

Uses and Conservation of Plant Species in a National Park—A Case Study of Ben En, Vietnam

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This paper surveys the use of wild and cultivated plants by local people in Ben En National Park, Vietnam, and analyzes its impact on the conservation status of some of the utilized species. A total of 208 species used for a range of nonmedicinal purposes are listed. See Hoang et al. (2008a) for 230 medicinal plants used in the park. Most species are used for food. The use of plants contributes very significantly to the livelihood of local people in the park, but the current use patterns are not sustainable and would lead to local extinction of rare and endangered species if no additional conservation measures are introduced. Men collect nonmedicinal plants more often than women. A total of 38 useful plant species are commercialized, and contribute 12% of the average income of individual households. Bamboo shoots of *Schizostachyum funghomii* (Poaceae) are the most important for income generation. The monetary equivalent of noncommercialized useful plants probably far exceeds the value of the traded plant products. Plant use is independent of the ethnicity of the different populations living in the park. Larger households make use of a greater variety of useful plant species than small families. Abundant species in the forest have a higher use index (UI) than less common species. Out of the 208 useful species, as many as 27 were found to be endangered locally, many more than the 11 or 8 endangered species included in national or global red lists. Currently, useful plants, especially important timber trees, are more abundant in the less disturbed parts of the park, far away from the villages, indicating the pressures of illegal logging and harvesting near villages on the ecosystems.

Key Words: Useful plants, Ben En National Park, food plants, construction, firewood, household tools, conservation, Use Index.

Introduction

Ben En National Park is one of 30 national parks in Vietnam, established in 1992 to conserve the rich, but seriously threatened, biodiversity of the country. The Ben En area was designated for the protection of fauna in 1979, and as a nature reserve in 1986, although commercial logging operations continued until 1992. The park is inhabited by 4,000 local people belonging to five ethnic groups. Although initially all uses of wild natural resources were forbidden in the national

parks, current policies in Vietnam seek to find an optimal and realistic balance between conservation and sustainable use of natural resources in these parks. Apart from very preliminary species surveys (Anonymous 2000; Todoff et al. 2000), very little is known of either the plant biodiversity or the ethnobotany of Ben En. The current study of native and cultivated plant use in the park forms part of a larger study including traditional medicinal plant use (Hoang et al. 2008a) and detailed botanical plot studies analyzing the effect of selective harvesting of NTFP and of illegal logging on the plant species diversity within the park (Hoang et al. 2008b; Hoang et al. in preparation). This knowledge is crucial for the development of a

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sound management policy that is aimed both at nature conservation and at improving the livelihood of the local communities within the park.

The commercial extraction of useful plants as a conservation strategy is based on the argument that forest conservation must be able to offer economic incentives to local rural people in order to counter the threat of destructive land uses such as logging, shifting cultivation, and cattle ranching (Amacher 2002; Nepstad and Schwartzman 1992; Panayotou and Ashton 1992). However, the growing commercial trade of natural products, in particular medicinal plants and woodcrafts, has resulted in increasing exploitation of wild plant populations (Lange 1998), and this has generated concern about threats for local extinction (Clay 1997; Cunningham 2001; Tiwari 2000).

Specific research questions of the present study are these: 1) Which plant species are used for which purpose? 2) Which species are commercialized? 3) What is their relative importance for the local communities based on a use index and on monetary revenues from commercialized species? 4) What is the impact of local people on these useful plants in the wild? and 5) How do factors such as ethnicity, size of each household, and species density in the park affect plant use?

It is hoped that the answers to these questions can serve to model management strategies in other national parks in Vietnam and elsewhere and contribute to the conservation of both cultural and plant diversity.

Methodology

ETHNOBOTANICAL INVENTORY

Household surveys and interviews were carried out in 45 randomly-selected households per village (out of a total of about 110–150 households per village) during a 6-month field survey held from October 2005 to March 2006 by the senior author and four students. The standard interviews contained specific questions on age, gender, and ethnic background of the gatherers and main users of plant products. Additionally, we used the “walk-in-the-wood” method (Prance et al. 1987) to determine which products are harvested (and for what purpose) in the forests surrounding the villages. These trips were also used to collect voucher specimens for reliable identification of the harvested plants. Special collecting trips were organized with local experts,

for instance, people usually collecting useful plants, or locals with a detailed knowledge of plants. Furthermore, several companies making furniture in and around the research area were visited to determine which timber species were used and from which sources they came. Local names were noted during these surveys as recommended by Martin (1995). Most information was double-checked with different informants and with manuals such as the Flora of Vietnam (Ho 2000), the manual on non-timber forest products in Vietnam (Hung 2007), and the PROSEA Handbooks (1989–2003). Market inventories were used to determine the price of the forest products. These served as an independent way to determine which products are harvested from the surrounding forest. We also assessed local uses of these forest products.

All plants that were considered by local people to have useful properties were collected and identified. These plants included not only wild species but also cultivated plants and wild plants that had been taken from the forest and planted in gardens or agricultural fields. One herbarium voucher of each specimen was deposited in the herbarium of the Vietnam Forestry University; additional vouchers were sent to the National Herbarium of the Netherlands (L) and specialists elsewhere for identification.

The importance of useful plant species was identified using standard Participatory Rural Appraisal (PRA) techniques (PID and NES 1989; Ngai 2001), whereby local people were asked to rank a list of regularly-used plants. We also quantified the relative use of species by calculating a Use Index (UI) based on the proportion of households utilizing a given species (see below).

The relative importance of timber species was assessed using three criteria: (1) ranking of species from a given list by forest rangers of Ben En National Park, who were asked how often certain illegally-harvested species were confiscated from local people both inside and outside the park; (2) proportion of listed species harvested by local people; and (3) frequency of tree stumps found during the field inventory. Stumps were identified by leaves and fruits or flowers left in the forest when the timber trees had been felled very recently, or from sucker shoots which emerged when the trees had been felled a long time ago. Bark characters were also used to identify the stumps. Additionally, local informants with expertise in tree (and stump) identification assisted us.

The market demand, intensity of collection and abundance in the wild were classified as low, medium, or high (based on the interviews with local people and by using PRA techniques).

Plants were divided into five end-use categories, largely following Prance et al. (1987):

- a. Food: Any plant or plant part (fruits, seeds, leaves, bark, flowers, or latex) used for human consumption.
- b. Construction: All roundwood and sawn boards used for house frames, furniture, canoes, and bridges.
- c. Household tools and related products: All plants or plant parts used for house equipment, handicrafts, tools, poisons, shampoo, candles.
- d. Medicine (see Hoang et al. 2008a)
- e. Firewood: All plants that are used for firewood, including charcoal.
- f. Others: Plants used as ornamentals, wrapping material, or pulp and paper.

Plants with multiple uses fall into more than one category.

PLOT INVENTORY

For a detailed analysis of plant biodiversity patterns in the park (Hoang et al. 2008b), and to study the impact of local people on collecting useful plants in the wild (this study), we established 41 transects, 200 m long, at 250 m intervals at right angles to and along the old logging road from Song Chang forest ranger station to Cong Troi. The total length of these transects combined is ca. 7.4 km. We also established four 10×10 m plots at 50 m from the logging road and at 40 m forward intervals on each transect, resulting in ca. 147 plots for all transects combined (in some transects we were not able to establish 4 plots, because of steep, inaccessible limestone slopes). In each plot of 10×10 m, all trees with a dbh ≥ 5 cm were identified. In this study, we combined 4 plots in each transect into 1 larger plot (we use the term “0.04 ha plot” for these combined plots). We also established 6 transects to cover the rest of the park, with a total length of about 26 km. In each transect we noted all species and collected specimens of plants which could not be identified in the field. In all 6 transects, we established 30 random plots of 10×10 m and identified all species

in the plots. Furthermore we also collected many plants outside the plots and transects, to make sure that our inventory was as representative as possible of the entire species richness of the local flora.

DATA ANALYSIS

The database resulting from the ethnobotanical inventory was used to calculate a use index (UI) for each species by using the following equation: $UI = U_s/N$, where U_s is the number of households which mentioned a use for species s , and N is the total of households that were interviewed in the research area. This Use Index is a modification of the Use Value (UV), introduced by Phillips and Gentry (1993) and recently used by De Lucena et al. (2007), which is calculated from the relative number of times a species is mentioned by various informants in ethnobotanical inventories.

Simple regression analysis (SPSS 16.0) was used to examine whether the number of stumps and distances from villages to plots relate to number of useful plants and number of important timber trees, the relation between Use Index and number of useful plant species and number of important timber trees in plots, and the number of people in each household and number of useful plant species used by their households. Additionally, we used One Way ANOVA analysis to test if the number of useful plant species used is different among ethnic groups.

