the attention they deserve.*" However, we understand that the ecological and social basis must be decisive in constructing a more adequate definition to this set of resource heterogeneity – one that is not only based on a utilitarian concept. In this sense, all of the debates put forth previously bring about some thoughts in relation to the most widespread NTFP concepts.

The NTFP come from intimate human-nature relationships, and, most of the time, reflect adaptations to the physical environment. They can also mirror beliefs and values from different domains. They present ecological responses that are quite differentiated – and in some cases antagonistic – that depend on many variables. The richness of organs exploited is vast, as well as the products that result from harvesting and improvement. Diversity is also found in management and exploitation practices.

Lastly, the NTFP are difficult to study due to their inherent complexity and the social, economic, and ecological context within which they are inserted. In this sense, there are few ecological and social characteristics that can unify the non-timber forest products. In fact, the belief is that the NTFP are unified by the diversity and complexity of this group of resources.

The theoretical background that is currently available, which was summarized in this article, allows one to better put the NTFP concept that is most widely used into perspective. As shown, many cultures use a vast range of exotic plants and have a possibility to diversify the resources used. Since cultures are dynamic and humans question their own habits and modify them by incorporating new practices and values (Laraia 1993), the use of these exotic resources can be understood as a "natural process" (see Albuquerque 2006). Considering that the most complete NTFP definitions recognize cultural factors, such as social and religious importance, we believe exotic plants can be understood as NTFP too. Similarly, considering cultural aspects when creating a NTFP definition, we believe that harvesting these resources from physiognomies that have undergone different degrees of human intervention must be a requirement to consider a given resource a non-timber forest product. Nevertheless, as pointed out previously, the phenomenon of natural resources use by local communities is not restricted to forest formations and it is hard (or at least arbitrary) to define ecosystems as "natural" or "managed."

Based on what was presented here, we believe that the non-timber forest products are all native or exotic resources extracted from distinct plant formations – not only forests – that are submitted to different management intensities, never cultivated, non-timber, and are used for different productive activities that are either for auto-subsistence or are included in the market as goods or services. The NTFP come from a vast richness of plant life, are diverse in relation to the plant parts harvested, and to the ecological response in different levels of biological organization. However, sustainability is not an inherent characteristic of this kind of extraction practice. Finally, the NTFP can influence the identity of different groups, as well as its discourse, rites, beliefs, and way of life. Thus, they have high social, cultural, and religious value.

Non-timber forest products have an important role in the survival of many cultures throughout the world, both in daily subsistence activities or in local, regional, or even international markets. The specificities of this group of diverse resources can be used to bring about the conservation of biological and cultural richness. However, this role in preservation will only truly happen after rigorous evaluations of extraction processes are carried out and when the "common discourse" that says that NTFP extraction does not cause considerable impact to the different ecosystems is disregarded. We believe we have moved in this direction, presenting some thoughts on NTFP use and some study methods. Nevertheless, new advances are anticipated as these methods are applied and the experiences regarding each situation are shared. These advances will be generated by researchers' critical views from analyses based on distinct outlooks about a kind of diversity that is evident among the NTFP.

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REFERENCES

Albert B (2000) Associações indígenas e desenvolvimento sustentável na Amazônia brasileira. In: Ricardo CA (Ed) *Povos indígenas do Brasil, 1996-2000* (1st Edn), Instituto Socioambiental, São Paulo, SP, Brasil, pp 197-207

Albuquerque UP (2006) Re-examining hypotheses concerning the use and knowledge of medicinal plants: a study in the Caatinga vegetation of NE Brazil. *Journal of Ethnobiology and Ethnomedicine* **2**, 1-10

Albuquerque UP, Andrade LHC (2002) Conhecimento botânico tradicional e conservação em uma área de Caatinga no estado de Pernambuco, nordeste do Brasil. *Acta Botânica Brasílica* **16**, 273-285

Albuquerque UP, Lucena RFP (2005) Can apparency affect the use of plants by local people in tropical forests? *Interciencia* **30**, 506-511

Albuquerque UP, Lucena RFP, Monteiro JM, Florentino STN, Ramos MA, Almeida CFCBR (2006) Evaluating two quantitative ethnobotanical techniques. *Ethnobotany Research Applications* **4**, 51-60

