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## Sustainability aspects of commercial medicinal plant harvesting in Suriname

Tinde van Andel\*, Reinout Havinga

National Herbarium of The Netherlands, Department of Plant Ecology and Biodiversity, Utrecht University, Sorbonnelaan 16, 3584 CA Utrecht, The Netherlands

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## ABSTRACT

The commercial harvest of herbal medicine to meet the growing urban demand has become an environmentally destructive activity in many countries. Non-sustainable harvesting not only threatens the survival of medicinal plant species, but also the people that depend on them. In Suriname, the urbanization of Maroons has created a lively trade in medicinal plants, but little is known on the ecological effects of this trade. To find out whether this commercial harvest was a destructive activity, we carried out a market survey and followed commercial extractors into the forest to look for signs of overharvesting. We analyzed our results from three perspectives: the market, the harvesters and the post-harvest survival of the particular plants. Of the 249 commercial species, less than half was harvested exclusively from the wild. Most extraction took place in secondary forest or man-made vegetation close to the capital. Leaves were the main product. Apart from a few primary forest-based species (e.g., *Begonia glabra*), we found little evidence for declining resources. Maroons were actively cultivating and managing wild plants. Our three-way analysis enabled us to distinguish between species without sustainability problems (abundant, domesticated, cultivated, limited market value, disturbance species or surviving harvest) and species with conservation priorities. This study illustrates that the increased commercialization of medicinal plants due to urbanization does not invariably lead to declining resources and species loss. With its low population density and market dominated by disturbance species, Suriname offers good possibilities for sustainable medicinal plant extraction.

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## 1. Introduction

Medicinal plants are used by billions of people in developing countries, because of their low costs, their effectiveness, the frequently inadequate provision of modern medicine, and cultural and religious preferences (Sheldon et al., 1997; Shanley and Luz, 2003). The annual global market for herbal remedies, estimated at approximately US\$ 23 billion (Crabb, 2004), makes a considerable contribution to the economies of producer countries (Schippmann et al., 2002). In the past, harvesting of medicinal herbs was primarily done by traditional healers. As a result of urbanization and increased demand, however, harvesting has often become the domain of untrained, and often indifferent, commercial gatherers with no other income sources (Williams et al., 2000). The vast majority of medicinal plants are still harvested from the wild (Schippmann et al., 2002). Harvesting without planting, deforestation and the increased marketing of medicinal plants have resulted in the decline and sometimes near-extinction of several valued

medicinal plant species around the world (Sheldon et al., 1997; Ticktin, 2004). For many countries and medicinal species, however, information on the current harvest sustainability of medicinal plants is entirely lacking.

To assess the ecological effect of the medicinal plant trade in a certain area, it is essential to distinguish the true non-timber forest products (NTFPs) from those that come from cultivated or domesticated sources and therefore less likely to encounter sustainability problems. Learning which wild-harvested plants are sold, the extent to which they are traded, and the perceived scarcity and popularity of these plants are the first steps in identifying species with resource management priorities (Cunningham, 2001). Although plant vendors can often provide information on which species are becoming rare, a better way to detect the sustainability of harvest is to visit the locality where the plants grow (Martin, 1992). One should also consider the particular plant part that is extracted, as this determines the survival of the individual species after harvesting. The removal of wood, roots or whole plants generally leads to the death of an individual, as does the cutting of bark when ring-barking takes place (Cunningham, 1993). The harvest of leaves, fruits or seeds is considered less destructive, although intensive pruning can

\* Corresponding author. Tel.: +31 62 8523329; fax: +31 30 2518061.  
E-mail address: [T.R.vanAndel@uu.nl](mailto:T.R.vanAndel@uu.nl) (T. van Andel).

affect reproductive performance (Gaoue and Ticktin, 2007). The vegetation type from where wild plants are collected, their abundance and growth rate are other major determinants for the sustainability of their extraction. Slow-growing primary forest species that occur in low densities are particularly vulnerable for overharvesting (Peters, 1996).

Non-sustainable harvesting not only threatens the survival of valuable medicinal plant species, but also the livelihoods of communities that depend on them. Species with a great cultural and economic significance that are at risk of overexploitation and population decline should be given conservation priority (Hamilton, 2004). Such endangered species, for which a moving front of depletion exists, where harvesters exhaust one resource-rich zone and then move on to another, should play a key role in resource management plans (Cunningham, 2001). Here we present the results of a rapid assessment of the ecological sustainability of the medicinal plant trade in Suriname.