Study Area

Field work was conducted in Ben En National Park, situated in Nhu Thanh and Nhu Xuan districts of the Thanh Hoa province in Vietnam at 19° 40' N by 105° 21' to 105° 35' E. (Fig. 1). Before its establishment in 1986, the park was a logging enterprise, resulting in the fact that big trees with a diameter at breast height of over one meter were rarely observed during our field work. Ben En National Park was established as a protected area in 1986 and as a national park in 1992. Since then all logging activities have been illegal. The core zone of the national park covers 15,800 ha, while the buffer zone covers around 12,000 ha. About 18,000 people live in the buffer and core zones of the national park. (Tordoff et al. 2000). The majority of the people living in the national park belong to the Kinh, Thai, Muong, and Tay ethnic groups, although there are also a small number of Tho people. All ethnic groups

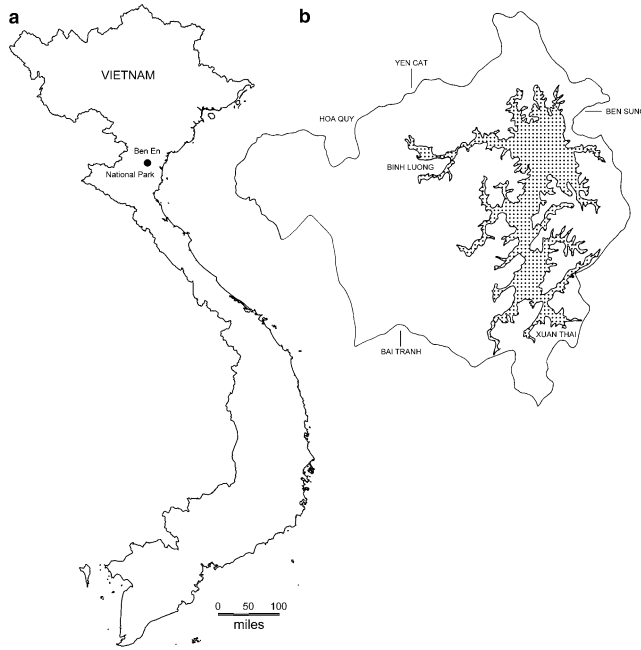


Fig. 1. a) Map of Vietnam. b) Map of Ben En National Park.

have their own languages, but all can communicate in the national King (Viet) language. Most households in the research area have their own home garden, varying in size from 100 to 2,000 sq.m, implying that 26% of the total land in the buffer zone is thus managed by local people. This includes 2,620 ha (8.4%) of secondary forest and poor forest lands, 2,256 ha (7.3%) of bare land or land with some small trees and shrubs, 443 ha (1.4%), of plantation forest, and 2,554 ha (8.2%) of agricultural land. There are plans to allocate more land to local households in the future. In some areas, land is being planted with sugar cane and cassava, and in other areas reforestation is taking place with *Eucalyptus camaldulensis*, (Myrtaceae), *Acacia mangium*, *Acacia auriculiformis* (Mimosaceae), *Hevea brasiliensis* (Euphorbiaceae), and fruit trees.

The interviews were carried out in three villages: Xuan Thai, Binh Luong, and Hoa Quy. Additional information on useful plants was collected in the Ben Sung, Yen Cat, and Xuan Thai markets and from several companies making furniture in and around the park. There are nine vegetation types in Ben En National Park (Hoang et al. 2008b); the vegetation of the core zone is dominated by tropical evergreen forest, which has been disturbed by human activities, principally by logging.

Results

DIVERSITY OF USEFUL PLANT SPECIES

A total of 208 plant species were found to be used by local people in Ben En National Park (excluding medicinal plant species, which are surveyed elsewhere, see Hoang et al. 2008a). These species belong to 130 genera and 64 families. A complete list of useful nonmedicinal plant species is given in Appendix 1.

From the 208 useful species, 59% are collected exclusively from the wild (primary, secondary, and logged-over forest); 31% of the species are cultivated in home gardens or in fields and mostly used as vegetables or for their fruits, e.g., *Mangifera indica* (Anacardiaceae), *Artemisia vulgaris* (Asteraceae), and *Diospyros kaki* (Ebenaceae); another 10% of the species are taken from the forest and planted in home gardens, e.g., *Garcinia cowa*, *Garcinia multiflora* (Clusiaceae), and *Dracontomelon dao* (Anacardiaceae).

PLANT PARTS USED

In Appendix 1, the different plant parts used of each species are indicated. Stems of trees, shrubs, and lianas are most commonly used, for construction, firewood, or handicrafts. Fruits and leaves are also commonly used, mostly for food.

Twenty-two species are used by local people as whole plants, mostly for ornamental purposes, e.g., *Euphorbia pulcherrima* (Euphorbiaceae), and *Acanthopanax trifoliatum* (Araliaceae). Some small plants are used as vegetables, such as *Centella asiatica* (Apiaceae). Local people use seeds, resin, branches, or bark of only a few species. For instance, seeds of *Michelia tonkinensis*, and *Michelia mediocris* (Magnoliaceae) are used as spice for food. Resin of *Canarium album* and *Canarium tramdenum* (Burseraceae) is used for making candles. Bark of *Artocarpus tonkinensis* (Moraceae) is chewed, together with leaves of *Piper betle* (Piperaceae) and fruits of *Areca catechu* (Areaceae)—this is a traditional custom in Vietnam.

DIVERSITY OF COMMODITY GROUPS

Table 1 shows the distribution of useful plants in the five end-use categories. The different commodity groups are discussed below.

Food

Food (fruits and vegetables) is the most important end-use category. Sixty wild species are collected from the forest, e.g., leaves of *Meliantha suavis* (Opiliaceae), *Maesa balansae* (Myrsinaceae), *Vernonia solaniflora* (Asteraceae), *Callipteris esculenta* (Athyriaceae), *Erythralium scandens* (Olacaceae), *Schefflera octophylla* (Araliaceae), fruits of *Baccaurea ramiflora* (Euphorbiaceae), and tubers of *Dioscorea persimilis* (Dioscoreaceae). A total of 64 wild species have already been introduced in home gardens or agricultural fields, such as *Polyscias fruticosa* (Araliaceae), *Telosma cordatum* (Asclepiadaceae), *Dracontomelon dao*, and *Spondias lakoensis* (Anacardiaceae). All households interviewed collect bamboo shoots of *Schizostachyum funghomii* (Poaceae) for food; 32% of the households also collect these shoots for trading, both fresh and dried in local markets,

and sell them to traders from Yen Cat, Ben Sung, and Bai Tranh, three neighboring towns at a distance of 8–20 km from Ben En.

Construction

Although Ben En was established as a national park in 1992, illegal logging by people inside and outside the park is still taking place. A total of 40 species are used by local people for construction and furniture, e.g., *Erythrophloeum fordii* (Caesalpinaceae), *Paviesia annamensis* (Sapindaceae), *Vatica odorata* (Dipterocarpaceae), *Actinodaphne obovata* (Lauraceae), and *Dysoxylum cauliflorum* (Meliaceae). Some rattan and bamboo species, such as *Dendrocalamus barbatus* and *Bambusa blumeana* (Poaceae), are used for construction of animal cages (pigs, cows, buffaloes, chickens), and some households still use leaves of the palm *Livistona chinensis* for thatching. The 15 most important local timber species, according to interviews with forest rangers and local people, and according to their stump frequency in the research plots (Hoang et al. 2008b; Hoang et al. in preparation), are listed in Table 2.

Firewood

All households in the research area still depend on firewood for their cooking, heating, and other energy sources. Twenty-five species were recorded for firewood use; most of them are collected from the forest, particularly forest land that belongs to the individual families. Small trees or branches are used that can easily be chopped into small pieces and quickly lit, from species such as *Xylopia pierrei* (Annonaceae), *Cratoxylum polyanthum* (Clusiaceae), *Melastoma normale*, or *Melastoma septemnerivium* (Melastomataceae). Some cultivated species are also used, such as *Acacia auriculaeformis*, *Acacia mangium* (Mimosaceae), *Eucalyptus camaldulensis* (Myrtaceae), *Pinus massoniana*, and *P. merkusii* (Pinaceae). Local people also make charcoal by burning the stumps and branches of *Erythrophloeum fordii* (Caesalpinaceae) that have already been cut for their timber.

TABLE 1. COMMODITY GROUPS OF USEFUL PLANTS IN BEN EN NATIONAL PARK.

Commodity group	Number of plant species	Percent/total (%)
Food	142	68
Construction	40	19
Firewood	25	12
Household tools and related products	18	9
Other	16	8

Household Tools and Related Products

A total of 18 species are used for household tools and related products, e.g., *Dendrocalamus barbatus*, *Bambusa blumeana*, and *Schizostachyum funghomii* (Poaceae) to make baskets; *Calamus balansaeanus*,

TABLE 2. IMPORTANT TIMBER TREES IN BEN EN NATIONAL PARK AND THEIR USE INDEX (UI).

