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

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Uses and Conservation of Plant Species in a National Park—A Case Study of Ben En, Vietnam. 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: $UI = Us/N$, where Us 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

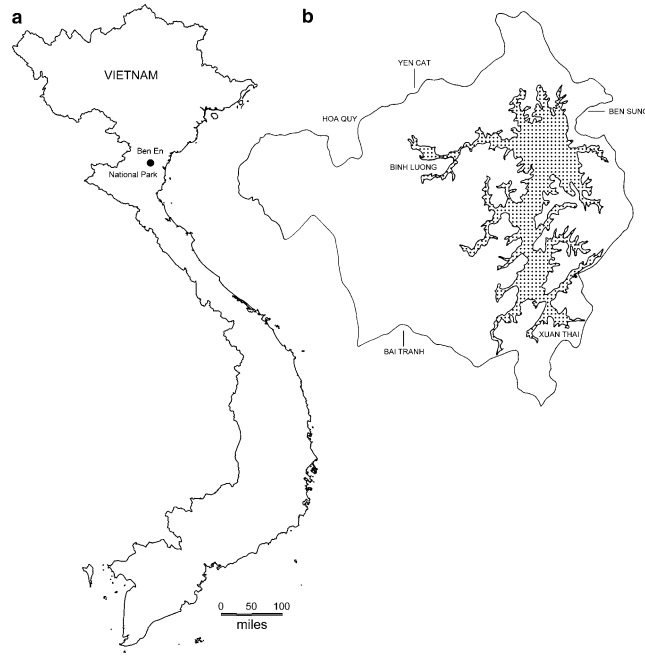

Fig. 1. a) Map of Vietnam. b) Map of Ben En National Park.

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 trifoliatus* (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 tramdennum* (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* (Arecaceae)—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), *Erythropalum 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.

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

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* (Caesalpiniaceae), *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 septemnervium* (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* (Caesalpiniaceae) that have already been cut for their timber.

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)
Actinodaphne obovata Blume	Lauraceae	0.65
Aglaia spectabilis (Miq.) S.S. Jain & Bennet	Meliaceae	0.56
Amesiodendron chinense (Merr.) Hu	Sapindaceae	0.56
Aphanamixis grandifolia Blume	Meliaceae	0.53
Dysoxylum cauliflorum Hiern	Meliaceae	0.78
Erythrophloeum fordii Oliv.	Caesalpiniaceae	0.99
Garcinia fagraeoides A. Chev.	Clusiaceae	0.52
Lagerstoemia calyculata Kurz	Lythraceae	0.81
Michelia mediocris Dandy	Magnoliaceae	0.84
Parashorea chinensis Wang Hsie	Dipterocarpaceae	0.81
Pavieasia annamensis Pierre	Sapindaceae	0.85
Peltophorum tonkinensis Pierre	Caesalpiniaceae	0.54
Phoebe paniculata Nees	Lauraceae	0.66
Vatica harmandiana Pierre	Dipterocarpaceae	0.54
Vatica odorata (Griff.) Symingtom	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 trifoliatus* (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* (Ceasalpiniaceae) 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 *Erythroploeum fordii* (Ceasalpiniaceae) (0.99), *Pavieasia 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 in Red Data Book of Vietnam	Threat category in IUCN Red List 2006	Threat category in Ben En (this study)
Actinodaphne obovata Blume	Lauraceae	nl	nl	t
Aglaia spectabilis (Miq.) S.S. Jain & Bennet	Meliaceae	vu	nl	t
Alstonia scholaris (L.) R. Br.	Apocynaceae	nl	lr	nl
Amesiodendron chinense (Merr.) Hu	Sapindaceae	nl	lr	t
Aphanamixis grandifolia Blume	Meliaceae	nl	nl	t
Caesalpinia sappan L.	Caesalpiniaceae	nl	nl	r
Calamus platyacanthus Warb. ex Becc	Arecaceae	vu	nl	r
Calamus tetradactylus Hance	Arecaceae	nl	nl	r
Canarium tramdenum Dai et Yakovl	Burseraceae	vu	nl	r
Chukrasia tabularis A. Juss.	Meliaceae	vu	lr	nl
Cycas chevalieri Leandri	Cycadaceae	lr	cr	r
Cycas revoluta Thunb.	Cycadaceae	nl	nl	r
Dysoxylum cauliflorum Hiern	Meliaceae	vu	nl	t
Erythroploeum fordii Oliv.	Caesalpiniaceae	nl	e	t
Garcinia fagraeoides A. Chev.	Clusiaceae	vu	nl	e
Hopea odorata Roxb.	Dipterocarpaceae	nl	nl	r
Hopea chinensis (Merr.) Hand.-Mazz.	Dipterocarpaceae	nl	cr	r
Lagerstroemia calyculata Kurz	Lythraceae	nl	nl	r
Manglietia fordiana Oliv.	Magnoniaceae	vu	nl	r
Markhamia stipulata (Wall.) Soem. ex Schum.	Bignoniaceae	vu	nl	e
Meliantha suavis Pierre	Opiliaceae	vu	nl	r
Michelia mediocris Dandy	Magnoliaceae	nl	nl	r
Parashorea chinensis (Wang Hsie) H. Zhu	Dipterocarpaceae	nl	e	t
Pavieasia anamensis Pierre	Sapindaceae	nl	nl	t
Peltophorum tonkinensis Pierre	Caesalpiniaceae	nl	nl	vu
Phoebe paniculata Nees	Lauraceae	nl	nl	t
Vatica odorata (Griff.) Symingtom	Dipterocarpaceae	nl	nl	r
Vatica harmandiana Pierre	Dipterocarpaceae	nl	e	r
Vatica subglabra 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

