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Title of project: **Diversity and sustainable use of tree species producing valuable non-timber products after shifting cultivation in Ben En National Park, Vietnam**

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1. Introduction

Non-timber forest products (NTFPs) play a crucial role in the livelihoods of forest dependent communities (local communities in and around forests) since timber trees produce economically valuable nontimber products and these products may be used for subsistence purposes or for sale and thus providing cash income (Ros-Tonen and Wiersum 2005). Many of the timber trees in the tropical rainforests produce a variety of highly valuable non-timber products like edible and medicinal fruits, seeds, nuts and oils. Also, a considerable number of trees produce industrial materials like latex, tannin, gum exudates, dyes and resin (Olajide, Udo et al. 2008) . The utilization of non-timber forest products for food, health care, cultural practices and income generation have become a major way of life of most forest dwellers. Ford Foundation in 1998 opined that non-timber forest products are a particularly important part of multiple-use strategies because they increase the range of income generating options of forest-dependent communities, while avoiding some of the ecological costs of timber cutting (Olajide, Udo et al. 2008)

Ben En National Park was established for the protection of fauna in 1979 and as a nature reserve in 1986. Around 26% of the total forestland in the buffer zone is managed by local people. This land consists of 2,600 ha (8.4%) of secondary forest and poor forest lands, about 2,300 ha of bare land (with some small trees and shrubs), 443 ha of plantation forest and approximately 2,500 ha (about 8%) of agricultural land (Anonymous 2011). In order to prevent the destruction of the forest areas and ensure the conservation of its rich biodiversity, the park prohibits the harvesting of non-timber forest products according to a special forest management regulation. However, in order to incorporate NTFP exploitation and production into sustainable and multiple-use forest management schemes, a broadly oriented NTFP study should be carried out and adequate quantitative and qualitative ecological data on tree species in relation to a NTFP identification and utilisation survey, an ecological inventory of NTFP plant resources, species composition, abundance of each species, stem diameter distribution and abundance of regeneration of each species must be collected in the park. This study therefore assessed the diversity and population density of timber tree species producing valuable non-timber products with the aim of providing the required ecological data for fashioning out realistic and effective conservation strategies as well as the management of biodiversity.

2. Objectives

2.1. General objectives

1. The diversity and population density of all tree species assesses in undisturbed forest and three sites which are forest stands of 0-26 -year-old fallows. A good knowledge on floristic composition and forest structure is important in order to conceive them for a sustainable use;
2. This study is undertaken to assess the diversity, richness and regeneration status of woody species along with NTFP tree species;
3. The project also determines the most vulnerable NTFP species to make suggestions for sustainable use and conservation of these species.

2.2. Specific outcomes

This study is clearly indicated as follows:

1. List of all woody tree species and species producing non-timber forest products with a DBH ≥ 5 cm recorded in three successional forests and in untouched forests;
2. List of regeneration with a DBH < 5 cm;
3. Data sets including tree density, basal areas, forest structure and floristic composition (species and family) of all woody tree species and species offerring NTFPs in three successional forests and in untouched forests;
4. Diversity indices including Shannon-Wiener, Simpson's diversity, and similarity index (Evenness index) of all woody tree species and species producing NTFPs in three successional forests and in untouched forests;
5. Details of parts extracted and uses of NTFP species, life form/habit, harvesting methods and management, economic values, species used for medicinal purposes;
6. Current constraints for biodiversity conservation and use of NTFP resources;
7. Recommendations for improving effective forest management of NTFPs and benefit-sharing mechanisms;
8. Management implications for conservation and more sustainable use of NTFP species.

3. Sampling procedures

In this study, the chronosequence approach or space-for-time substitution widely used in studies of succession in forests after abandoned pasture and after slash and burn agriculture was applied in order to study changes in tree abundance, species richness, species and family composition. Identifying the ages of agricultural fallows and the history of the secondary forest sites was determined by interviewing long-term residents of the study areas and several technical key officers of Ben En National Park who had knowledge of local land use; the interviewing process also took into account personal life-events and significant historic events such as periods of political upheaval.

One transect was constructed at each successional forest phase depending on the time elapsed since the slash and burn agriculture occurred: an early secondary forest with a recovery age of 14-15 years since abandonment (from 1997 to 1998); an intermediate phase, 19-20 years after fallow (from 1991 to 1992); a late one after 25-26 years (from 1986 to 1987); and undisturbed forest stands. At each transect, a point was randomly selected to be used as center of the each sample plot; 20 circular sample plots with an area of 500 m² (radius R = 12.6 m) were arranged in a systematic design along transects, intervals between adjacent sampling plots were 50 m in length. A smaller circular subplot of 100 m^2 was set at the center of a 500 m² circular plot (Fig. 1) leading to 20 subplot of 100 m^2.

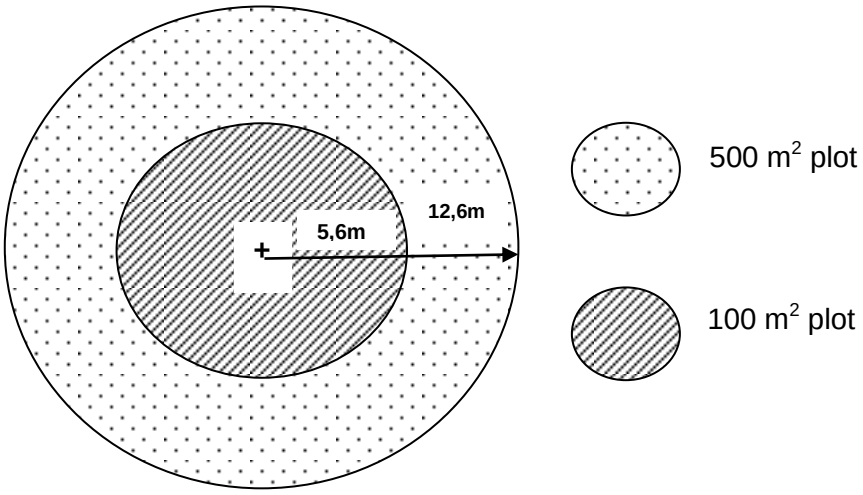

Fig. 1 The layout of the two circular sample plots; the large circle has an area of 500 m^2 (12.56 m radius from the center point), while the smaller circular subplot, set within the 500 m² plot, is 100 m² (5.64 m radius from the center point).