Scientific Name	Family	Use Index (UI)
<i>Actinodaphne obovata</i> Blume	Lauraceae	0.65
<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & Bennet	Meliaceae	0.56
<i>Amesiodendron chinense</i> (Merr.) Hu	Sapindaceae	0.56
<i>Aphanamixis grandifolia</i> Blume	Meliaceae	0.53
<i>Dysoxylum cauliflorum</i> Hiern	Meliaceae	0.78
<i>Erythrophloeum fordii</i> Oliv.	Caesalpiniaceae	0.99
<i>Garcinia fagraeoides</i> A. Chev.	Clusiaceae	0.52
<i>Lagerstoemia calyculata</i> Kurz	Lythraceae	0.81
<i>Michelia mediocris</i> Dandy	Magnoliaceae	0.84
<i>Parashorea chinensis</i> Wang Hsie	Dipterocarpaceae	0.81
<i>Pavieasia annamensis</i> Pierre	Sapindaceae	0.85
<i>Peltophorum tonkinensis</i> Pierre	Caesalpiniaceae	0.54
<i>Phoebe paniculata</i> Nees	Lauraceae	0.66
<i>Vatica harmandiana</i> Pierre	Dipterocarpaceae	0.54
<i>Vatica odorata</i> (Griff.) Symington	Dipterocarpaceae	0.50

Calamus faberi, and *Calamus tetradactylus* (Arecaceae) for handicrafts, e.g., cane chairs and tables, pillows, boxes; and *Baeckea frutescens* for making brooms.

Other Uses

Only 11 species are used as ornamental plants in the research area, e.g., *Camellia amplexicaulis* (Theaceae), *Acanthopanax trifoliatum* (Araliaceae), *Cycas revoluta* (Cycadaceae), *Barringtonia acutangula* (Lecythidaceae), and several orchid species.

Leaves of *Phrynium placentarium* (Marantaceae) are used for wrapping rice cake. Twelve species are collected for paper making (e.g., *Acacia auriculaeformis*, *Acacia mangium* [Mimosaceae], and *Schizostachyum funghomii* [Poaceae]) and sold to a pulp mill in Lam Son, 15 km away from the park. *Pterocarya tonkinensis* (Juglandaceae) is used to stupefy fish: leaves are crushed and immersed in streams and ponds as a mild fish poison that immobilizes the fish but does not affect their edibility after the fish is caught in this way.

COMMERCIALIZATION OF USEFUL PLANTS

A total of 38 of the 208 useful species in the park are commercialized. Most of these species are sold to traders or in the local markets. The commercial plant species are listed in Appendix 2. Of these, 14 are cultivated in home gardens, mostly as fruit trees and vegetables, e.g., *Musa paradisiaca* (Musaceae), *Citrus maxima*, *Citrus sinensis* (Rutaceae), *Psidium guajava* (Myrtaceae), *Ocimum basilicum* (Lamiaceae), *Luffa cylindrica*, and *Lagenaria siceraria* (Cucurbitaceae). The remaining 24 commercial species are collected from the forest for a variety of end-uses, such as resin for candle manufacturing (from *Canarium album* and *Canarium tramdenum* [Burseraceae]) or leaves and shoots as vegetables (e.g., from *Meliantha suavis* [Opiliaceae] and *Schizostachyum funghomii* [Poaceae]). Illegal logging of 15 timber species (Table 2) for domestic use and trade is still ongoing. The most important species is *Erythrophloeum fordii* (Caesalpiniaceae). The timber is sold to traders or furniture manufacturers. Only 24

TABLE 3. ANNUAL INCOME PER HOUSEHOLD IN BEN EN NATIONAL PARK.

Resource	Income in US\$	Percentage (%)	Remark
Agriculture	150	36	Crops such as rice and corn
Livestock	100	24	Pigs, chickens, dogs, and cows
Nonmedicinal useful plants	50	12	See Appendix 2
Medicinal plants	45	11	See Hoang et al. 2008a
Others	75	17	Employment, fishing, trading, etc.
Total	420	100	

TABLE 4. GENDER AND AGE CLASSES OF LOCAL PEOPLE HARVESTING USEFUL PLANTS IN BEN EN NATIONAL PARK.

Age	Gender	Percentage of individuals harvesting useful plants (%)
> 50	Male	15
	Female	8
26–50	Male	34
	Female	23
16–25	Male	8
	Female	7
< 16	Male	3
	Female	2
Average % of Males		60
Average % of Females		40

families collect firewood for trade, but the income from it is low. Eight families produce charcoal for trading at a price of about USD 6/100 kg.

The income of each commercialized plant species is shown in Appendix 2. Income of local people per household in Ben En National Park is shown in Table 3.

WHO IS COLLECTING USEFUL PLANTS?

Interviews with households and key informants revealed that men collect useful plants more often than women at almost every age level, especially in the age range from 20 to 50 (Table 4). This is in contrast to medicinal plants, which are chiefly collected by women (Hoang et al. 2008a). Moreover, activities such as cutting timber, harvesting firewood, collecting honey, and making charcoal are almost all carried out by men. Young people participate more actively in collecting nonmedicinal useful plants than medicinal ones (Hoang et al. 2008a). However, people younger than 25 years are less active in collecting both nonmedicinal useful and medicinal plants than older people, because the older people in the research area have a better knowledge of useful plants, and many young people are employed outside the park (Hoang et al. 2008a).

IMPORTANCE OF USEFUL PLANTS FOR THE LOCAL COMMUNITIES

Firewood is considered to be the most important useful plant by local people, irrespective of which species is used. All households in the study area use firewood as the main fuel to cook food for people and pigs (pigs are also an important

source of income—see Table 3) and for heating. In fact, the prices of the alternative fuels like electricity, gas, and kerosene are too high and cannot be afforded by the local people, while firewood is freely available.

In addition to firewood, the bamboo shoots of *Schizostachyum funghomii* (Poaceae) are also very important because they are not only collected for local consumption, but also for generating cash. The average income from this species was US\$ 13/per year/per household in 2005. *Erythrophloeum fordii* (Caesalpiniaceae) is the most important timber species, not only for timber, but also for charcoal.

The use index of species varies widely (Appendix 1), from 0.01 to 1, indicating that some species are only used by 1% of all households (e.g., the orchid *Dendrobium aloideum* used by only two households for ornamental purposes), while others are used by virtually all households (e.g., onion, ginger, garlic, and sweet potato). Most species with UI higher than 0.75 are cultivated food plants, but some timber trees also have high use value, such as *Erythrophloeum fordii* (Caesalpiniaceae) (0.99), *Paviesia annamensis* (Sapindaceae) (0.85), *Michelia mediocris* (Magnoniaceae) (0.84), and *Parashorea chinensis* (Dipterocarpaceae) (0.81). The vast majority of species are, however, used by less than half of the households, and 37% of the useful species have use indices lower than 0.25.

CONSERVATION STATUS

A total of 8 plant species used by local people from Ben En National Park are listed in the IUCN Red Data List (IUCN 2006), and 11 species are listed in the Red Data Book of Vietnam (Ban 2007) (Table 5). Based on our plot inventories (density of living trees and stumps) and interviews with forest rangers and local people, a total of 27 species appears to be endangered, vulnerable, rare, or threatened in the park (Table 5). For instance, *Cycas revoluta*, and *Cycas chevalieri* (Cycadaceae) are rare in Ben En, and local people also collect these species for ornamental purposes, although the pressure of collecting is low and the market demand is not high. All the used timber tree species are illegally exploited by local people in Ben En, and trespassers are often caught by the forest ranger of the park. *Actinodaphne obovata*, *Phoebe paniculata* (Lauraceae), and *Erythrophloeum fordii* (Caesalpiniaceae) are not difficult to find in the

TABLE 5. USEFUL PLANTS IN BEN EN NATIONAL PARK LISTED IN THE IUCN RED LIST OF THREATENED SPECIES (2006), THE RED DATA BOOK OF VIETNAM (BAN 2007), AND CONSIDERED AS THREATENED SPECIES IN BEN EN NATIONAL PARK ON THE BASIS OF THIS STUDY.