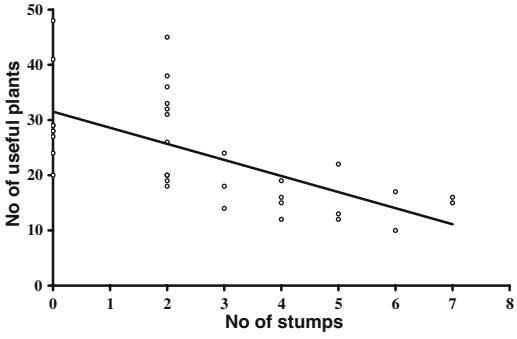

Fig. 2. Relation between the number of useful plants and number of stumps per 0.04 ha plot; $y = 30.72 - 2.84x$; $R^2 = 0.45$.

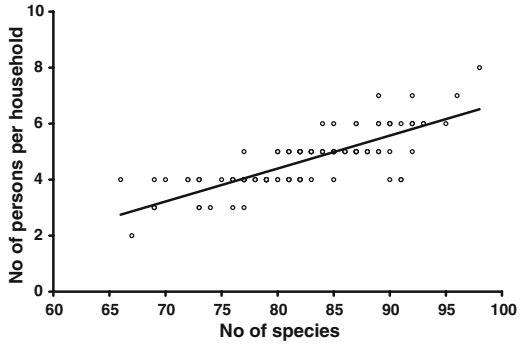

Fig. 4. Relation between number of persons in each household and number of useful plant species used. $y = 0.12x - 5.02$; $R^2 = 0.64$.

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 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,

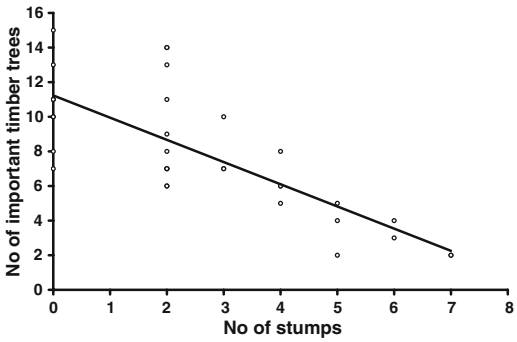

Fig. 3. Relation between the number of important timber trees and number of stumps per 0.04-ha plot: $y = 11.34 - 1.29x$; $R^2 = 0.60$.