Fig. 2: Sampling design in successional site

Fig. 3: Tree measurement in sample plot

4. Data collection

4.1. Adult trees

All tree species with a DBH ≥ 5 cm were recorded and measured in the 500 m² circular plots. All trees within the plots, regardless of size, had their botanical name recorded, and, where possible, their local names. For multi-stemmed individuals, each stem with a DBH ≥ 5 cm was considered an individual. The DBH was measured using a “meter tape”, the total tree height was taken as the distance from the base of the tree to the top of the crown using a Blume-Leiss.

4.2. Regeneration

The various parameters for regenerated tree species, including total tree height, tree name, and original regeneration, were recorded in smaller 100 m^2 circular sample plots with radius of 5.6 m. The tree height and DBH were utilized to identify the classification of regeneration. Types of regeneration consisting of seedlings and saplings were modified based on previous studies of regeneration in natural forests, where all seedlings with a tree height ≤ 130 cm; saplings with a tree height > 130 cm and a DBH < 5 cm were recorded. Various parameters including total tree height, tree name, tree quality, and original regeneration were recorded. The diameter of the saplings was measured at ground-level; the height pole meter was used to measure the height of regeneration trees.

4.3. Identifying trees producing NTFPs and their purpose of use and parts used

The list of 164 woody tree species recorded during the field trips was prepared in sheets. At the community meeting, different groups which are indigenous experts, village elders, women and other local people were asked in order to determine medicinal plants, trees producing non-timber forest products and their purpose of use and parts used. Park rangers of the Ben En Nation Park were invited to participate in the field survey and during the meetings at village. The use of a well-structured questionnaire and oral interview was adopted to obtain relevant data. The set questionnaires consisting of the local names of the tree species offering NTFPs, the plant parts used, different uses and tree species producing NTFPs preffered by local people were administered to the respondents. A total of 16 copies of the questionnaire were allocated to 16 participants (a copy for each) in the meeting.

5. Data analysis

Tree density per ha was calculated with the count of all tree individuals from 25 sample plots; relative tree density was obtained via Formula (1).

$$RD = \frac{n_i}{N} \times 100 \quad \textbf{(1)}$$

where,
RD = Relative density,
n_i = Number of individuals of species i and
N = Total number of individuals in the entire population.

The basal area of the trees was calculated by Formula (2). The total basal area of one ha was calculated by the sum of the BA of all trees in the 25 subplots.

$$BA = \frac{\pi}{4} \times D^2 \quad (\textbf{2})$$

where,
BA = Basal area (m^2),
π = Constant (3.14), and
D = Diameter at breast height (cm).

The importance value index of species and families is one criterion in the measure of a forest structure. The Importance value index of each species and family was determined by the arithmetic sum of relative abundance, dominance, and the frequency of each species or family *i* as follows:

$$IVI_i = Ar_i + Dr_i + Fr_i \quad (3)$$

where,

Ar_i = Relative abundance,

Dr_i = Relative dominance, and

Fr_i = Relative frequency.

The absolute abundance of each species was defined as the number of individuals per unit area. The relative abundance of each species corresponds to the percentage of species in relation to the total number of trees sampled($\sum_{i=1}^{s} Aa_i$). The result is thus:

$$\mathrm{Ar_i} = \frac{\mathrm{Aa_i}}{(\sum_{\mathrm{i=1}}^{\mathrm{s}} \mathrm{Aa_i})} \times 100 \quad (4)$$

where,

Ar_i = Relative abundance, and

Aa_i = Absolute abundance of species i^{th}.

The absolute dominance of one species was calculated as the sum of transversal area (g_i) of trees of the species, expressed as $m^2\ ha^{-1}$.

$$\mathrm{Da_i} = \sum_{i=1}^{s} \mathrm{g_i} \quad (5)$$

where,

Da_i = Absolute dominance of species i^{th}

g_i = Basal area of species i^{th}

The absolute frequency was defined as the ratio of the number of sample units where the species occurred to the total number of units established:

$$Fa_i = \frac{\text{Number of sample units}}{\text{Total number of units established}} \times 100 \quad (6)$$

where,

Fa_i = Relative dominance of species i^{th}

The species diversity indices were calculated to determine tree species diversity in the one-ha plot. The species richness was taken as a count of the number of species occurring in all plots of each forest type. The Margalef index of species richness was calculated based on Formula (7).

$$SR = \frac{S-1}{\text{Ln (N)}} \quad (7)$$

where,

SR = Margalef index of species richness,

S = Number of species, and

N = Total number of individuals.

The Shannon-Wiener index, the most commonly used index in ecological studies combines both richness and abundance while also accounting for the order or abundance of a species within a sample plot. As such, it is often used for identifying areas of high natural biological diversity.

$$H' = -\sum_{i=1}^{k}\left[\left(\frac{n_i}{N}\right) x \ln\left(\frac{n_i}{N}\right)\right] \quad (8)$$

where,

n_i = the number of individuals or amount of each species (the i^{th} species), and

N = the total number of individuals (or amount) for the site.

The maximum diversity (H_{max}) could be found if all species were of equal abundance, which implies $H' = H_{max} = \ln(S)$, where *S* is the total number of species.