Species	Family	Threat category	Threat category	Threat category
		in Red Data Book of Vietnam	in IUCN Red List 2006	in Ben En (this study)
<i>Actinodaphne obovata</i> Blume	Lauraceae	nl	nl	t
<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & Bennet	Meliaceae	vu	nl	t
<i>Alstonia scholaris</i> (L.) R. Br.	Apocynaceae	nl	lr	nl
<i>Amesiodendron chinense</i> (Merr.) Hu	Sapindaceae	nl	lr	t
<i>Aphanamixis grandifolia</i> Blume	Meliaceae	nl	nl	t
<i>Caesalpinia sappan</i> L.	Caesalpiniaceae	nl	nl	r
<i>Calamus platyacanthus</i> Warb. ex Becc	Arecaceae	vu	nl	r
<i>Calamus tetradactylus</i> Hance	Arecaceae	nl	nl	r
<i>Canarium trandenum</i> Dai et Yakovl	Burseraceae	vu	nl	r
<i>Chukrasia tabularis</i> A. Juss.	Meliaceae	vu	lr	nl
<i>Cycas chevalieri</i> Leandri	Cycadaceae	lr	cr	r
<i>Cycas revoluta</i> Thunb.	Cycadaceae	nl	nl	r
<i>Dysoxylum cauliflorum</i> Hiern	Meliaceae	vu	nl	t
<i>Erythrophloeum fordii</i> Oliv.	Caesalpiniaceae	nl	e	t
<i>Garcinia fagraeoides</i> A. Chev.	Clusiaceae	vu	nl	e
<i>Hopea odorata</i> Roxb.	Dipterocarpaceae	nl	nl	r
<i>Hopea chinensis</i> (Merr.) Hand.-Mazz.	Dipterocarpaceae	nl	cr	r
<i>Lagerstroemia calyculata</i> Kurz	Lythraceae	nl	nl	r
<i>Manglietia fordiana</i> Oliv.	Magnoniaceae	vu	nl	r
<i>Markhamia stipulata</i> (Wall.) Soem. ex Schum.	Bignoniaceae	vu	nl	e
<i>Melanthia suavis</i> Pierre	Opiliaceae	vu	nl	r
<i>Michelia mediocris</i> Dandy	Magnoliaceae	nl	nl	r
<i>Parashorea chinensis</i> (Wang Hsie) H. Zhu	Dipterocarpaceae	nl	e	t
<i>Pavieasia anamensis</i> Pierre	Sapindaceae	nl	nl	t
<i>Peltophorum tonkinensis</i> Pierre	Caesalpiniaceae	nl	nl	vu
<i>Phoebe paniculata</i> Nees	Lauraceae	nl	nl	t
<i>Vatica odorata</i> (Griff.) Symingtom	Dipterocarpaceae	nl	nl	r
<i>Vatica harmandiana</i> Pierre	Dipterocarpaceae	nl	e	r
<i>Vatica subglabra</i> Merr.	Dipterocarpaceae	en	nl	e

Key: en, e = endangered; vu = vulnerable; r = rare; t = threatened; k = insufficiently known; lr = least concern; cr = critically endangered; nl = not listed.

forest, but the intensity of harvesting these species by local people is high, and recent stumps were often seen during the field inventory. Additional species that are often confiscated by the forest ranger are *Garcinia fagraeoides* (Clusiaceae) and *Markhamia stipulata* (Bignoniaceae). These species are in high demand but rare in the forest, and thus locally endangered.

IMPACT OF LOCAL PEOPLE ON USEFUL PLANTS IN BEN EN NATIONAL PARK

Of all useful species in the park, 54 were recorded in the plot inventories (see Appendix 1). These species were further analyzed for impact of local use on their occurrence and density in the

plots (Hoang et al. in preparation). Most of these species are used for construction and firewood. Useful plants in general and important timber trees in particular are more abundant in remote (and less disturbed) plots than close to the villages (data not shown). Not surprisingly, the density of useful plant species, especially of important timber trees, is negatively correlated with the number of stumps found in each plot (Figs. 2 and 3).

RELATION OF USE INDEX, TREE DENSITY, AND NUMBER OF PEOPLE IN EACH HOUSEHOLD

There is a strong correlation between number of people in each household and number of useful plant species used by each household in the

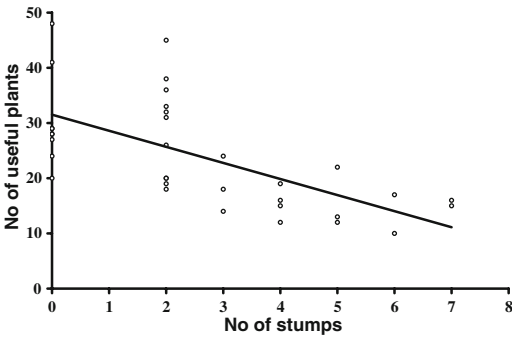


Fig. 2. Relation between the number of useful plants and number of stumps per 0.04 ha plot; $y=30.72 - 2.84x$; $R^2=0.45$.

park (Fig. 4). There are also weak but significant correlations between use index and the density of useful plants (Fig. 5).

Discussion

CONSERVATION OF USEFUL PLANT SPECIES IN BEN EN NATIONAL PARK

Local people, living in and around the park, still depend on natural resources. Dependence on these resources is highest in those communities living inside the core zone of the national park. The remoteness of these communities makes it difficult for people to bring building materials or other plant commodities from outside the park to their village. As a result, 27 useful plant species in Ben En National Park appear in danger of being lost locally; 16 of these are not recorded in the Red Book of Vietnam (Ban 2007). They are perhaps not only threatened in Ben En, but also in other parts of Vietnam, because the information on endangered

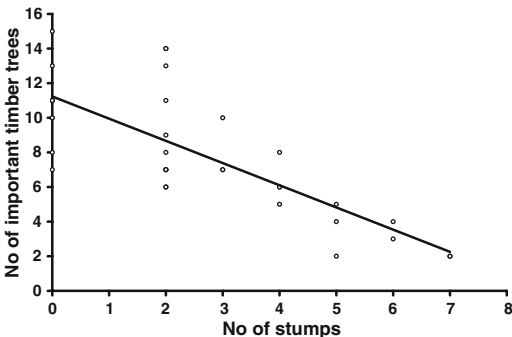


Fig. 3. Relation between the number of important timber trees and number of stumps per 0.04-ha plot; $y=11.34 - 1.29x$; $R^2=0.60$.

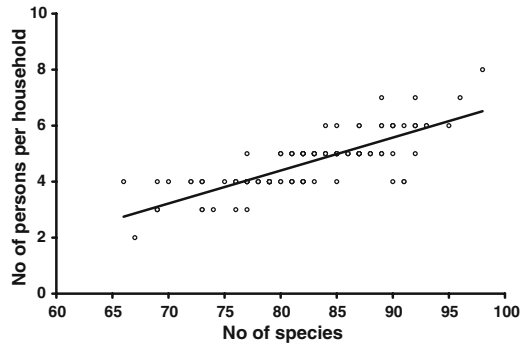


Fig. 4. Relation between number of persons in each household and number of useful plant species used. $y=0.12x - 5.02$; $R^2=0.64$.

species was—and still is—very incomplete. *Chukrasia tabularis* is listed both in the 2006 Red List of IUCN and the Red Book of Vietnam (Ban 2007); this species is endangered in nature, and it is rare in the natural forest. However, *Chukrasia tabularis* is planted widely in plantation forests in Vietnam, especially in and around Ben En National Park. Therefore, we did not list this species in the list of threatened species in Ben En. Another species, *Alstonia scholaris* (Apocynaceae), listed by IUCN (2006), is very common in plantations throughout the whole country. In contrast, *Garcinia fagraeoides* (Clusiaceae) is not on the IUCN list, but locally this species is endangered because of the high intensity of illegal logging and its rarity in the field inventories. *Markhamia stipulata* (Bignoniaceae) was an important timber tree for local people 5–10 years ago. However, this species has become endangered in Ben En: only a single tree with a diameter over 5 cm was found during the field inventory.

Recently illegal logging has decreased because of the strict protection by forest rangers (Hien 2006,

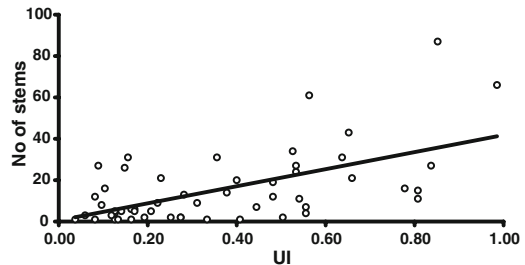


Fig. 5. Relation between number of stems per 0.04 ha plot and Use Index (UI) of 54 useful plant species. $y=42.22x + 0.56$; $R^2=0.34$.

2007). Local people also obtain land to plant trees. However, some illegal logging is still carried out in the Dong Tho, Song Chang, Duc Luong, and Bai Tranh areas. In order to reduce the impact of local people on forest resources and to improve their living conditions, the Vietnamese Government issued Decree 02/CP in 1994, making it possible to allocate forest land to individual households for protection and re-plantation, and that policy still applies in the whole country. In some buffer zones of national parks, land is being planted with sugar cane and cassava; in others reforestation is taking place with *Eucalyptus camaldulensis*, *Acacia mangium*, *Acacia auriculiformis*, and various fruit trees. This could reduce the pressure from local people on the park in general and in the core zone in particular. Additionally, local people should be encouraged to cultivate plant species in home gardens, using modern techniques that would increase the yield of commonly used and commercialized species.