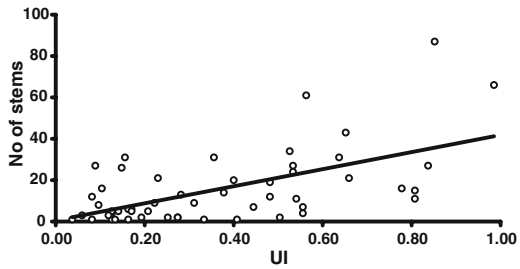

Fig. 5. Relation between number of stems per 0-.04 ha plot and Use Index (UI) of 54 useful plant species. $y = 42.22x + 0.56$; $R^2 = 0.34$.

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	**Họ Guột**				
Dicranopteris linearis (Burm.) Underw.	Guột	0.28	W	Whole plant	Firewood
Marsileaceae	**Họ Rau Bợ**				
Marsilea quadrifolia L.*	Rau bợ	0.14	W	Leaves	Food
Woodsiaceae	**Ráng gỗ nhỏ**				
Diplazium esculentum (Retz.) Sw.	Rau rớn	0.30	W	Leaves	Food
Gymnosperms	**Ngành Thông**				
Cycadaceae	**Họ Tuế**				
Cycas chevalieri Leandri	Nghèn	0.12	W	Whole plant	Ornamental
Cycas revoluta Thunb.	Vạn tuế	0.08	W	Whole plant	Ornamental
Gnetaceae	**Họ Dây gắm**				
Gnetum gnemon L.	Gắm	0.29	W	Fruit	Food
Pinaceae	**Họ Thông**				
Pinus massoniana D. Don	Thông đuôi ngựa	0.33	W,C	Branch, stem	Construction, firewood
Pinus merkusii Jungh. & de Vriese	Thông nhựa	0.36	W,C	Branch, stem	Construction, firewood
Angiosperms	**Ngành Ngọc Lan**				
Dicotyledons	**Lop Ngọc Lan**				
Amaranthaceae	**Họ Rau Dền**				
Alternanthera sessilis (L.) A. DC.	Rau diếp dại	0.24	W	Leaves	Food
Amaranthus spinosus L.	Dền cơm	0.26	C	Leaves	Food
Amaranthus tricolor L.	Dền tía	0.08	C	Leaves	Food
Anacardiaceae	**Họ Xoài**				
Dracontomelon dao (Blanco) Merr. & Rolfe	Sấu	0.19	W,C	Fruit, leaves, stem	Food, construction
Mangifera indica L.	Xoài	0.43	C	Fruit	Food
Mangifera reba Pierre	Quéo	0.06	W,C	Fruit	Food
Spondias axillaris Roxb.	Xoan nhừ	0.08	W	Fruit	Food
Spondias lakoensis Pierre * +	Dâu da xoan	0.25	W,C	Fruit	Food
Annonaceae	**Họ Na**				
Annona squamosa L. *	Na	0.16	C	Fruit	Food
Xylopia vielana Hance * +	Dền	0.91	W	Stem	Firewood
Apiaceae	**Họ Hoa Tán**				
Anethum graveolens L.	Thì là	0.27	C	Leaves, stem	Food
Centella asiatica (L.) Urb. *	Rau má	0.30	W	Whole plant	Food
Coriandrum sativum L.	Rau mùi	0.32	C	Leaves, stem	Food
Eryngium foetidum Thunb.	Mùi tàu	0.31	C	Leaves, stem	Food
Hydrocotyle sibthorpioides Lamk.	Rau má	0.67	W	Whole plant	Food
Apocynaceae	**Họ Trúc Đào**				
Alstonia scholaris (L.) R. Br. *	Sữa	0.04	W	Whole plant	Ornamental
Holarrhena antidysentirica Wall.	Mộc hoa trắng	0.04	W	Whole plant	Ornamental
Aquifoliaceae	**Họ Nhựa ruồi**				
Ilex macrocarpa Oliv.	Bùi quả to	0.07	W	Leaves	Drink
Ilex rotunda Thunb. +	Nhựa ruồi	0.08	W	Leaves	Drink
Araliaceae	**Họ Ngũ ra bì**				
Acanthopanax aculeatum Seem.	Ngũ ra bì	0.07	W	Whole plant	Ornamental
Polyscias fruticosa Harms	Đinh lăng	0.42	C	Leaves	Food
Schefflera alpina Grushv. & Skvorts.	Chân chim	0.30	W	Leaves	Food
Schefflera octophylla Harms *+	Chân chim 8 lá	0.48	W	Leaves	Food
Asclepiadaceae	**Họ Thiên lý**				
Telosma cordata Merr.*	Thiên lý	0.26	C	Flower	Food
Asteraceae	**Họ Cúc**				
Artemisia vulgaris L. *	Ngãi cứu	0.52	C	Leaves	Food