The Simpson's diversity index was obtained following Magurran (1988). The value of D ranges between 0 and 1; with this index, 0 represents infinite diversity and 1 means no diversity. In other words, the bigger the value of D, the lower the diversity.

$$D = \frac{\sum_{i=1}^{k} n_i(n_i-1)}{[N(N-1)]} \quad (\mathbf{9})$$

where,

n_i = Number of individuals of "i^{th}" species,
k = Number of species that occurring in the sample area,
N = Total number of sampled individuals.

Similarity indices measure similarity between communities based on species composition. The Evenness index or Shannon-Weaver´s equitability = Evenness or Pielou (J') (distribution of abundances among species) was determined according to Pielou (1966).

$$E=J'=\frac{H'}{H_{max}}=\frac{H'}{\ln (S)} \quad (\mathbf{10})$$

where,

H = Shannon-Weaver diversity index,
H'_{max} = ln (S), and
S = Total number of observed species in the community.

Sørensen's index of a species is a very simple measure of beta diversity that ranges from a value of 0 (where there is no species overlap between the communities) to a value of 1 (when the same species are found in both communities). The similarity index was calculated by the following formula given by Sørensen (1948):

$$SI = \frac{2c}{a+b} \quad (\mathbf{11})$$

where,

a = Number of species recorded in stand A,
b = Number of species recorded in stand B, and
c = Number of common species in two stands being compared.

The Jaccard's coefficient mentioned by Jaccard (1901) was calculated based on formula (12) as given by Small et al. (2004).

$$J = \frac{a}{a + b + c} \quad (12)$$

where,

a = The number of species shared between the plots,

b = The number of species unique to plot 1, and

c = The number of species unique to plot 2.

6. General description of Ben En National Park

6.1 History, location and natural areas

In 1979, the area that makes up present-day Ben En National Park was designated as a protected area for fauna and flora and managed by Nhu Xuan Logging Enterprise until 1986. According to the Council of Ministers' Decision No. 194/CT on August 9, 1986, it was established to protect "the wildlife, elephant and forest areas in the upper part of the Muc River". By 1990, the site achieved special-use forest status, and two years later the park was established on January 27, 1992 (Tordoff and Grindley 2000). The park (19°31' to 19°43' N - 105°25' to 105°38' E) is situated between the Nhu Thanh and Nhu Xuan Districts of Thanh Hoa Province in the North Central Coast (Anonymous 2011). The core zone covers three communes: Xuan Thai, Binh Luong, and Xuan Binh (Tordoff and Grindley 2000). It borders Hai Long and Xuan Khang Communes to the north; Xuan Quy Commune, Hoa Quy Commune, and Song Chang Enterprise to the west; Hai Van and Xuan Phuc Communes to the east; and Xuan Binh and Xuan Thai Communes to the south (Anonymous 2009).

According to the Ben En National Park Management Board, the park has a total area of approximately 16,600 ha and is divided into the following zones:

1. Strictly-protected zone, declared so as to maintain the ecosystems and diversity of wildlife and plant species;
2. Ecological restoration zone, to rehabilitate strongly disturbed ecosystems; and
3. Administrative and tourism zone, which consists of the main office, the Forest Protection Department office, and the Tourism Services Centre.