IMPACT OF LOCAL PEOPLE ON USEFUL PLANTS

Our analysis of the occurrence and densities of useful plants in the plots (only 54 species out of the 208) has shown a significant and negative impact of harvesting and illegal logging near villages. It must be feared that—without appropriate measures—plant resources will in the future also become depleted in more remote areas. A more detailed assessment of the impact of local people on plant species diversity and species densities throughout the park is currently in preparation (Hoang et al. in preparation).

SOME FACTORS AFFECTING PLANT USE

We found no differences among ethnic groups regarding plant use (data not shown), but instead a significant relationship between the size of households and the number of species used per household. According to Philips and Gentry (1993), Johns et al. (1990), and De Lucena et al. (2007), traditional plant use is strongly influenced by factors such as abundance in the forest and plant size and conspicuousness of individual species. Our analysis of the Use Index (UI) and other indicators of plant uses such as species ranking by informants and commercial value to some extent confirm this: in the plots, species with a high UI are indeed more common than species with a low UI (Fig. 5), and all very useful commercial timber trees (both by species

ranking and high UI, Table 2) are indeed big and conspicuous. There are, however, major exceptions to these trends: several important timber tree species with high UI are of very infrequent occurrence in all plots, e.g., *Vatica odorata* (UI = 0.50), *Parashorea chinensis* (0.81) *Amesiodendron chinense* (0.56), and *Garcinia fagraeoides* (0.52) (Hoang et al. in preparation). Also, several species with very high UI are inconspicuous, small plants in the forest, e.g., *Artemisia vulgaris* (0.52), *Hydrocotyle sibthorpioides* (0.67), *Bauhinia coccinea* (0.69), and *Perilla frutescens* (0.57) (cf. Appendix 1). For many cultivated plant species, there is an interesting discrepancy between the calculated UI and the relatively low ranking given in the PRA questionnaires (results not shown), suggesting that local people take many cultivated species “for granted” in their response to our interviews using PRA techniques.

The Use Index spectrum for nonmedicinal useful plants is quite different from that of medicinal plants (Hoang et al. 2008a): for medicinal plant species, the vast majority (68%) have low UI values (< 0.25), and only 8% have high values > 0.75 (for the nonmedicinal plants these values are 32% and 16%, respectively). This indicates that traditional medicinal use of wild plant species is less common than the use of nonmedicinal plants, perhaps because in many households the knowledge of or confidence in the therapeutic efficacy of a certain species is low, while nonmedicinal uses are much more straightforward.

VALUATION OF TRADITIONAL PLANT USE

The contribution to income generation of nonmedicinal and medicinal plants collected in the wild or grown in home gardens was calculated to amount to 23% or USD 95 per household per annum (Table 3). These figures are only rough approximations since they are based on interviews with local people and on market inventories, each with their own sources of error and imprecision. Nevertheless, the total economic value of traditional plant use far exceeds this monetary component for the people of Ben En National Park, since it offers important commodities such as vegetables, fruits, condiments, fuel, construction materials, medicines, etc., “free of monetary charge,” but in return for fairly light collecting and plant cultivation efforts. It would be interesting to calculate the monetary equivalents for all these free commodities, but our data unfortunately do not allow this. Conversely, the costs of overexploitation and

ecological degradation should also be modeled—an even more difficult exercise, beyond the scope of this study.

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APPENDIX 1. PLANT SPECIES USED BY LOCAL PEOPLE IN BEN EN NATIONAL PARK.

Scientific name	Common name	Use index	Wild/Cultivated	Part utilized	Use
Ferns					
Gleicheniaceae					
<i>Dicranopteris linearis</i> (Burm.) Underw.	Họ Guột	0.28	W	Whole plant	Firewood
Marsileaceae					
<i>Marsilea quadrifolia</i> L.*	Họ Rau Bợ	0.14	W	Leaves	Food
Woodsiaceae					
<i>Diplazium esculentum</i> (Retz.) Sw.	Ráng gỗ nhỏ	0.30	W	Leaves	Food
Gymnosperms					
Cycadaceae					
<i>Cycas chevalieri</i> Leandri	Ngành	0.12	W	Whole plant	Ornamental
<i>Cycas revoluta</i> Thunb.	Vạn tuế	0.08	W	Whole plant	Ornamental
Gnetaceae					
<i>Gnetum gnemon</i> L.	Họ Dây gắm	0.29	W	Fruit	Food
Pinaceae					
<i>Pinus massoniana</i> D. Don	Họ Thông	0.33	W,C	Branch, stem	Construction, firewood
<i>Pinus merkusii</i> Jungb. & de Vriese	Thông nhựa	0.36	W,C	Branch, stem	Construction, firewood
Angiosperms					
Dicotyledons					
Amaranthaceae					
<i>Alternanthera sessilis</i> (L.) A. DC.	Họ Rau Dền	0.24	W	Leaves	Food
<i>Amaranthus spinosus</i> L.	Rau diếp dại	0.26	C	Leaves	Food
<i>Amaranthus tricolor</i> L.	Dền cơm	0.08	C	Leaves	Food
Anacardiaceae					
<i>Dracontomelon dao</i> (Blanco) Merr. & Rolfe	Họ Xoài	0.19	W,C	Fruit, leaves, stem	Food, construction
<i>Mangifera indica</i> L.	Sầu	0.43	C	Fruit	Food
<i>Mangifera reba</i> Pierre	Xoài	0.06	W,C	Fruit	Food
<i>Spondias axillaris</i> Roxb.	Qué	0.08	W	Fruit	Food
<i>Spondias lakoensis</i> Pierre * +	Xoan nhừ	0.25	W,C	Fruit	Food
Annonaceae					
<i>Annona squamosa</i> L. *	Họ Na	0.16	C	Fruit	Food
<i>Xylopia vielana</i> Hance * +	Na	0.91	W	Stem	Firewood
Apiaceae					
<i>Anethum graveolens</i> L.	Họ Hoa Tán	0.27	C	Leaves, stem	Food
<i>Centella asiatica</i> (L.) Urb. *	Thì là	0.30	W	Whole plant	Food
<i>Coriandrum sativum</i> L.	Rau má	0.32	C	Leaves, stem	Food
<i>Eryngium foetidum</i> Thunb.	Rau mùi	0.31	C	Leaves, stem	Food
<i>Hydrocotyle sibthorpioides</i> Lamk.	Mùi tàu	0.67	W	Whole plant	Food
Apocynaceae					
<i>Alstonia scholaris</i> (L.) R. Br. *	Họ Trúc Đào	0.04	W	Whole plant	Ornamental
<i>Holarrhena antidysenterica</i> Wall.	Sữa	0.04	W	Whole plant	Ornamental
Aquifoliaceae					
<i>Ilex macrocarpa</i> Oliv.	Họ Nhựa ruối	0.07	W	Leaves	Drink
<i>Ilex rotunda</i> Thunb. +	Bùi quả to	0.08	W	Leaves	Drink
Araliaceae					
<i>Acanthopanax aculeatum</i> Seem.	Họ Ngũ ra bì	0.07	W	Whole plant	Ornamental
<i>Polyscias fruticosa</i> Harms	Ngũ ra bì	0.42	C	Leaves	Food
<i>Schefflera alpina</i> Grushv. & Skvorts.	Đỉnh lăng	0.30	W	Leaves	Food
<i>Schefflera octophylla</i> Harms *+	Chân chim	0.48	W	Leaves	Food
Asclepiadaceae					
<i>Telosma cordata</i> Merr.*	Họ Thiên lý	0.26	C	Flower	Food
Asteraceae					
<i>Artemisia vulgaris</i> L. *	Họ Cúc	0.52	C	Leaves	Food
	Ngải cứu				