## 2. Study area and background

Suriname, a former Dutch colony in South America with less than half a million inhabitants, has more than 90% of its surface covered with dense tropical forest. The population is concentrated in the capital Paramaribo. The country's interior is home to several tribes of Amerindians and Maroons, descendants of enslaved Africans that escaped into the forests and created their own autonomous, traditional societies (Price, 1996). The civil war of the 1980s, road improvement, and the lack of employment and educational opportunities in the interior have caused a steady migration of Maroons to Paramaribo (St.-Hilaire, 2000). Because of their rich traditional plant knowledge and contacts with their forest communities, Maroons are the main harvesters, traders, exporters and consumers of medicinal plants in Suriname (van Andel et al., 2008). There are several medicinal plant markets in Paramaribo, and herbal medicine is exported in significant amounts to the Netherlands, where it plays a key role in the health care of Surinamese immigrants (van Andel and van 't Klooster, 2007). The ongoing urbanization of Maroons stimulates the trade in herbal medicine, but how does this affect the availability of popular plant medicines? Are there indications that commercialization has led to declining populations or local extinction of medicinal plant resources? What is the proportion of wild-harvested species in the trade and from which vegetation types are they extracted? Can we identify species with conservation priority? To address these questions and to find out whether the trade in herbal medicine in Suriname can be defined as a destructive activity, we choose to analyze the case from three different perspectives: the market, the harvesters and the plants themselves.

## 3. Methods

Fieldwork was carried out between January and August 2006, and took place around Paramaribo and commercial extraction sites near Rijsdijkweg (Pará District), Marchalkreek, Nieuw Lombe, Klaaskreek (Brokopondo District), Albina and Bigiston (Marowijne District). Herbarium vouchers were collected of all commercial medicinal plants and deposited at the National Herbarium of Suriname (BBS) and the National Herbarium of the Netherlands (U). In April–May 2006, we conducted a systematic quantitative survey on six market locations in Paramaribo. We recorded species, uses, prices and volumes sold on 65 (15%) of the 432 market tables and questioned 46 vendors on their harvesting site, ethnicity, and village of origin. We accompanied several harvesters into the forest to collect voucher material and asked them about the amount of plant material they harvested, bought, sold, and discarded per week, as well as the scarcity and popularity of the species. From these data, we could calculate the volume and monetary value of plant material offered for sale per meter. Subsequently, we estimated the total annual sales per market (van Andel et al., 2008).

For each species, we recorded the particular harvesting techniques, the part harvested, the observed harvesting sites and the vegetation type from which it was extracted. We recorded indigenous management systems and looked for possible signs of destructive harvesting, such as the killing of individual plants during their harvest. We witnessed medicinal plant extraction in forest fields and fallows, house yards and city gardens, which allowed us to distinguish between wild-harvested, cultivated wild plants and domesticated exotics. We asked why certain herbs were more expensive than others, and which species were difficult to obtain, paying special attention to market vendor's complaints about increasingly distant sources of particular forest-based medicinals. We verified our observations on the species' natural growth form and habitat with the Flora's of Suriname, the Guianas, and Central French Guiana. We classified plants as weeds when they were listed as such for Suriname (Everaarts and Teunissen, 1989) or Brazil (Lorenzi, 2000). For all commercial species we compared prices, volumes marketed, domestication status, perceived scarcity, survival after harvest, vegetation type, growth form, distance of harvesting site from the market, endemism (Boggan et al., 1997), and official threat status (IUCN, 2007; CITES, 2007), in order to identify species with conservation priorities.

## 4. Results

### 4.1. Economic value and provenance of market species

About 136 metric tons of herbal medicine was sold in 2006, with a total estimated value of over US\$ 1 million. According to shipping agents and custom officers in Paramaribo, at least

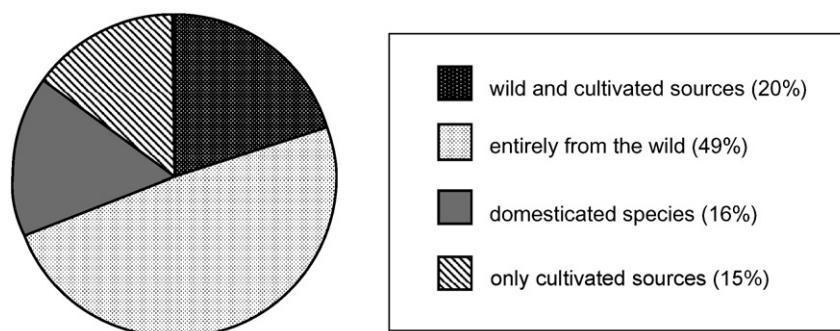


Fig. 1. Provenance of commercially harvested medicinal plant species in Suriname, 2006 ( $n = 249$ ).