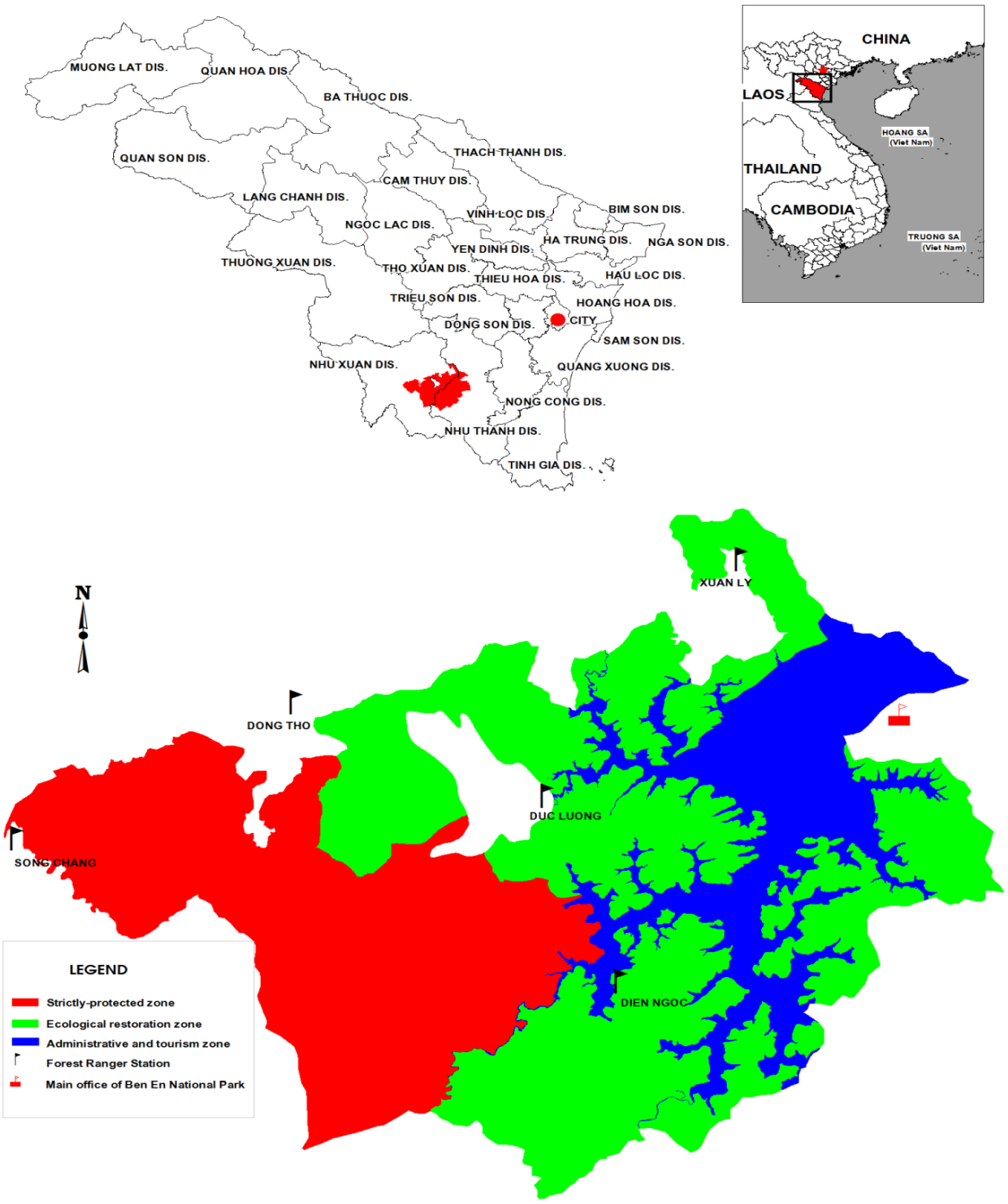

Fig. 4 The location and various zones of Ben En National Park, Vietnam.

6.2 Population

According to official statistics published by the Nhu Thanh and Nhu Xuan Districts, the total population in 2009 of both the core and buffer zones of the park was approximately 26,600 people belonging to four main ethnic groups (Kinh ≈ 52%; Thai ≈ 22%; Muong ≈ 17% and Tho ≈ 8.5%) (Anonymous 2009; Anonymous 2011). The labour force is quite abundant, but the

local occupational structure is not diverse, it consists of mainly seasonal agricultural occupations. The average population density in the buffer zone is approximately 230 people per km^2, albeit unevenly distributed: most people live along the main road (Anonymous 2011), as the majority of local people have settled near the park. As a result, local people's livelihood activities have noticeably impacted forest resources. It, therefore, is necessary to apply synchronized and coordinated measures in order to improve the socio-economic situation for local communities, teach the sustainable usage of forest resources, and raise awareness for nature conservation (Anonymous 2011).

6.3 Climate

Because it shares a sub-tropical climate with other regions in North-Central, Vietnam, the winter in Ben En National Park is warm and dry, whereas the summer is hot and wet. In Table 2.1, data recorded over a 10-year period (2002-2011) indicate that the mean temperature is highest (28 - 29°C) between June and August and lowest in January and December (16 and 18°C, respectively). The heaviest rainfall occurs between the months of July and October. Mean monthly rainfall is below 17 mm in February and reaches 358 mm in September and the mean annual rainfall is 1,600 mm.

Table 6.1 Monthly mean temperatures, and rainfall in Nhu Thanh District, Thanh Hoa Province, Vietnam. These values are means for a period of 10 years (2002 to 2011).

Month	**Temperature** [°C]			**Precipitation** [mm/month]
	Average	Min	Max	
Jan.	16	14	18	31
Feb.	19	13	22	17
Mar.	20	17	22	38
Apr.	24	22	26	66
May	27	26	29	149
June	29	28	31	170
July	29	29	31	198
Aug.	28	27	28	296
Sep.	27	26	27	358
Oct.	25	23	26	191
Nov.	22	19	24	49
Dec.	18	17	20	23
Total				**1,586**

Database: Nhu Thanh Meteorological Station.

Figure 5 shows the climate diagram of monthly averages for temperature and precipitation the course of over 10 years; capital letters along the horizontal line indicate a month. The diagram begins with January in the left-hand corner, where 20 mm of monthly precipitation (right ordinate) equal 10°C average temperature (left ordinate). When the precipitation curve undercuts the temperature curve, the area in between them is dotted, indicating a dry season. When the precipitation curve supersedes the temperature curve, vertical lines are plotted for each month, showing the wet season. There are two periods of time in the year (January, March and November-December) that receive considerably less rainfall; June and July consistently have the highest temperatures, while the lowest consistently occur in January and December.