Scientific name	Common name	Use index	Wild/Cultivated	Part utilized	Use
<i>Artemisia japonica</i> Thunb.	Ngải cứu rừng	0.16	W	Leaves	Food
<i>Gynura crepidioides</i> Benth *	Rau tàu bay	0.21	W	Leaves	Food
<i>Lactuca indica</i> L.	Bồ công anh	0.36	W	Leaves	Food
<i>Vernonia andersonii</i> C. B. Clarke	Dây rau ráu	0.22	W	Leaves	Food
Basellaceae	Họ Mồng tơi				
<i>Basella alba</i> L.	Mồng tơi	0.70	C	Leaves	Food
Bignoniaceae	Họ Đinh				
<i>Markhamia stipulata</i> Seem ex Schum.+	Đinh	0.41	W	Stem	Construction
<i>Oroxylum indicum</i> (L.) Benth. ex Kurz* +	Núc nác	0.13	W	Fruit	Food
Brassicaceae	Họ Cải				
<i>Brassica chinensis</i> L.	Cải bẹ trắng	0.91	C	Leaves	Food
<i>Brassica integrifolia</i> West.	Cải ngọt	0.73	C	Leaves	Food
<i>Brassica juncea</i> (L.) Czern.	Cải canh	0.74	C	Leaves	Food
<i>Raphanus sativus</i> L.	Cải củ	0.70	C	Leaves, tuber	Food
Bursaceae	Họ Trám				
<i>Canarium album</i> Rauesch.+	Trám trắng	0.53	W	Resin, fruit	Candles, food
<i>Canarium tonkinensis</i> L.+	Trám chim	0.27	W	Resin, fruit	Candles, food
<i>Canarium tramdenum</i> Dai & Yakovl.+	Trám đen	0.53		Resin	Candles
Caesalpinjiaceae	Họ Vang		W,C	Whole plant	Ornamental
<i>Bauhinia variegata</i> L.	Ban	0.04	W	Stem	Drink
<i>Bauhinia coccinea</i> DC	Quạch	0.69	W	Stem, branch	Drink
<i>Caesalpinia sappan</i> L. *	Vang	0.07	W	Fruit	Shampoo
<i>Gleditsia australis</i> Hemsl. ex Forb. & Hemsl.+	Bồ kết	0.25			
<i>Erythropheum fordii</i> Oliv.+	Lim xanh	0.99	W	Stem	Construction
<i>Peltophorum tonkinensis</i> Pierre+	Lim xẹt	0.54	W	Stem	Construction
<i>Tamarindus indica</i> L.	Me	0.20	W	Fruit	Food
Caricaceae	Họ Đu đủ				
<i>Carica papaya</i> L. *	Đu đủ	0.40	C	Fruit	Food
Clusiaceae	Họ Măng cụt				
<i>Cratoxylum polyanthum</i> Korth. *	Thành ngạnh	0.18	W	Whole plant	Firewood
<i>Garcinia fagraeoides</i> A. Chev.+	Trái lý	0.52	W	Stem	Construction
<i>Garcinia cowa</i> Roxb.	Tai chua	0.16	W,C	Fruit, leaves	Food
<i>Garcinia multiflora</i> Champ. ex Benth.	Dọc	0.22	W,C	Fruit, leaves	Food
<i>Garcinia oblongifolia</i> Champ. ex Benth.*+	Bứa	0.23	W	Fruit, leaves	Food
Convolvulaceae	Họ Bìm bịp				
<i>Ipomoea batatas</i> (L.) Lam	Khoai lang	0.99	C	Tuber, leaves	Food
<i>Ipomoea aquatica</i> Foir.	Rau muống	0.99	C	Leaves, stem	Food
Cucurbitaceae	Họ Bầu bí				
<i>Benincasa hispida</i> (Thunb.) Cogn.	Bí xanh	0.27	C	Fruit	Food
<i>Cucurbita maxima</i> Lam*	Bí đỏ	0.30	C	Fruit	Food
<i>Lagenaria siceraria</i> (Molina) Staney	Bầu	0.26	C	Fruit, leaves	Food
<i>Luffa aegyptiaca</i> M. Roem.	Mướp	0.88	C	Fruit	Food
<i>Momordica charantia</i> L.	Mướp đắng	0.20	C	Fruit	Food
<i>Momordica cochinchinensis</i> (Lour.) Spreng *	Gấc	0.42	C	Fruit	Food
Dilleniaceae	Họ Sỗ				
<i>Dillenia heterosepala</i> Finet & Gagnep.	Lọng bàng	0.10	W	Fruit, stem	Food, firewood
<i>Dillenia indica</i> L.+	Sỗ	0.10	W	Fruit, stem	Food, firewood
Dipterocarpaceae	Họ Dầu				
<i>Hopea odorata</i> Roxb.	Sao đen	0.56	W	Stem	Construction
<i>Hopea chinensis</i> (Merr.) Hand.-Mazz.+	Sao	0.39	W	Stem	Construction
<i>Parashorea chinensis</i> Wang Hsie +	Chò chỉ	0.81	W	Stem	Construction
<i>Vatica harmandiana</i> Pierre+	Tầu nước	0.54	W	Stem	Construction
<i>Vatica odorata</i> (Griff.) Symington+	Tầu mật	0.50	W	Stem	Construction

Scientific name	Common name	Use index	Wild/Cultivated	Part utilized	Use
<i>Vatica subglabra</i> Merr.	Táo xanh	0.20	W	Stem	Construction
Ebenaceae	Họ Thị				
<i>Diospyros decandra</i> Lour. *	Thị	0.42	C	Fruit	Food
<i>Diospyros kaki</i> L.f.	Hồng	0.33	C	Fruit	Food
Elaeagnaceae	Họ Nhót				
<i>Elaeagnus bonii</i> Lecomte *	Nhót	0.18	W	Fruit	Food
<i>Elaeagnus tonkinensis</i> Serv.	Nhót nhà	0.33	C	Fruit	Food
Euphorbiaceae	Họ Thầu Dấu				
<i>Baccaurea ramiflora</i> Lour. *+	Dâu da đất	0.44	W	Fruit	Food
<i>Bischofia javanica</i> Blume *+	Nhội	0.21	W	Leaves	Food
<i>Breynia fleuryi</i> Beille *	Bồ cu vẽ	0.05	W	Leaves	Food
<i>Euphorbia pulcherrima</i> Willd. ex Klotzsch	Trạng nguyên	0.06	W,C	Whole plant	Ornamental
<i>Euphorbia hirta</i> L. *	Cỏ sữa	0.10	W	Whole plant	Drink
<i>Macaranga denticulata</i> Mull. Arg.+	Lá nèn	0.10	W	Stem	Firewood
<i>Mallotus paniculatus</i> (Lam) Mull. Arg.+	Ba soi	0.38	W	Stem	Firewood
<i>Manihot esculenta</i> Crantz	Sắn	0.80	C	Tuber	Food
<i>Phyllanthus emblica</i> L.	Me rừng	0.19	W	Fruit	Food
<i>Sauropus androgynus</i> Merr.	Rau ngót	0.39	C	Stem	Food
<i>Vernicia montana</i> Lour.+	Trầu	0.17	W,C	Fruit	Oil, firewood
Fabaceae	Họ Đậu				
<i>Lablab purpureus</i> (L.) Sweet	Đậu ván	0.29	C	Fruit	Food
<i>Pachyrhizus erosus</i> (Lour.) Merr.	Củ đậu	0.19	C	Tuber	Food
<i>Pueraria phaseoloides</i> Benth.*	Sắn dây	0.33	C	Tuber	Food
<i>Sophora japonica</i> L. *	Hoè	0.21	W,C	Flower, fruit	Drink
<i>Tephrosia candida</i> DC.	Cốt khí	0.16	W,C	Whole plant	Firewood
<i>Vigna radiata</i> (L.) Wilczek.	Đậu xanh	0.42	C	Fruit	Food
<i>Vigna unguiculata</i> (L.) Walp.	Đậu đen	0.45	C	Fruit	Food
Fagaceae	Họ Dẻ				
<i>Castanopsis boisii</i> Hickel & Camus+	Dẻ ăn quả	0.14	W	Fruit, stem	Food, construction
<i>Castanopsis indica</i> A. DC+	Cà ổi	0.13	W	Stem	Firewood, construction
<i>Lithocarpus pseudosundaicus</i> (Hick. & A. Camus) A. Camus+	Sồi xanh	0.17	W	Stem	Construction
<i>Quercus platycalyx</i> Hick. & A. Camus+	Dẻ cau	0.12	W	Stem	Construction
Flacourtiaceae	Họ Mông quân				
<i>Flacourtia balansae</i> Gagnep.+	Mông quân	0.09	W	Fruit	Food
Hamamelidaceae	Họ Sau sau				
<i>Liquidambar formosana</i> Hance	Sau sau	0.26	W	Leaves, resin	Food, candles
Juglandaceae	Họ Hồ đào				
<i>Engelhardtia chrysolepsis</i> Hance+	Chẹo tía	0.22	W	Stem	Firewood
<i>Pterocarya tonkinensis</i> Dode	Cơi	0.13	W	Leaves	Fishing
Lamiaceae	Họ Hoa môi				
<i>Acrocephalus indicus</i> Kuntze	Nhân trần	0.41	W	Stem, leaves	Drink
<i>Mentha crispa</i> L.	Húng	0.53	C	Leaves	Food
<i>Ocimum basilicum</i> L.	Húng quế	0.42	C	Leaves	Food
<i>Perilla frutescens</i> Britton.	Tía tô	0.57	C	Leaves	Food
Lauraceae	Họ Long não				
<i>Actinodaphne obovata</i> Blume+	Song xanh	0.65	W	Stem	Construction
<i>Beilschmiedia poilanei</i> H. Liou+	Chấp	0.04	W	Stem	Construction
<i>Beilschmiedia ferruginea</i> H. Liou+	Chấp xanh	0.16	W	Stem	Construction
<i>Cinnamomum cassia</i> Blume *	Quế	0.50	W,C	Bark	Spice
<i>Litsea cubeba</i> Pers. *	Mãng tang	0.38	W	Leaves, fruit	Spice
<i>Machilus bonii</i> Lecomte+	Kháo vàng	0.40	W	Stem	Construction