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

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

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

Scientific name	Common name	Use index	Wild/Cultivated	Part utilized	Use
Oxalidaceae	**Họ Chua me**				
Oxalis corniculata L. *	Chua me	0.25	W	Whole plant	Food
Piperaceae	**Hồ tiêu**				
Piper betle L.*	Trầu không	0.53	C	Leaves	Chewing betel
Piper lolot C. DC. *	Lá lốt	0.96	W, C	Leaves	Food
Rhamnaceae	**Họ Táo**				
Ziziphus mauritiana Lam. *	Táo nhà	0.92	C	Fruit	Food
Ziziphus oenoplia (L.) Mill.	Táo rừng	0.42	W	Fruit	Food
Rosaceae	**Họ Hoa Hồng**				
Rubus alcaefolius Poir.	Mân xôi	0.60	W	Fruit	Food
Rubus cochinchinensis Tratt. *	Ngấy	0.36	W	Fruit	Food
Rutaceae	**Họ Cam**				
Acronychia pedunculata Miq.	Bưởi bung	0.53	W	Fruit	Food
Clausena dunniana H.Lev. +	Hồng bì rừng	0.36	W	Fruit	Food
Clausena indica Oliver+	Mắc mật	0.33	W	Fruit	Food
Clausena lansium Skeels *+	Hồng bì	0.19	C	Fruit	Food
Citrus aurantifolia Swingle	Chanh	0.95	C	Fruit, leaves	Food
Citrus maxima Osbeck	Bưởi	0.81	C	Fruit	Food
Citrus sinensis Osbeck	Cam	0.79	C	Fruit	Food
Sapindaceae	**Họ Bồ hòn**				
Dimorcarpus longan Lour.	Nhãn	0.96	C	Fruit	Food
Litchi chinensis Sonn.	Vải	0.95	C	Fruit	Food
Amesiodendron chinense (Merr.) Hu+	Trường Sâng	0.56	W	Stem	Construction
Mischocarpus pentapetalus Radlk.+	Trường kẹn	0.15	W	Stem	Construction
Pavieasia annamensis Pierre+	Trường mật	0.85	W	Stem	Construction
Sapotaceae	**Ho Hồng xiêm**				
Achras sapota L.	Hồng xiêm	0.19	C	Fruit	Food
Chrysophyllum cainito L.	Vú sữa	0.20	C	Fruit	Food
Pouteria sapota (Jacq.) H. E. Moore & Stearn.	Trứng gà	0.50	C	Fruit	Food
Theaceae	**Họ Chè**				
Camellia amplexicaulis Cohen-Stuart+	Hải đường	0.23	W	Whole plant	Ornamental
Camellia sinensis Kuntze *	Chè	0.94	C	Leaves	Drink
Tiliaceae	**Họ Đay**				
Microcos paniculata L.+	Cò ke	0.16	W	Stem	Firewood
Ulmaceae	**Họ Du**				
Trema orientalis (L.) Blume *	Hu đay	0.22	W	Stem	Firewood
Monocotyledons	**Lớp Hành**				
Alliaceae	**Họ Hành**				
Allium fistulosum L. *	Hành	0.99	C	Whole plant	Spice, food
Allium sativum L. *	Tỏi	1.00	C	Whole plant	Spice, food
Arecaceae	**Họ Cau Dừa**				
Areca catechu L. *	Cau	0.56	C	Fruit, stem	Chewing betel, firewood
Calamus balansaeanus Becc.	Mây nước	0.36	W	Stem	Handicrafts
Calamus faberi Becc.	Mây thủ công	0.19	W	Stem	Handicrafts
Calamus platyacanthus Warb. ex Becc.	Song mật	0.36	W	Stem	Handicrafts
Calamus tetradactylus Hance	Mây mật	0.79	W	Stem	Handicrafts
Caryota mitis Lour. *	Đùng đình	0.21	W	Stem	Handicrafts, food
Cocos nucifera L.	Dừa	0.67	C	Fruit, stem	Food, firewood
Daemonorops longispathus Becc.	Hèo	0.38	W	Stem	Handicrafts
Livistona chinensis (Jacq.) R. Br. & Mart.	Cọ	0.35	C	Leaves, fruit	Oil, roofs
Costaceae	**Họ Mía dò**				
Costus speciosus (Koenig) Smith	Mía dò	0.36	W	Stem	Food
Dioscoreaceae	**Họ Củ nâu**				