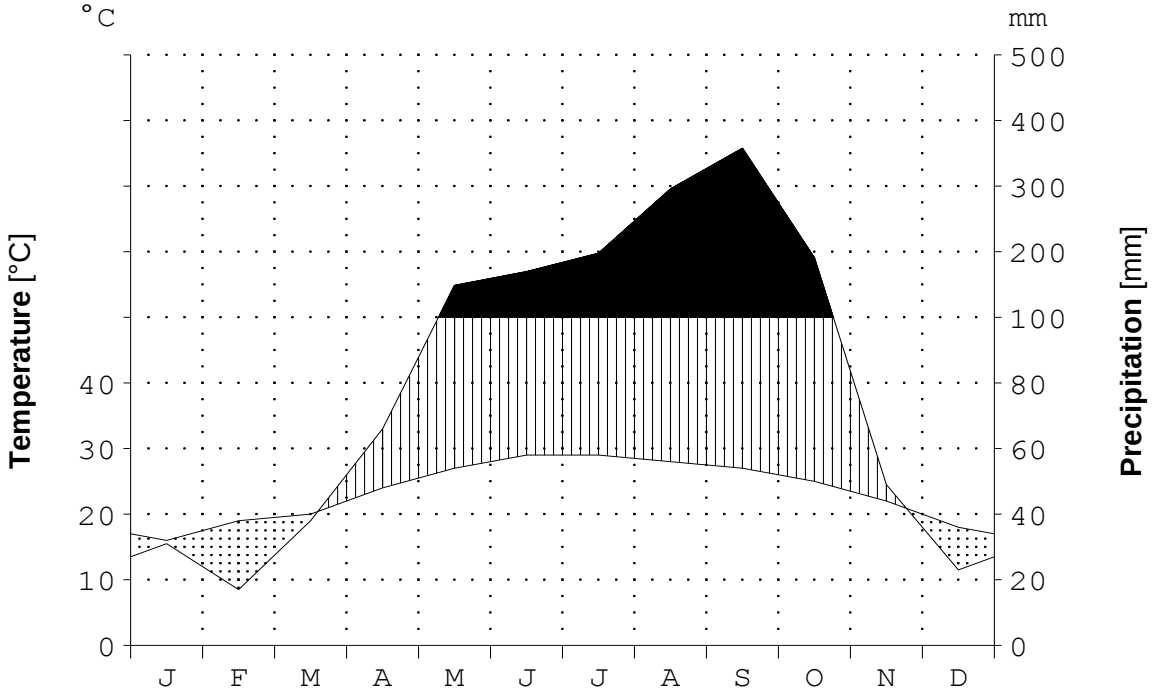

Fig. 5 Climate diagram in Ben En National Park, Thanh Hoa Province, Vietnam. Temperature and rainfall data are based on data collected from 2002 to 2011.

7 Main results of adult tree species

7.1 Species richness and the tree abundance of all tree species

A total of 2607 individuals and 516 stems ≥ 5 cm DBH were counted and measured in 3 hectares across three successional sites and the undisturbed forest. It was found that the longer the time period of succession, the greater the diversity among the number of individuals. The highest forest stand abundance (944 stems ha^{-1}) was recorded in the stand that had been abandoned after 25-26 years earlier; the lowest (516 stems ha^{-1}) was found in the undisturbed forest (Table 6.1).

Table 1 Tree abundance, basal area, and the number of species and families of all trees with a DBH ≥ 5 cm collected in the three phases of succession and undisturbed forest in Ben En National Park, Vietnam.

Variables	Year since abandonment			Undisturbed forest
	14-15	19-20	25-26	
Tree abundance [n/ha]	726	937	944	516
BA [m^2/ha]	12.2	14.3	26.3	41.5
Species number [n/ha]	58	80	115	110
Family number [n/ha]	31	34	37	36

Basal area increased linearly with plot age for the secondary and old-growth forests with the highest basal area being recorded in the undisturbed forest (41.5 m^2 ha^{-1}) and the lowest in the early secondary forest (12.2 m^2 ha^{-1}). Significant differences were found in the basal area among the successional forest phases and between the old-growth forest and each phase of succession thereafter. The old-growth forests were in this way significantly greater in total basal area and lower in tree abundance than was the secondary forest.

Results indicate that the number of families in the earlier phase and the species richness thereof were consistently lower than in both other phases and the old-growth forest. The lowest number of species (58) and families (31) were revealed in the early stage; the third phase represented the highest number of species (115) and families (37). Over the course of 15 years, the number of species in the first phase did not reach 60 species, whereas 115 species were distinguished in the third stage after 26 years. The number of species in the third phase were nearly double that of the earlier stage.

7.2 The diameter distribution and basal area of all tree species

Changes observed in tree abundance and the basal area by diameter class revealed important developments in the forest structure. The diameter distribution of the three different stages of succession and the two mature stands of old-growth forest is shown in Figure 6. The majority of species showed a gradual change in forest structure and tree composition when compared with the secondary and mature forest stands, but it is clear that there was a

downward trend -indeed, a reverse-J pattern-in the amount of individuals with an increasing diameter in all sites. While the several smaller size classes in all stages and the two mature stands were the most abundant, the shift from smaller stems towards stems with larger DBH values with increasing forest types was as expected.

Differences in tree abundance were evident, particularly in the smaller diameter classes of the first, intermediate and latest stages of succession; here, a higher proportion of individuals were counted in the first three diameter classes with a respective 88.6%, 90.5%, and 75.2%, abundance as compared with the old-growth forest. This generally indicates that forest stands are developing and that regenerated tree species are present in the forest. In contrast, the old-growth forests had a significantly higher number of large individuals ≥ 40 cm DBH; individuals with small diameter sizes were predominant in the secondary forests. The bar charts demonstrated a lack of large stems, and no individuals grew larger than 50 cm DBH in the first two phases. The biggest trees observed in the third successional phase were 75-80 cm, whereas in the undisturbed forest they grew up to 100-105 cm.

The proportional distribution of the basal area using DBH interval classes is given in Figure 5.1. Like the diameter distribution, the pattern of basal distribution (an inverted-J shaped curve) was observed in three successional phases; however, the trends in basal area distribution differed in the old growth forest, where the distribution peaked at a DBH of 15-20 cm in the earliest and latest phases. In the middle phase, the highest basal area was found in the 10-15 cm range; it was in the 45-50 cm diameter classes in the undisturbed forest, respectively. The basal area for those diameter classes ≤ 40 cm DBH was always significantly higher in the regenerating forests than in the mature forest. No basal area contribution of the diameter ≥ 50 cm was obtained in the first two phases of succession. Approximately 6.6% and 42.2% of the total basal area were respectively found in the latest phase and in the undisturbed forest.