Scientific name	Common name	Use index	Wild/Cultivated	Part utilized	Use
<i>Phoebe paniculata</i> Nees+	Kháo nước	0.66	W	Stem	Construction
Lecythidaceae	Lộc vùng				
<i>Barringtonia acutangula</i> (L.) Gaertn.	Lộc vùng	0.04	W, C	Whole plant	Ornamental
Lythraceae	Họ Sang lẻ				
<i>Lagerstoemia calyculata</i> Kurz+	Sang lẻ	0.81	W	Stem	Construction
Magnoliaceae	Họ Ngọc Lan				
<i>Michelia mediocris</i> Dandy+	Giôi xanh	0.84	W	Seed, stem	Spice, construction
<i>Michelia tonkinensis</i> A. Chev.+	Giôi bắc bộ	0.24	W	Seed, stem	Spice, construction
<i>Manglietia conifera</i> Dandy	Mỡ	0.32	W,C	Stem	Construction
<i>Manglietia fordiana</i> Oliver+	Vàng tâm	0.29	W,C	Stem	Construction
Melastomataceae	Họ Mua				
<i>Melastoma normale</i> D. Don *	Mua	0.12	W	Stem, fruit	Firewood, food
<i>Melastoma septemnerium</i> Merr.	Mua đồi	0.28	W	Stem, fruit	Firewood, food
Meliaceae	Họ Xoan				
<i>Aphanamixis grandifolia</i> Blume+	Gội trắng	0.53	W	Stem	Construction
<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & Bennet+	Gội nếp	0.56	W	Stem	Construction
<i>Chukrasia tabularis</i> A. Juss.	Lát hoa	0.52	W,C	Stem	Construction
<i>Dysoxylum cauliflorum</i> Hiern+	Đinh hương	0.78	W	Stem	Construction
<i>Melia azedarach</i> L. *	Xoan ta	0.61	C	Stem	Construction
Mimosaceae	Họ Trinh nữ				
<i>Acacia auriculaeformis</i> A. Cunn. ex Benth.	Keo lá trăm	0.90	C	Stem	Construction, paper, firewood
<i>Acacia mangium</i> Willd.	Keo Tai tượng	0.87	C	Stem	Construction, paper, firewood
Moraceae	Họ Dâu tằm				
<i>Antiaris toxicaria</i> Lesch.+	Sui	0.31	W	Bark, stem	Twine, firewood
<i>Artocarpus heterophyllus</i> Lam.	Mít	0.65	C	Fruit, stem	Food, firewood
<i>Artocarpus tonkinensis</i> A. Chev. *	Chay	0.16	W,C	Fruit, bark	Food, to chew betel
<i>Broussonetia papyrifera</i> Vent. *	Dướng	0.07	W	Leaves, stem	Firewood, twine
<i>Ficus auriculata</i> Lour. *+	Vả	0.23	W	Fruit, stem	Food, firewood
<i>Morus alba</i> L.	Dâu tằm	0.22	C	Fruit	Food
Myrsinaceae	Họ Đơn nem				
<i>Embelia laeta</i> Mez	Ngút trắng	0.19	W	Leaves	Food
<i>Embelia oblongifolia</i> (Benth.) Hemsl.	Chua ngút lá dài	0.10	W	Leaves	Food
<i>Maesa balansae</i> Mez	Đơn nem	0.11	W	Leaves	Food
Myrtaceae	Họ Sim				
<i>Baeckea frutescens</i> L.	Thanh Hao	0.09	W	Whole plant	Brooms, firewood
<i>Cleistocalyx operculatus</i> Merr. & L.M. Perry	Trâm vôi	0.19	W	Leaves	Drink
<i>Eucalyptus camaldulensis</i> Dehnh.*	Bạch đàn trắng	0.58	C	Stem	Construction, firewood, paper
<i>Psidium guajava</i> L. *	Ổi	0.68	C	Fruit	Food
<i>Rhodomirtus tomentosa</i> Hassk. *	Sim	0.38	W	Fruit	Food
<i>Syzygium polyanthum</i> Walp.+	Sắn thuyền	0.28	W	Leaves	Food
Olacaceae	Họ Bù Khai				
<i>Erythrolalum scandens</i> Blume	Bù Khai	0.37	W	Leaves	Food
Opiliaceae	Họ Rau sắng				
<i>Meliantha suavis</i> Pierre+	Rau sắng	0.58	W	Leaves	Food

Scientific name	Common name	Use index	Wild/Cultivated	Part utilized	Use
Oxalidaceae	Họ Chua me				
<i>Oxalis corniculata</i> L. *	Chua me	0.25	W	Whole plant	Food
Piperaceae	Hồ tiêu				
<i>Piper betle</i> L. *	Trầu không	0.53	C	Leaves	Chewing betel
<i>Piper lolot</i> C. DC. *	Lá lốt	0.96	W, C	Leaves	Food
Rhamnaceae	Họ Táo				
<i>Ziziphus mauritiana</i> Lam. *	Táo nhà	0.92	C	Fruit	Food
<i>Ziziphus oenoplia</i> (L.) Mill.	Táo rừng	0.42	W	Fruit	Food
Rosaceae	Họ Hoa Hồng				
<i>Rubus alcaefolius</i> Poir.	Mân xôi	0.60	W	Fruit	Food
<i>Rubus cochinchinensis</i> Tratt. *	Ngây	0.36	W	Fruit	Food
Rutaceae	Họ Cam				
<i>Acronychia pedunculata</i> Miq.	Bưởi bung	0.53	W	Fruit	Food
<i>Clausena dunniana</i> H. Lev. +	Hồng bì rừng	0.36	W	Fruit	Food
<i>Clausena indica</i> Oliver+	Mắc mật	0.33	W	Fruit	Food
<i>Clausena lansium</i> Skeels *+	Hồng bì	0.19	C	Fruit	Food
<i>Citrus aurantifolia</i> Swingle	Chanh	0.95	C	Fruit, leaves	Food
<i>Citrus maxima</i> Osbeck	Bưởi	0.81	C	Fruit	Food
<i>Citrus sinensis</i> Osbeck	Cam	0.79	C	Fruit	Food
Sapindaceae	Họ Bồ hòn				
<i>Dimorcarpus longan</i> Lour.	Nhãn	0.96	C	Fruit	Food
<i>Litchi chinensis</i> Sonn.	Vải	0.95	C	Fruit	Food
<i>Amesiodendron chinense</i> (Merr.) Hu+	Trường Sâm	0.56	W	Stem	Construction
<i>Mischocarpus pentapetalus</i> Radlk. +	Trường kẹn	0.15	W	Stem	Construction
<i>Pavieasia annamensis</i> Pierre+	Trường mật	0.85	W	Stem	Construction
Sapotaceae	Họ Hồng xiêm				
<i>Achras sapota</i> L.	Hồng xiêm	0.19	C	Fruit	Food
<i>Chrysophyllum cainito</i> L.	Vú sữa	0.20	C	Fruit	Food
<i>Pouteria sapota</i> (Jacq.) H. E. Moore & Stearn.	Trứng gà	0.50	C	Fruit	Food
Theaceae	Họ Chè				
<i>Camellia amplexicaulis</i> Cohen-Stuart+	Hải đường				
<i>Camellia sinensis</i> Kuntze *	Chè	0.23	W	Whole plant	Ornamental
Tiliaceae	Họ Đay				
<i>Microcos paniculata</i> L. +	Cò ke	0.16	W	Stem	Firewood
Ulmaceae	Họ Đu				
<i>Trema orientalis</i> (L.) Blume *	Hu đay	0.22	W	Stem	Firewood
Monocotyledons	Lớp Hành				
Alliaceae	Họ Hành				
<i>Allium fistulosum</i> L. *	Hành	0.99	C	Whole plant	Spice, food
<i>Allium sativum</i> L. *	Tỏi	1.00	C	Whole plant	Spice, food
Areaceae	Họ Cau Dừa				
<i>Areca catechu</i> L. *	Cau	0.56	C	Fruit, stem	Chewing betel, firewood
<i>Calamus balansaeanus</i> Becc.	Mây nước				
<i>Calamus faberi</i> Becc.	Mây thủ công	0.36	W	Stem	Handicrafts
<i>Calamus platyacanthus</i> Warb. ex Becc.	Song mật	0.19	W	Stem	Handicrafts
<i>Calamus tetradactylus</i> Hance	Mây mật	0.36	W	Stem	Handicrafts
<i>Caryota mitis</i> Lour. *	Đùng đình	0.79	W	Stem	Handicrafts
<i>Cocos nucifera</i> L.	Dừa	0.21	W	Stem	Handicrafts, food
<i>Daemonorops longispathus</i> Becc.	Hèo	0.67	C	Fruit, stem	Food, firewood
<i>Livistona chinensis</i> (Jacq.) R. Br. & Mart.	Cọ	0.38	W	Stem	Handicrafts
Costaceae	Họ Mía dò				
<i>Costus speciosus</i> (Koenig) Smith	Mía dò	0.35	C	Leaves, fruit	Oil, roofs
Dioscoreaceae	Họ Củ nâu				
		0.36	W	Stem	Food