**Table 1**  
Leading wild-harvested medicinal plants on the Paramaribo markets, 2006

Species	Growth form	Plant part	Vegetation type	Frequency (% stalls)	Marketed volume (kg/day)
<i>Campomanesia aromatica</i>	Tree	Leaves	Secondary	44	183
<i>Carapa guianensis</i>	Tree	Oil from seed	Primary	63	150
<i>Begonia glabra</i>	Epiphyte	Whole plant	Primary	25	132
<i>Siparuna guianensis</i>	Shrub	Leaves	Secondary	41	117
<i>Vismia guianensis</i>	Tree	Leaves	Secondary	31	99
<i>Phyllanthus amarus</i>	Herb	Whole plant	Garden weed	44	81
<i>Renealmia floribunda</i>	Herb	Whole plant	Primary	38	72
<i>Aristolochia consimilis</i>	Liana	Wood	Secondary	53	61

55,000 kg of fresh plant material is exported annually to the Netherlands. We identified 249 species of medicinal plants that were offered for sale at the Paramaribo markets. The species list is available in the on-line [Supplementary Appendix](#). Almost 16% of the species encountered at the market were domesticated exotics (e.g., *Aloe vera*). Although the remaining 84% of the commercial species were native to Suriname's forests and savannahs, less than half of the species was in fact harvested from the wild (Fig. 1).

Many native species were planted around villages, in agricultural fields and city gardens, from where they were extracted for the market. About 20% ( $n = 50$ ) of the commercial species were classified as a weed in Suriname and/or Brazil. These weeds consisted of wild herbs, vines or shrubs, but also of escaped cultivars (e.g., *Sesamum orientale*). Some of these weeds were frequently cultivated for their medicinal use (e.g., *Piper marginatum*). Of the 15 leading medicinal products, four came from exotic, domesticated plants: molasses, coconut oil, calabashes and sesame seeds. Three (*Quassia amara*, *Scoparia dulcis* and *Justicia pectoralis*) were originally native species, but harvested almost exclusively from home gardens. The remaining eight species were collected in the wild, and on those species we will focus when assessing harvest effect. Table 1 lists the wild-harvested species recorded with greatest frequency and largest volumes on an average market day in Paramaribo.

Three of these best-selling medicinal products were leaves of common, fast-growing trees in secondary forest. These species are commonly found in forest patches in the outskirts of Paramaribo, and occur in large numbers along the roads leading into the interior. Many of these trees sprout back after felling, and we saw leaves harvested frequently from the same stumps. *Phyllanthus amarus* was harvested entirely, but this is a common weed, even in urban environments. Therefore, we are certain that these species suffer little from overharvesting. We saw, however, that entire individuals of *Begonia glabra* and *Renealmia floribunda* were harvested in significant amounts from primary forest. This suggests a greater susceptibility to overharvesting, which would result in a high market value. The average price of herbal medicine was \$3.50 per kilogram. The most expensive products were medicinal oils and aphrodisiac mixtures, reflecting their labor-intensive preparation methods, even though their crude ingre-

dients were common and cheap. Prices of medicinal products were not only determined by processing costs, but also by resource scarcity, distance to harvesting sites, and local demand. Therefore, to get an idea of species with conservation priorities, we should focus on expensive, but unprocessed plant species (Table 2).

By far the most expensive species was *Psychotria ulviformis*, a small, creeping herb with purple-brown leaves very similar in color to decaying litter. The herb's cryptic habit has led to the belief that it could make people or objects invisible, the reason behind its popularity among cocaine smugglers. The difficulty in locating this herb, combined with its high demand by people wanting to make quick money, has resulted in its high price. *Aristolochia consimilis* was a common vine in successional vegetation, but because of its very light wood, its price per kilogram was relatively high. The remaining species in Table 2 all occurred in low densities in mature forest. The peculiar 'babar udu' (noisy wood) represented a variety of species, as it consisted of the magic bark of two tree trunks that leaned against each other and made a sinister sound when the wind moved their crowns. The small ferns *Trichomanes vittaria* and *Selaginella radiata* were only occasionally sold. Their high price per kilogram was caused by their low mass per sales unit and obscure magic application, instead of to their rareness.