Scientific name	Common name	Use index	Wild/Cultivated	Part utilized	Use
Dioscorea cirrhosa Lour. *	Củ nâu	0.34	W	Tuber	Food
Dioscorea persimilis Prain & Burk *	Củ mài	0.19	W	Tuber	Food, to plaster board
Marantaceae	**Họ Lá Dong**				
Phrynium placentarium (Lour.) Merr.	Lá dong	0.95	W	Leaves	Wrapping cakes
Musaceae	**Họ Chuối**				
Musa basjoo Sieb.	Chuối ngự	0.97	C	Fruit, flower bud, stem	Food
Musa balbisiana Colla	Chuối hột	0.39	C	Fruit, flower bud, stem	Food
Musa acuminata Colla	Chuối rừng	0.21	W	Fruit, flower bud, stem	Food
Musa paradisiaca L.	Chuối tiêu	0.94	C	Fruit, flower bud, stem	Food
Orchidacea	**Họ Phong lan**				
Cymbidium lowianum Reichb.f.	Phong lan	0.06	W	Whole plant	Ornamental
Dendrobium aloideum La Llave & Lex.	Hoàng thảo	0.01	W	Whole plant	Ornamental
Phormiaceae	**Họ Hương bài**				
Dianella nemorosa Lam. *	Hương bài	0.04	W	Whole plant	Incense
Poaceae	**Họ Cỏ**				
Arundinaria sat Balansa	Sặt	0.50	W	Stem	Firewood
Bambusa blumeana Schult. f.	Tre gai	0.41	C	Stem, shoot	Construction, food, tools
Cymbopogon citratus Stapf*	Sả	0.51	C	Tuber	Food
Dendrocalamus barbatus Hsueh & D.Z.Li	Luồng	0.78	C	Stem, shoot	Paper, construction, food, tools
Indosasa angustata McClure	Vầu đắng	0.37	W	Stem, shoot	Food, construction
Indosasa sinica C.D. Chu & C.S.Chao	Vầu ngọt	0.33	W	Stem, shoot	Food, construction
Panicum miliaceum L.	Kê	0.36	C	Seed	Food
Saccharum officinarum L.	Mía	0.96	C	Stem	Food
Schizostachyum funghomii McClure	Nứa	0.99	W	Stem, shoot	Paper, food, tools
Zingiberaceae	**Họ Gừng**				
Curcuma longa L. *	Nghệ	0.97	C	Tuber, leaves	Spice, food
Curcuma zedoaria Rosc.*	Nghệ đen	0.39	W,C	Tuber	Spice, food
Zingiber officinale 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					
Dracontomelon dao (Blanco) Merr. & Rolfe	Cultivated		Not stable	0.5	Medium
Mangifera indica L.	Cultivated		0.07/2fruits	0.6	Medium
Spondias lakoensis Pierre	Cultivated		Not stable	0.1	Medium
Annonaceae					
Annona squamosa L.	Cultivated		0.07/3 fruits	0.6	Medium
Araliaceae					
Schefflera alpina Grushv. & Skvorts.	High	Medium	Not stable	0.2	Medium
Schefflera octophylla Harms	High	Medium	0.28/kg	1	Medium
Burseraceae					
Canarium tonkinensis L.	Medium	High	1.3/kg resin	1.2	High