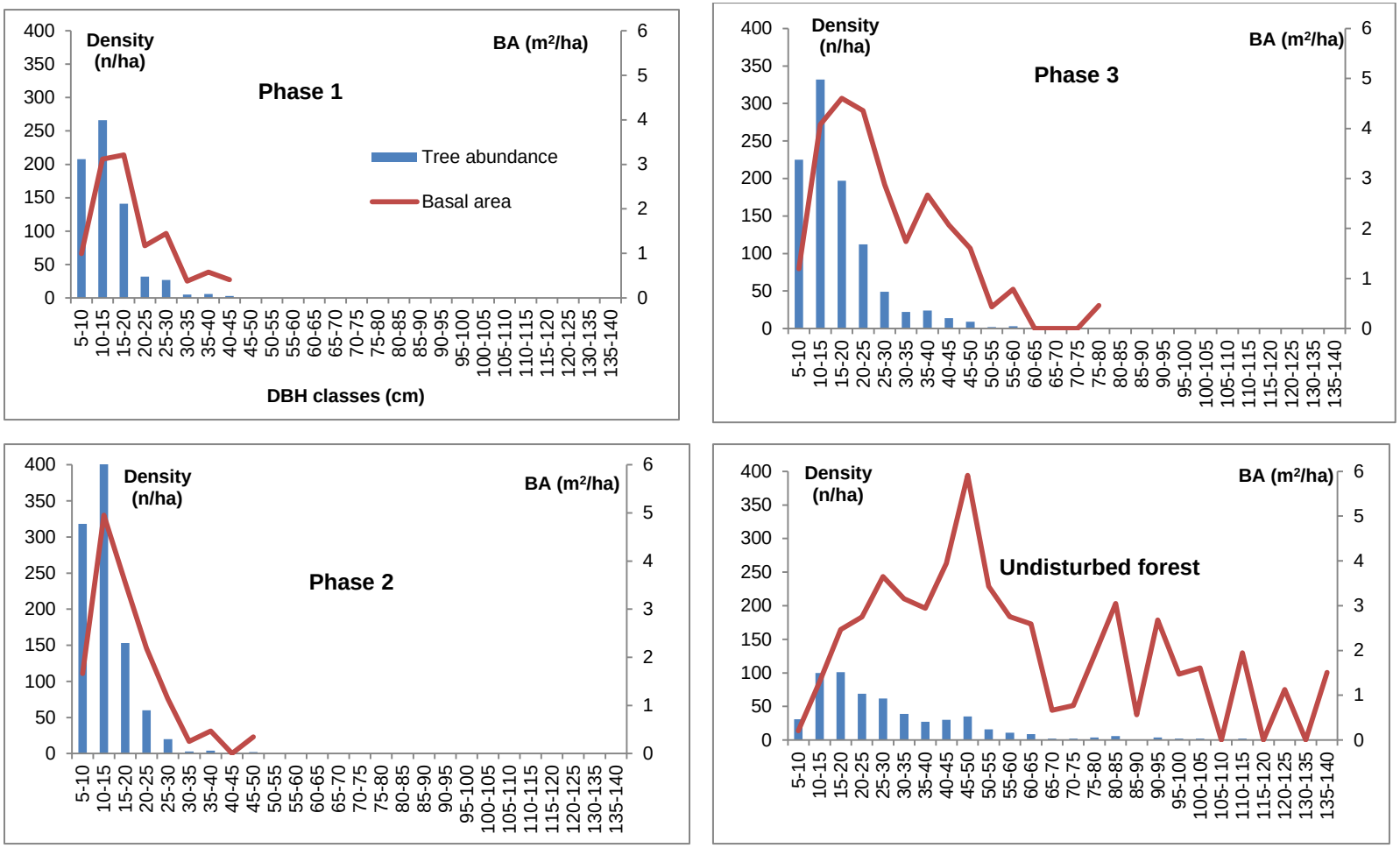

Fig. 6 The distribution of diameter classes and the basal area of all stems ≥ 5 cm DBH in each phase of succession and the undisturbed forest in Ben En National Park, Vietnam.

7.3 Tree composition of species and family of all tree species

The 10 most dominant tree species of the three stages of succession and undisturbed forest are shown in Table 2 and Appendices 1, 2, 3, and 4. 58 species were recorded in the early stage after 14-15 years fallow; most are light-demanding pioneer species such as *Vernicia montana* and *Alangium chinense*. The top three species captured in this forest stand formed around 150% of the total IVI, while 55 other species contributed 151% combined. Of these three top species, the most essential was *Vernicia montana* which contributed approximately 87% (nearly one-third) of the total IVI. This species also presented the greatest basal area (5.26 m^2 ha^{-1}) with 258 individuals showing 100% frequency in the plots sampled. The second highest basal area belonged to the *Alangium chinense* with 2.44 m^2 ha^{-1} and 51.5% IVI. In comparison with the other two stages surveyed in the 20 sample plots, this stage represented the lowest basal area and tree abundance.

In the intermediate stage, the dominating tree species were three light-demanding species: *Hypericum japonicum, Alangium chinense*, and *Vernicia montana*. The tree abundance of each species was a respective 340, 99, and 90 individuals ha^{-1} and together they contributed 56.4% of the total abundance. Of these species, *Hypericum japonicum* ranked first in absolute abundance, dominance, and frequency, but *Alangium chinense* and *Vernicia montana* contributed approximately 27% of the IVI each. Of the 80 species identified in the 20 sample plots, *Hypericum japonicum* was present in all plots.

115 species were found in the late stage, accounting for more than 80% of the total number of species in all three phases combined. This phase showed the largest variables of total basal area, tree abundance, species richness, and families. Of the ten most dominant species, *Cinnamomum tetragonum* contributed the largest IVI (19.5%); nine other species accounted for approximately 10% of the IVI each. The top five species accounted for about 67.9% of total value of the IVI, while the top 10 species comprised approximately only 115% of the total IVI; species abundance and dominance were thus shared equally by all of them.

Table 2 The 10 most dominant species of all stems with a DBH ≥ 5 cm in the three phases of succession and the undisturbed forest in Ben En National Park, Vietnam.