Although its oily seeds and bark were harvested without felling the trunk, its valuable timber was the reason that *Carapa guianensis* was becoming scarce in the vicinity of Paramaribo. It was, however, *B. glabra* that most vendors mentioned as becoming rare and expensive. This fleshy epiphyte, which grows on tree trunks in primary forest, is a major ingredient in herbal baths to calm down stress and anxiety. Such baths are frequently used by drug traffickers just before taking their flight to the Netherlands with their intestines full of cocaine balls. Vendors told us that wholesale prices of *B. glabra* had increased the last few years from \$29 to \$39 for a 7-kilo bag, as a result of increasing scarcity and high transport costs from remote harvesting sites. Its abundance on the market, however, implied that resources were still available. In spite of its popularity and extraction from primary forest, the price of *R. floribunda* was not above average. Not once did the gatherers or vendors mention a species that no longer appeared on the market because of overexploitation or local extinction.

**Table 2**  
Most expensive, unprocessed medicinal plant products at the Paramaribo markets, 2006

Species	Growth form	Product	Forest type	Retail price (US\$/kg)
<i>Psychotria ulviformis</i>	Herb	Whole plant	Primary	182
<i>Trichomanes vittaria</i>	Fern	Whole plant	Primary	91
<i>A. consimilis</i>	Liana	Wood	Secondary	46
<i>B. glabra</i>	Epiphyte	Whole plant	Primary	34
<i>Heteropsis flexuosa</i>	Epiphyte	Aerial root	Primary	22
miscellaneous 'babar udu'	Tree	Bark	Primary	18
<i>Selaginella radiata</i>	Fern	Whole plant	Primary	18
<i>C. guianensis</i>	Tree	Bark	Primary	18

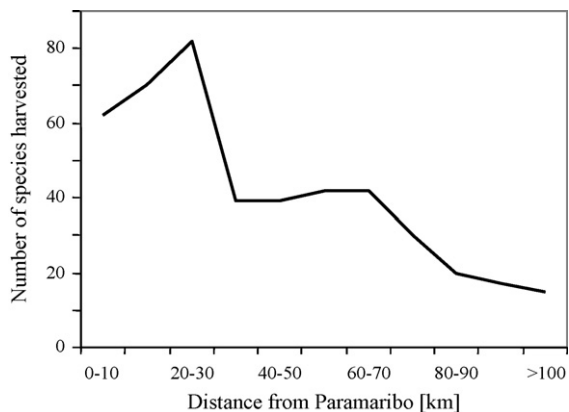


Fig. 2. Number of species harvested in relation to distance from the market.

#### 4.2. Extraction sites

The majority of commercial species is harvested within a radius of 65 km around Paramaribo (Fig. 2). Many market vendors collected their own plants, and they managed to find the bulk of their weekly merchandise within a few hours walk from home. Most vendors live in the city outskirts and small Maroon migrant settlements at 20–30 km from the city center.

Transport from the forest to the market was a limiting factor, as few harvesters had their own vehicle. The high fuel price and their struggle with bulky herb bags in the crowded busses limited the amount of plant material that they could bring to the market. Most urban consumers preferred fresh herbs, which limited the transport distance. Species were only transported from larger distances if they did not occur closer to the market. If we plot harvest intensity as a function of distance to the market (Fig. 3), we also see that the greatest volumes (and market value) of herbal medicine were harvested within this radius of 25 km from the city center, from home gardens, parks, abandoned plantations, and along the roads that enter the country's forested interior. The greater part of the herbal medicine was thus harvested from degraded forests and shrub land.