Albuquerque UP, Oliveira RF (2007) Is the use-impact on native caatinga species in Brazil reduced by the high species richness of medicinal plants? *Journal of Ethnopharmacology* **113**, 156-170

Araújo EL, Castro CC, Albuquerque UP (2007) Dynamics of Brazilian Caatinga – a review concerning the plant environment and people. *Functional Ecosystems and Communities* **1**, 15-29

Begossi A, Hanazaki N, Peroni N, Silvano RAN (2005) Estudos de Ecologia Humana e Etnobiologia: uma revisão sobre usos e conservação. In: Rocha CFD, Bergalho HG, Sluys MV, Alves MAS (Eds) *Biologia da Conservação: Essências* (1st Ed), RiMa, São Carlos, pp 537-562

Begossi A, Richerson PJ (1992) The animal diet of families from Buzios Island: an optimal foraging approach. *Journal of Human Ecology* **3**, 433-458

Bennett BC, Prance GT (2000) Introduced plants in the indigenous pharmacopoeia of Northern South America. *Economic Botany* **54**, 90-102

Boot RGA, Gullison RE (1995) Aproaches to developing sustainable extraction systems for tropical forest products. *Ecological Applications* **5**, 896-903

Castellani DC (2002) Plantas Medicinais e Aromáticas: Produtos Florestais Não-Madeireiros (PFNM). In: Coelho FMB, Junior PC, Dombroski JLD (Eds) *Diversos olhares em Etnobiologia, Etnoecologia e Plantas Medicinais* (1st Edn), Unicen, Cuiabá, pp 199-211

Clement CR (2006) A lógica do Mercado e o futuro da produção extrativista. In: Kubo RR, Bassi JB, Souza GC, Alencar NL, Medeiros PM, Albuquerque UP (Eds) *Atualidades em Etnobiologia e Etnoecologia* (Vol III, 1st Edn), NUPEEA/ Sociedade Brasileira de Etnobiologia e Etnoecologia, Recife, PE, Brasil, pp 135-150

Cunningham AB (1993) *African Medicinal Plants: Setting Priorities at the Interface. People and Plants Working Paper* (1st Edn), UNESCO, Paris, 50 pp

Diegues AC (2002) *O Mito Moderno da Natureza Intocada* (4st Edn), Annablume: Hucitec, São Paulo, Brasil, 176 pp

Dzerefos K, Witkowski ETF (2001) Density and potential utilization of medicinal grassland plants from Abe Bailey Nature Reserve, South Africa. *Biodiversity and Conservation* **10**, 1875-1896

Estomba D, Ladio A, Lozada M (2006) Medicinal wild plant knowledge and gathering patterns in a Mapuche community from North-western Patagonia. *Journal of Ethnopharmacology* **103**, 109-119

Filho HC, Felfili JM (2003) Avaliação dos níveis de extrativismo da casca de barbatimão [*Stryphnodendron adstringens* (Mart.) Coville] no Distrito Federal, Brasil. *Revista Árvore* **27**, 735-745

Freckleton RP, Matos DMS, Bovi MLA, Watkinson AR (2003) Predicting the impacts of harvesting using structured population models: the importance of density-dependence and timing of harvest for a tropical palm tree. *Journal of Applied Ecology* **40**, 846-858

Gaoue O, Ticktin, T (2007) Patterns of harvesting foliage and bark from the multipurpose tree *Khaya senegalensis* in Benin: variation across ecological regions and its impacts on population structure. *Biological Conservation* **137**, 424-436

Garibaldi A, Turner, N (2004) Cultural Keystone species: Implications for conservation and restoration. *Ecology and Society* **9**, 1

Ghimire SK, Mckey D, Aumeeruddy-Thomas Y (2005) Conservation of Himalayan medicinal plants: harvesting patterns and ecology of two threatened species, *Nardostachys grandiflora* DC. and *Neopicrorhiza scrophulariiflora* (Pennell) D.Y. Dong. *Biological Conservation* **124**, 463-475