Scientific name	Absolute			IVI
	Abundance [n/ha]	Dominance [m^2/ha]	Frequency [%]	[%]
Phase 1				
Vernicia montana	258	5.26	100	86.8
Alangium chinense	169	2.44	100	51.5
Hypericum japonicum	24	0.47	55	11.7
Gironniera cuspidata	15	0.43	50	9.7
Sapium discolor	14	0.37	40	8.3
Ficus racemosa	9	0.43	25	6.8
Wrightia laevis	9	0.27	40	6.7
Trema orientalis	17	0.13	35	6.2
Ficus annulata	10	0.11	45	6.0
Cinamomum blansae	7	0.25	35	5.9
48 other species	194	2.04		100.4
Total	**726**	**12.2**		**300**
Phase 2				
Hypericum japonicum	340	3.73	100	69.0
Alangium chinense	99	1.61	90	27.7
Vernicia montana	90	1.48	95	26.2
Gironniera cuspidata	27	0.73	55	11.6
Sapium discolor	23	0.81	50	11.4
Peltophorum tonkinensis	29	0.52	45	9.7
Croton tiglium	23	0.33	55	8.4
Aglaia dasyclada	16	0.41	50	7.9
Canarium parvum	17	0.26	60	7.6
Wrightia laevis	19	0.35	45	7.5
70 other species	254	4.06		113
Total	**937**	**14.3**		**300**
Phase 3				
Cinnamomum tetragonum	72	2.25	80	19.5
Pometia pinnata	46	1.54	65	13.4

Gironniera cuspidata	42	1.44	70	12.8
Ficus vasculosa	44	0.82	85	11.3
Gironniera mollissima	34	1.15	70	10.9
Gironniera subaequalis	26	1.49	55	10.7
Schima superba	48	0.75	65	10.6
Alangium chinense	49	1.04	30	10.4
Sapium discolor	22	1.25	70	9.9
Mellettia lasiopetala	29	0.80	55	8.4
95 other species	532	13.7		182
Total	**944**	**26.3**		**300**
Undisturbed forest				
Pometia pinnata	31	2.90	80	17.3
Mischocarpus oppositifolius	22	2.93	50	14.0
Gironniera subaequalis	30	1.42	80	13.5
Erythrophleum fordii	18	2.02	55	11.3
Cinnamomum subavenium	18	1.85	60	11.1
Cinnamomum tetragonum	22	1.48	45	10.2
Gironniera cuspidata	21	0.67	60	8.9
Schima superba	21	0.50	60	8.5
Mellettia lasiopetala	22	0.70	45	8.3
Wrightia laevis	17	0.57	60	7.9
100 other species	294	26.4		189
Total	**516**	**41.5**		**300**

It is clear, then, that the species composition has indeed changed through time. In terms of the IVI value, *Vernicia montana* dominated in the first stage (258 individuals ha^{-1}) with an IVI value that was twice that of the next-highest species, *Alangium chinense*. *Hypericum japonicum* was the most dominant species in the second phase (340 individuals ha^{-1}), while *Alangium chinense* ranked second, followed by *Vernicia montana*. It was observed that *Vernicia montana*, *Alangium chinense,* and *Hypericum japonicum* were the most important species in the early phase but were less common in the later ones, whereas *Cinnamomum tetragonum,* and *Pometia pinnata* were common in the third stage but much rarer in the first one.

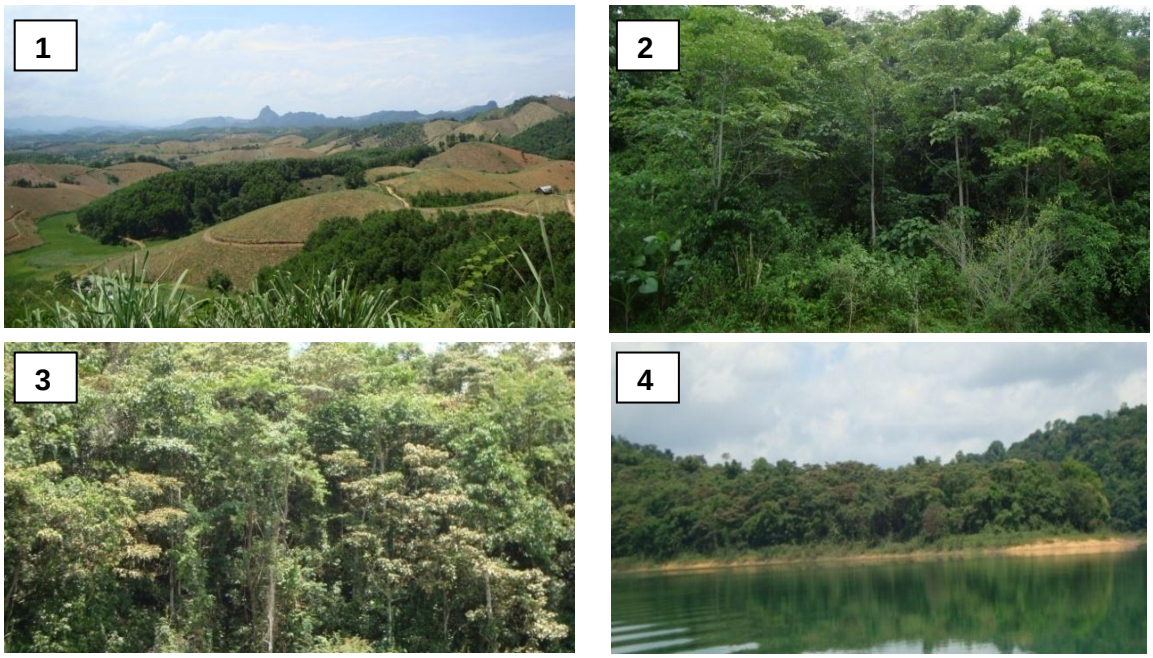

Fig. 7 Four pictures representing four different forest situations: (1) Bare land; (2) The early stage (14-15 years after abandonment); (3) The intermediate phase (19-20 years); and (4) The late phase (25-26 years).