No more than 28 commercial species (11%) were harvested exclusively from primary forest. These were mostly collected in the first patches of primary forest easily accessible by public transport (30–70 km from the capital). Local people complained, however, that the popular species *B. glabra*, *R. floribunda*, *Arrabidaea bilabiata* and *Miconia lateriflora* had already vanished in this area. We noticed trees felled by commercial harvesters to get the *B. glabra* from their branches. Just a small number of species is transported from remote areas (Fig. 2), but their market value increases sharply (Fig. 3). Significant amounts of *B. glabra* were collected in the fringes of the Brownsberg Nature Reserve (ca. 130 km from the capital), while other vendors ordered this plant from as far as Djumu (190 km inland). *R. floribunda* was one of the few plant products that were sold by Amerindian bush meat vendors in Paramaribo, because the plant was still common in the remote areas where they hunted wildlife. The price of *R. floribunda* was nevertheless comparable to that of the more common herbs. Of all commercial species, only *B. glabra* and *R. floribunda* clearly showed a moving front of depletion where plants were brought from increasingly remote areas.

#### 4.3. Indigenous management and cultural taboos

Almost all commercial wild species were subject to some form of domestication by Maroons. Highly appreciated wild plants were

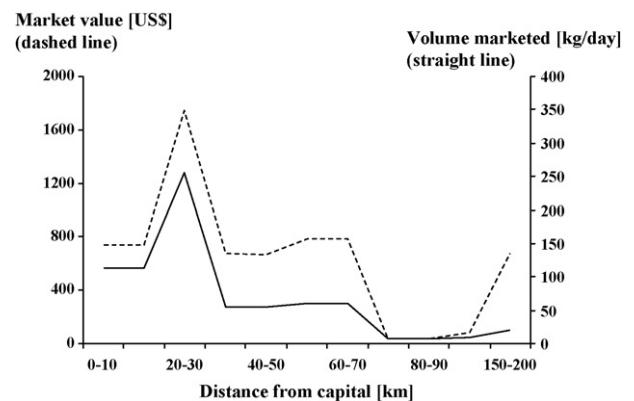


Fig. 3. Harvest intensity of medicinal plants in relation to distance from the market.

tolerated as a weed, encouraged in their wild environment or planted in forest fields or house yards. Even common species in secondary shrub land were frequently cultivated, although meant for subsistence rather than commercial use. One of the reasons why Maroons are such active domesticators must be sought in their religion. Many Maroons (as well as many Creoles) are strong believers in the Afro-Surinamese winti religion, in which spirits and plants play an important role. Wild forest plants are often planted in yards to protect the household from evil influences, and the winti religion also includes many taboos that limit extractivist activities. Trees or epiphytes that house certain spirits (e.g., *Ceiba pentandra*) are never cut down, because the revenge of their inhabitants will be dreadful. People can pick their leaves, but should first ask permission from the deities in question. We heard traditional healers having lengthy conversations with forest spirits before they entered the forest, but we did not observe this among commercial harvesters. Many people, vendors and healers alike, fear the magic power of certain herbs (e.g., *Lycopodiella cernua*) of which improper application can put the user in great danger. Some forests are sacred and no harvesting is allowed unless the spirits are paid with offerings and libations. No harvesting is done after dark. Women do not handle plants during their menstruation period, because this will destroy the plant's healing power. We never saw people ring-barking or cutting down entire trees to harvest the bark. Maroons explained that they only cut bark from the sunny side of the trunk. The shadow side (which they consider the evil side) should be left intact. We did see signs of repeated bark removal, but mostly on one side only, so the percentage of debarking was almost always below 50% of the bark below 2 m height. These cultural taboos may indirectly contribute to a reduced harvest pressure.

#### 4.4. Plant parts harvested

Foliage (twigs with leaves attached) was the primary commercial product on the market (83 spp., 44% of the total number of species). Even though wild shrubs that were planted in house yards often showed signs of destructive pruning, we did not see signs of damage among their conspecifics in the forest. So during extraction from the wild, foliage was always harvested without killing the individual shrub or tree. We expect that complete removal of reproductive herbs has a much stronger effect on the species' population dynamics. Of the 188 native species (extracted from wild and cultivated sources), about 28% (52 spp.) was harvested as a whole. At least half of these species, however, were common herbaceous weeds that were in no danger of extinction. We did not observe destructive bark removal from the 11 species (6%) that