Godoy RA, Bawa AK (1993) The economic value and sustainable harvest of plant and animals from the tropical forest: assumptions, hypotheses and methods. *Economic Botany* **47**, 215-219

Gotelli NJ (2007) *Ecologia* (3st Edn), Editora Planta, Londrina, PR, Brasil, 260 pp

Grünewald RA (2004) Etnogênese e "regime de índio" na Serra do Umã. In: Oliveira JP (Ed) *A Viagem da Volta: Etnicidade, Política e Reelaboração Cultural do Nordeste Indígena* (2st Edn), Contra Capa, Rio de Janeiro, RJ, Brasil, pp 139-174

Kala CP (2005) Indigenous uses, population density, and conservation of threatened medicinal plants in protected areas of the Indian Himalayas. *Conservation Biology* **19**, 368-378

Kremen C, Raymound I, Lance K (1998) An interdisciplinary tool for monitoring conservations impacts in Madagascar. *Conservation Biology* **12**, 549-563

Hall B, Bawa K (1993) Methods to assess the impact of extraction of non-timber tropical forest products on plant population. *Economic Botany* **47**, 234-247

Ladio A, Lozada M (2004) Patterns of use and knowledge of wild edible plants in distinct ecological environments: a case study of a Mapuche community from northwestern Patagonia. *Biodiversity and Conservation* **13**, 1153-1173

Laraia RB (1993) *Cultura: Um Conceito Antropológico* (8th Edn), Zahar J (Ed), Rio de Janeiro, RJ, Brasil, 116 pp

Lawrence DC, Leighton M, Peart DV (1995) Availability and Extraction of Forest Products in Managed and Primary Forest around a Dayak Village in West Kalimantan, Indonesia. *Conservation Biology* **9**, 76-88

Layrargues PPA (1998) *A Cortina de Fumaça; O Discurso Empresarial Verde e a Ideologia da Racionalidade Econômica* (1st Edn), Annablume, São Paulo, SP, Brasil, 236 pp

Lucena RFP, Albuquerque UP, Monteiro JM, Almeida CFCBR, Florentino ATN, Ferraz JSF (2007) Useful plants of the semi-arid northeastern region of Brazil - a look at their conservation and sustainable use. *Environmental Monitoring and Assessment* **125**, 281-290

Lucena RFP, Araújo EL, Albuquerque UP (2007) Does the local availability of woody caatinga plants (Northeastern Brazil) explain their use value? *Economic Botany* **61**, 347-361

Lucena RFP, Nascimento VT, Araújo EL, Albuquerque UP (2008) Local uses of native plants in an area of caatinga vegetation (Pernambuco, NE-Brazil). *Ethnobotany Research and Applications* **6**, 3-13

MacArthur RH, Pianka ER (1966) On optimal use of a patchy environment. *The American Naturalist* **100**, 603-609

Marx K (2006) *Trabalho Assalariado e Capital e Salário, Preço e Lucro* (1st Edn), Expressão Popular, São Paulo, SP, Brasil, 144 pp

Ndangalasia HJ, Bitariho RB, Dovitec DBK (2007) Harvesting of non-timber forest products and implications for conservation in two montane forests of East Africa. *Biological Conservation* **134**, 242-250

Neumman RP, Hirsh E (2000) *Commercialisation of Non-Timber Forest Products: Review and Analysis of Research* (1st Edn), Center for International Forestry Research, Bogor, Indonesia, 176 pp

Oliveira RLC, Neto EMF, Araújo EL, Albuquerque UP (2007) Conservations priorities and population structure of woody medicinal plants in an area of Caatinga vegetation (Pernambuco State, NE Brazil). *Environment Monitoring and Assessment* **132**, 189-206

Peters CM (1994) *Sustainable Harvest of Non-Timber Plant Resources in Tropical Moist Forest: An Ecological Primer*, World Bank Technical Paper (No 322), Washington, DC, USA, 48 pp

Pinedo-Vasquez M, Zarin D, Jipp P, Chota-Inuma J (1990) Use values of tree species in a communal forest reserve in northeast Peru. *Conservation Biology* **4**, 405-416