Scientific name	Common name	Use index	Wild/Cultivated	Part utilized	Use
<i>Dioscorea cirrhosa</i> Lour. *	Củ nâu	0.34	W	Tuber	Food
<i>Dioscorea persimilis</i> Prain & Burk *	Củ mài	0.19	W	Tuber	Food, to plaster board
Marantaceae	Họ Lá Dong				
<i>Phrynium placentarium</i> (Lour.) Merr.	Lá dong	0.95	W	Leaves	Wrapping cakes
Musaceae	Họ Chuối				
<i>Musa basjoo</i> Sieb.	Chuối ngự	0.97	C	Fruit, flower bud, stem	Food
<i>Musa balbisiana</i> Colla	Chuối hột	0.39	C	Fruit, flower bud, stem	Food
<i>Musa acuminata</i> Colla	Chuối rừng	0.21	W	Fruit, flower bud, stem	Food
<i>Musa paradisiaca</i> L.	Chuối tiêu	0.94	C	Fruit, flower bud, stem	Food
Orchidaceae	Họ Phong lan				
<i>Cymbidium lowianum</i> Reichb.f.	Phong lan	0.06	W	Whole plant	Ornamental
<i>Dendrobium aloideum</i> La Llave & Lex.	Hoàng thảo	0.01	W	Whole plant	Ornamental
Phormiaceae	Họ Hương bài				
<i>Dianella nemorosa</i> Lam. *	Hương bài	0.04	W	Whole plant	Incense
Poaceae	Họ Cỏ				
<i>Arundinaria sat</i> Balansa	Sắt	0.50	W	Stem	Firewood
<i>Bambusa blumeana</i> Schult. f.	Tre gai	0.41	C	Stem, shoot	Construction, food, tools
<i>Cymbopogon citratus</i> Stapf*	Sả	0.51	C	Tuber	Food
<i>Dendrocalamus barbatus</i> Hsueh & D.Z.Li	Luồng	0.78	C	Stem, shoot	Paper, construction, food, tools
<i>Indosasa angustata</i> McClure	Vầu đắng	0.37	W	Stem, shoot	Food, construction
<i>Indosasa sinica</i> C.D. Chu & C.S.Chao	Vầu ngọt	0.33	W	Stem, shoot	Food, construction
<i>Panicum miliaceum</i> L.	Kê	0.36	C	Seed	Food
<i>Saccharum officinarum</i> L.	Mía	0.96	C	Stem	Food
<i>Schizostachyum funghomii</i> McClure	Nứa	0.99	W	Stem, shoot	Paper, food, tools
Zingiberaceae	Họ Gừng				
<i>Curcuma longa</i> L. *	Nghệ	0.97	C	Tuber, leaves	Spice, food
<i>Curcuma zedoaria</i> Rosc.*	Nghệ đen	0.39	W,C	Tuber	Spice, food
<i>Zingiber officinale</i> Rosc. *	Gừng	0.99	C	Tuber	Spice, food

Wild/Cultivated: W = Wild, C = Cultivated.

*Species are also use for medicinal plant purposes (see Hoang et al. 2008a).

+Species recorded in plots.

APPENDIX 2. COMMERCIAL USEFUL PLANT SPECIES IN BEN EN NATIONAL PARK.

Scientific name	Abundance in the wild or cultivated	Intensity of collection	Price in US\$	Income/ household/ year in US\$	Market demand
Anacardiaceae					
<i>Dracontomelon dao</i> (Blanco) Merr. & Rolfe	Cultivated		Not stable	0.5	Medium
<i>Mangifera indica</i> L.	Cultivated		0.07/2fruits	0.6	Medium
<i>Spondias lakoensis</i> Pierre	Cultivated		Not stable	0.1	Medium
Annonaceae					
<i>Annona squamosa</i> L.	Cultivated		0.07/3 fruits	0.6	Medium
Araliaceae					
<i>Schefflera alpina</i> Grushv. & Skvorts.	High	Medium	Not stable	0.2	Medium
<i>Schefflera octophylla</i> Harms	High	Medium	0.28/kg	1	Medium
Burseraceae					
<i>Canarium tonkinensis</i> L.	Medium	High	1.3/kg resin	1.2	High
<i>Canarium album</i> Rauesch.	Medium	High	0.07/kg fruit 1.3/kg resin	2.9	Medium High
<i>Canarium tramdenum</i> Dai & Yakovlev	Medium	High	1.3/kg resin	1.1	High
Caesalpinjiaceae					
<i>Gleditsia australis</i> Hemsl. ex Forb. & Hemsl.	Low	Medium	0.07/4 fruits	0.2	Medium
<i>Tamarindus indica</i> L.	Low	High	0.07/6 fruits	0.2	Medium
Clusiaceae					
<i>Garcinia cowa</i> Roxb.	Low	Medium	0.07/5 fruits	0.5	Medium
<i>Garcinia multiflora</i> Champ. ex Benth.	Medium	Medium	0.07/4 fruits	0.8	Medium
Ebenaceae					
<i>Diospyros decandra</i> Lour.	Cultivated		0.07/6 fruits	0.8	Medium
<i>Diospyros kaki</i> L.f.	Cultivated		0.07/6 fruits	1.0	Medium
Euphorbiaceae					
<i>Vernicia montana</i> Lour.	Medium	High	0.17/kg fruit	0.2	Medium
Lamiaceae					
<i>Acrocephalus indicus</i> Kuntze	Medium	Medium	Not stable	0.2	Medium
Moraceae					
<i>Artocarpus tonkinensis</i> A. Chev.	Medium	High	Not stable	0.2	Medium
<i>Artocarpus heterophyllus</i> Lam.	Cultivated		0.28/fruit	0.6	Medium
Myrtaceae					
<i>Baeckea frutescens</i> L.	Medium	Medium	Not stable	0.3	Medium
<i>Psidium guajava</i> L.	Cultivated		0.07/4 fruits	1.0	Medium
Olacaceae					
<i>Erythralum scandens</i> Blume	High	Medium	Not stable	0.2	Low
Opiliaceae					
<i>Meliantha suavis</i> Pierre	High	Medium	0.14/kg	0.5	Medium
Rutaceae					
<i>Citrus aurantifolia</i> Swingle	Cultivated		0.07/5 fruits	0.5	Medium
<i>Citrus maxima</i> Osbeck	Cultivated		0.14/ fruits	0.6	Medium
<i>Citrus sinensis</i> Osbeck	Cultivated		0.07/3 fruits	0.8	Medium
Sapotaceae					
<i>Achras sapota</i> L.	Cultivated		0.07/5 fruits	0.5	Medium
<i>Chrysophyllum cainito</i> L.	Cultivated		0.07/5 fruits	0.7	Medium
<i>Pouteria sapota</i> (Jacq.) H. E. Moore & Stearn.	Cultivated		0.07/5fruits	0.8	Medium

Scientific name	Abundance in the wild or cultivated	Intensity of collection	Price in US\$	Income/ household/ year in US\$	Market demand
Liliopsida					
Areaceae					
<i>Calamus balansaeanus</i> Becc.	Low	Medium	0.17/kg	1.0	Medium
<i>Calamus faberi</i> Becc.	Low	Medium	0.17/kg	1.2	Medium
<i>Calamus tetradactylus</i> Hance	Low	Medium	0.17/kg	2.6	Medium
Dioscoreaceae					
<i>Dioscorea cirrhosa</i> Lour.	High	Low	Not stable	0.3	Low
<i>Dioscorea persimilis</i> Prain & Burk	High	Low	Not stable	0.4	Low
Marantaceae					
<i>Phrynium placentarium</i> (Lour.) Merr.	High	Medium	0.28/100 leaves	2.7	Medium
Poaceae					
<i>Indosasa sibata</i> C.D.Chu & C.S.Chao	Medium	High	0.2/fresh kg (Bamboo shoot)	2.0	High
<i>Indosasa sibataeooides</i> McClure	Medium	High	0.2/fresh kg (Bamboo shoot)	1.8	High
<i>Schizostachyum funghomii</i> McClure	High	High	1.1/dried, 0.17 fresh kg (Bamboo shoot) 0.0014/trees	13	High