**Table 3**  
Commercial species from primary forest that do not survive harvesting

Species	Product	Abundance	Commercial value (US \$/kg)	Use
<i>P. ulviformis</i> <sup>a</sup>	Whole plant	Rare?	182	Winti
<i>B. glabra</i> <sup>a</sup>	Whole plant	Rare	34	Winti
<i>Selaginella radiata</i> <sup>a</sup>	Whole plant	Rare	18	Winti
<i>Miconia lateriflora</i> <sup>a</sup>	Whole plant	Rare	9	Winti
<i>Asplenium serratum</i> <sup>a</sup>	Whole plant	Rare	8	Winti
<i>Philodendron scandens</i>	Whole plant	Common	7	Winti
<i>R. floribunda</i> <sup>a</sup>	Whole plant	Rare	5	Winti
<i>Strychnos melinoniana</i> <sup>a</sup>	Wood	Common	5	Aphrodisiac
<i>Arrabidaea bilabiata</i> <sup>a</sup>	Wood	Rare	5	Aphrodisiac, laxative
<i>Strychnos</i> sp.TVA4788 <sup>a</sup>	Wood	Rare	5	Aphrodisiac
<i>Bauhinia guianensis</i>	Wood	Common	5	Winti, paralysis, genital bath
<i>Bauhinia surinamensis</i>	Wood	Common	5	Winti, paralysis, genital bath

<sup>a</sup> Species with conservation priority.

were harvested for their bark. Roots were a minor item on the market (10 spp., 5%), and mostly consisted of aerial roots that were harvested without killing the individual plant.

From the 28 commercial species that were gathered exclusively in mature forest, only 12 did not survive harvesting (Table 3). These were either forest herbs that were harvested entirely or single-stemmed lianas killed while cutting their wood. From these 12 species, only the rare and most valuable ones were at risk from overharvesting.

#### 4.5. Species with conservation priority

Two trees of which the bark was sold in Paramaribo, *Couratari guianensis* and *Virola surinamensis*, appeared on the 2007 IUCN Red List of Threatened Species (IUCN, 2007). Both are valuable timber species that have suffered serious population declines in Latin America. In Suriname, however, they are still abundant in the coastal swamps. None of the commercial species we recorded appeared on any of the CITES Appendices (CITES, 2007). Some other valuable timber trees with medicinal bark (e.g., *C. guianensis*, *Hymenaea courbaril* and *Inga alba*), were becoming scarce in the vicinity of Paramaribo. Although these trees were planted or protected around Maroon communities, in the squatted settlements, where traditional control was lacking, people complained about outsiders stealing bark and timber. None of the commercial plants we recorded were endemic to Suriname.

Given its abundance on the market, its high demand, high price, specific habitat requirement and the reports on population decline and indiscriminate harvesting, we consider *B. glabra* as a species with conservation priority. Although most commercial *Begonia* was harvested from the wild, Maroons were actively cultivating it for their personal use. By planting the epiphyte in a dark and moist place, in between the leaves of an African oil palm for instance, they were sure of a regular supply from their garden. The location of the plant was kept strictly secret, as theft was not uncommon. A few vendors in Paramaribo started selling living *Begonia* plants in coconut husks, at a much higher price than wild-harvested individuals. Several of our informants tried to cultivate *R. floribunda*, but their attempts always failed. We saw only one person cultivating *Psychotria ulviformis*. Despite its high price, we do not have clear evidence that this herb is becoming overharvested. It needs a well-trained eye to locate it, and this might be the clue for its survival. With their current extraction rate, however, another six species from Table 3 are likely to encounter problems with overharvesting in the future. As soon as their prices start to increase rapidly, the sustainability of their harvest will be at stake. From the 249 medicinal species marketed in Paramaribo, at most nine (4%) have a conservation priority.

## 5. Discussion

The results of our three-way analysis (market, harvesters, and plants) indicate that, apart from a few species, the commercialization of medicinal plants has not yet led to overharvesting of resources in Suriname. One reason for the generally sustainable harvest levels is the large proportion of domesticated and cultivated plants on the market. The domestication of valuable wild plants is often seen as a measure to take the pressure of wild stocks and reduce extraction costs (Sheldon et al., 1997; Ticktin, 2004). Still, in many parts of the world there is no cultivation on any significant scale (Hamilton, 2004). According to Schippmann et al. (2002), people usually start to cultivate wild plants only after wild resources have declined to such an extent that transport costs, search time and long distance trade have driven up their price considerably. The Suriname Maroons, however, began to plant forest medicines long before populations declined and prices went up. As they do not consider cultivated plants qualitatively inferior to wild-gathered specimens, their efforts to cultivate forest medicinals should not be seen as an adaptation to the depletion of wild resources, but rather as an early action to prevent this.