Pinheiro S (2003) *Transgênicos: O Fim do Gênesis* (1st Edn), Fundação Juquira Candirú, Montevidéu, Uruguai, 115 pp

Posey DA (1987) Manejo da floresta secundária, campos e cerrados Kayapó. In: Ribeiro BR (Ed) *Suma Etnológica Brasileira* (2st Edn), Vozes, Petrópolis, RJ, Brasil, pp 173-185

Prance GT, Balée W, Boom BM, Carneiro RL (1987) Quantitative ethnobotany and the case for conservation in Amazônia. *Conservation Biology* **1**, 296-310

Primack RB, Rodrigues E (2001) *Biologia da Conservação* (1st Edn),Vida, Londrina, PR, Brasil, 328 pp

Purohit A, Maikhuri RK, Rao KS, Nautiyal S (2001) Impact of bark removal on survival of *Taxus baccata* L. (Himalayan yew) in Nanda Devi Biosphere Reserve, Garhwal Himalaya, India. *Current Science* **81**, 586-590

Pyke GH, Pulliam HR, Charnov EL (1977) Optimal foraging: A selective review of theory and tests. *The Quarterly Review of Biology* **52**, 137-154

Quintaneiro T, Barbosa MLO, Oliveira MGM (2007) *Um Toque de Clássicos: Marx, Durkheim e Weber* (2st Edn), UFMG, Belo Horizonte, MG, Brasil, 159 pp

Richardson DM, Pysek P, Rejmanek M, Barbour MG, Panetta FD, West CJ (2000) Naturalization and invasion of alien plants: Concepts and definitions. *Diversity and Distributions* **6**, 93-107

Ricklefs RE (2007) *A Economia da Natureza* (5th Edn), Guanabara Koogan, Rio de Janeiro, RJ, Brasil, 260 pp

Santos AJ, Hildebrand E, Pacheco CHP, Pires PTL, Rochadelli R (2003) Produtos não madeireiros: conceituação, classificação, valoração e mercados. *Revista Árvore* **33**, 215-224

Shaanker RU, Ganeshaiah KN, Rao KM, Aravind NA (2004) Ecological consequences of forest use: From genes to ecosystem. A case study in the Biligiri Rangaswamy Temple Wildlife Sanctuary, South India. *Conservation and Society* **2**, 347-363

Soldati GT (2005) Percepção e conhecimento botânico em uma comunidade do entorno da Mata do Paraíso, Viçosa- Minas Gerais. Universidade Federal de Viçosa, Viçosa, MG, Brasil, 47 pp

Souza RSO, Monteiro JM, Albuquerque UP, Amorim ELC (2008) Jurema-preta (*Mimosa tenuiflora* [willd.] poir.): a review of its traditional use, phytochemistry and pharmacology. *Brazilian Archives of Biology and Technology* **51**, 937-947

Ticktin T (2004) The ecological implications of harvesting non-timber forest products. *Journal of Applied Ecology* **41**, 11-21

Ticktin T, Nantel P, Ramírez F, Johns T (2002) Effects of variation on harvest limits for non-timber forest species in Mexico. *Conservation Biology* **16**, 691-705

Uniyal SK, Awasthi A, Rawat GS (2002) Current status and distribution of commercially exploited medicinal and aromatic plants in upper Gori valley, Kumaon Himalaya, Uttaranchal. *Current Science* **82**, 1246-1252

Vantomme P (2001) *Production and Trade opportunities for Non-Wood Forest Products, particularly food products for niche markets*. Geneva: Forest Products Division (FAO). Available online: http://www.fao.org/organicag/doc/unctad2001.htm

Veloso HP, Filho ALRR, Lima JCA (1991) *Classificação da Vegetação Brasileira, Adaptada a um Sistema Universal*, Instituto Brasileiro de Geografia e Estatística (IBGE), Rio de Janeiro, RJ, Brasil, 124 pp

Villalobos R, Ocampo R (1997) Productos no maderables del bosque en Centroamérica y el Caribe. *Serie Técnica, Eventos Especiales* **1**, 1-103

Walter S (1998) The utilization of non-timber forest products in the rainforests of Madagascar: a case study. *Plant Research and Development* **47/48**, 121-144