Canarium album Rauesch.	Medium	High	0.07/kg fruit 1.3/kg resin	2.9	Medium High
Canarium tramdenum Dai & Yakovlev	Medium	High	1.3/kg resin	1.1	High
Caesalpiniaceae					
Gleditsia australis Hemsl. ex Forb. & Hemsl.	Low	Medium	0.07/4 fruits	0.2	Medium
Tamarindus indica L.	Low	High	0.07/6 fruits	0.2	Medium
Clusiaceae					
Garcinia cowa Roxb.	Low	Medium	0.07/5 fruits	0.5	Medium
Garcinia multiflora Champ. ex Benth.	Medium	Medium	0.07/4 fruits	0.8	Medium
Ebenaceae					
Diospyros decandra Lour.	Cultivated		0.07/6 fruits	0.8	Medium
Diospyros kaki L.f.	Cultivated		0.07/6 fruits	1.0	Medium
Euphorbiaceae					
Vernicia montana Lour.	Medium	High	0.17/kg fruit	0.2	Medium
Lamiaceae					
Acrocephalus indicus Kuntze	Medium	Medium	Not stable	0.2	Medium
Moraceae			Not stable	0.2	Medium
Artocarpus tonkinensis A. Chev.	Medium	High			
Artocarpus heterophyllus Lam.	Cultivated		0.28/fruit	0.6	Medium
Myrtaceae					
Baeckea frutescens L.	Medium	Medium	Not stable	0.3	Medium
Psidium guajava L.	Cultivated		0.07/4 fruits	1.0	Medium
Olacaceae					
Erythropalum scandens Blume	High	Medium	Not stable	0.2	Low
Opiliaceae					
Meliantha suavis Pierre	High	Medium	0.14/kg	0.5	Medium
Rutaceae					
Citrus aurantifolia Swingle	Cultivated		0.07/5 fruits	0.5	Medium
Citrus maxima Osbeck	Cultivated		0.14/ fruits	0.6	Medium
Citrus sinensis Osbeck	Cultivated		0.07/3 fruits	0.8	Medium
Sapotaceae					
Achras sapota L.	Cultivated		0.07/5 fruits	0.5	Medium
Chrysophyllum cainito L.	Cultivated		0.07/5 fruits	0.7	Medium
Pouteria sapota (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					
Arecaceae					
Calamus balansaeanus Becc.	Low	Medium	0.17/kg	1.0	Medium
Calamus faberi Becc.	Low	Medium	0.17/kg	1.2	Medium
Calamus tetradactylus Hance	Low	Medium	0.17/kg	2.6	Medium
Dioscoreaceae					
Dioscorea cirrhosa Lour.	High	Low	Not stable	0.3	Low
Dioscorea persimilis Prain & Burk	High	Low	Not stable	0.4	Low
Marantaceae					
Phrynium placentarium (Lour.) Merr.	High	Medium	0.28/100 leaves	2.7	Medium
Poaceae					
Indosasa sibata C.D.Chu & C.S.Chao	Medium	High	0.2/fresh kg (Bamboo shoot)	2.0	High
Indosasa sibataeooides McClure	Medium	High	0.2/fresh kg (Bamboo shoot)	1.8	High
Schizostachyum funghomii McClure	High	High	1.1/dried, 0.17 fresh kg (Bamboo shoot) 0.0014/trees	13	High