Traditional spiritual values have influenced human behavior affecting their environment, and have played a role in protecting sacred forests in Africa until today (Byers et al., 2001). While such beliefs and practices are often abandoned by commercial gatherers elsewhere (Cunningham, 1993), Surinamers still take cultural taboos regarding medicinal plant handling quite seriously. There is much respect for the healing power of the forest and the winti religion is becoming more popular and openly practiced in Suriname. More than half of the species sold at the market were employed in supernatural rituals (van Andel et al., 2008). Plants only retain their magic power when picked with respect to cultural traditions. Being suspected of disobeying these rules (e.g., collecting or selling plants while menstruating) would immediately reduce customers' confidence in a vendor's merchandise. These religious taboos, combined with indigenous management techniques such as the cultivation of wild species, in situ encouragement and the careful removal of bark and roots, contribute to a generally respectful approach towards medicinal plant resources.

Other factors that facilitate the sustainable extraction of medicinal plants from Suriname are a low population density, vast areas of rainforest, a relatively small market, and the lack of complicated technology. In contrast to other tropical countries, where medicinal resources have become scarce because of conflicting land uses, there is no large-scale logging, cattle ranging or cash crop agriculture taking place in Suriname. Valuable timber species with medicinal bark are still commonly

found, while the same species are sharply declining near urban areas in Brazil (Shanley and Luz, 2003). Unlike in other Amazonian countries, market chains in Suriname are relatively short and debt peonage does not exist. Most market vendors double as harvesters, so little profit is lost to middlemen. The country's phytomedical industry started only recently, so there is hardly any industrial extraction of plant material. Plants are mainly sold unprocessed, and for traditional medicine only. Even if all overseas migrants were considered, the market for Surinamese herbal medicine would not exceed one million people. This demand could increase considerably, however, if the herbs were processed more professionally into tonics, creams or teas and marketed among urban consumers.

A final contributory factor for the sustainability of wild plant harvesting is that Suriname has a so-called disturbance pharmacopoeia (Voeks, 2004). As is evident by our results, the bulk of the commercial medicinal products consists of fast-growing herbaceous weeds or leaves from trees or shrubs growing in human-altered environments. These plants have a much better capacity for regeneration than the slow-growing roots, bulbs and barks that dominate the market in South Africa and Brazil (Cunningham, 1993; Shanley and Luz, 2003). The typically low density of valuable NTFP resources in tropical forests generally creates disincentives for sustainable commercial production (Peters, 1996). Surinamese extractors overcome this problem by gathering a wide range of different forest products during each field trip, thus increasing productivity per surface-area and optimizing their income through the diversification of their merchandise.

Our three-way analysis of the medicinal plant trade in Suriname enabled us to filter out species that were unlikely to encounter problems with harvest sustainability. They had either a limited market value, were locally abundant, grew in gardens or pioneer vegetation, or survived the harvesting process. In the end, we were left with a small group of species that were suffering from population decline or likely to do so in the future. As the increasing popularity of herbal medicine and winti religion in the country will secure the future demand for plant-based remedies (van Andel et al., 2008), cultivating wild species seems the best option to ensure sustainable harvesting. Special effort should be made to protect *B. glabra* and other vulnerable species. Although these plants are still common in remote, uninhabited or strictly protected forests (e.g., the Brownsberg Nature Reserve) and in the adjacent countries where they lack their magic connotation, they are becoming increasingly scarce around Maroon settlements. Such commercial extinction of valuable NTFPs tends to have serious consequences for local economies and livelihoods (Hamilton, 2004). Conservation organizations interested in supporting the trade in NTFPs as an alternative income for forest-dwelling communities in Suriname could promote the cultivation of *B. glabra* and other valuable medicinal plants. It is also essential to determine sustainable harvest levels for these species by comparing extraction rates to those of natural replacement. The traditional knowledge of the Maroons regarding the propagation, responsible harvesting and effective management of forest plants should receive more attention and appreciation from researchers and policy makers.

## 6. Conclusion

This study illustrates that the increased commercialization of medicinal plants due to urbanization does not invariably lead to declining resources and species loss. Provided the country's forest cover remains intact, there are good perspectives for a sustainable medicinal plant trade in Suriname.

## Acknowledgements

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.foreco.2008.06.031.

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