In comparison with the secondary forest, the old-growth forest had a very different floristic composition with an abundant amount of large tree species such as *Pometia pinnata* and *Gironniera cuspidata*. The highest number of stems counted in the undisturbed forest belonged to *Pometia pinnata* and *Gironniera subaequalis* (31 and 30 individuals, respectively). Across 25 sample plots, only 13 species (11.8% of total number of species) had more than 10 individuals, while 74 species (67%) were made up of less than six individuals. Two species, *Pometia pinnata* and *Gironniera cuspidate,* had an absolute frequency of 80%, whereas 41 species (37%) occurred in at least one sample plot.

7.4 Tree composition of family of all tree species

Of the 43 families identified over all the study sites as indicated in Table 3, Euphorbiaceae was the most dominant based on taxonomic diversity (represented by 8 species) in the phase 1, whereas Lauraceae was the most well-represented in the two later phases and old-growth forest. 11 and 16 species belonging to this family were found in the second stage and the undisturbed forest, respectively. 26 families were common to all five sites, two only appeared in the third phase, and two were restricted to the undisturbed forest. The highest family number (19) represented by a single species was found in the first two successional

phases and was lowest in the old-growth forest (10 out of 36 families). A similar pattern was found in terms of family abundance; of the 36 families in the undisturbed forest, two were represented by one individual, while two, eight, and seven families with a single individual were respectively counted in the first, second, and third phases.

Table 3 The species number of each family of all stems with a DBH ≥ 5 cm identified in the three phases of succession and undisturbed forests in Ben En National Park, Vietnam.

Family	Phase 1	Phase 2	Phase 3	Undisturbed forest
Alangiaceae	1	1	1	1
Amaranthaceae	0	0	0	2
Anacardiaceae	1	1	2	4
Annonaceae	0	1	1	0
Apocynaceae	4	4	2	2
Aquifoliaceae	0	0	1	0
Araliaceae	0	0	1	1
Bignoniaceae	1	1	2	2
Burseraceae	4	6	4	4
Caesalpiniaceae	1	2	3	2
Clusiaceae	2	1	3	3
Dilleniaceae	1	0	0	2
Dipterocarpaceae	1	1	1	2
Ebenaceae	0	1	1	3
Elaeocarpaceae	1	1	1	1
Euphorbiaceae	8	6	6	2
Fabaceae	2	1	2	2
Fagaceae	1	4	9	9
Hypericaceae	1	1	1	0
Juglandaceae	0	0	1	0
Lamiaceae	1	0	0	0
Lauraceae	5	11	20	16
Lythraceae	1	0	0	1
Magnoliaceae	2	3	4	6
Meliaceae	3	1	6	9
Mimosaceae	0	1	2	1
Moraceae	3	5	7	6

Myristicaceae	2	1	2	2
Myrtaceae	2	3	5	5
Opiliaceae	0	0	0	1
Oxalidaceae	1	1	1	1
Phyllanthaceae	0	1	1	1
Rosaceae	1	1	1	1
Rubiaceae	0	1	1	0
Rutaceae	1	1	0	0
Sapindaceae	1	4	4	4
Sapotaceae	0	0	2	3
Sterculiaceae	1	3	4	2
Symplocaceae	1	1	2	2
Theaceae	0	2	2	2
Tiliaceae	1	2	1	1
Ulmaceae	2	3	5	3
Verbenaceae	1	3	3	2

Based on tree abundance and basal area, Euphorbiaceae was abundant in the first phase with 291 individuals ha^{-1} and 5.87 m^2 ha^{-1} respectively accounting for approximately 42% and 50% of the total abundance and basal area, whereas Hypericaceae ranked first in the middle phase. Ulmaceae dominated the DNoLF with 25% of the basal area, while Lauraceae scored the highest tree abundance and basal area in the latest phase and the UDNoLF. It is worth noting that Euphorbiaceae and Hypericaceae were ranked in the top five most abundant families in the first two successional species; however, they were absent from the top five families in the third phase and mature forests.

7.5 Diversity patterns of all tree species

The summary for the various diversity indices is shown in Table 4. The species number and diversity indices increased along with the forest age chronosequence and there was an increasing trend in the Shannon-Weiner index. The H' values for the early, intermediate and late phases were 2.58, 2.84 and 4.01, respectively, while 4.08 were recorded in the undisturbed forest.

Table 4 The species richness, Shannon-Wiener index, Evenness index, and Simpson's diversity index of all trees with a DBH ≥ 5 cm collected in the three phases of succession and the undisturbed forest in Ben En National Park, Vietnam.

Variables	Year since abandonment			Undisturbed forest
	14-15	19-20	25-26	
Species number [n/ha]	58	80	115	110
Shannon-Wiener index (H')	2.58	2.84	4.01	4.08
Evenness index [%]	63.5	64.7	84.3	86.9
Simpson's diversity index (D)	0.18	0.16	0.03	0.02

These figures indicate that the undisturbed forest was the most complex in species diversity, whereas the early phase was the simplest community in terms of species composition. A similar pattern was revealed in Simpson's diversity index which ranged from 0.02 to 0.16; the highest value was found in the undisturbed forest, the lowest in the first phase. The Evenness was highest in the old-grow forest, followed by the late stage; the lowest was in the earliest stage. All variables calculated in the earlier phases were lower than those of the latest phase and old-growth forests, which could be explained by the fact that the high absolute abundance of *Vernicia montana* and *Hypericum japonicum* (approximately 37% of the total tree abundance ha^{-1} each) was recorded in the first and second phases.

7.6 Diversity of tree species producing NTFPs classified by parts used

Of 164 tree species identified in four forest sites, a total of 44 species belonging to 23 families classified by parts used produced non-timber forest products, of which 17 species were found in the first phase, 26, 27, and 24 were recorded in the second, thirst and undisturbed forests (Table 5). Almost tree species producing NTFPs were found in the secondary succession in abandoned shifting cultivation. Edible fruit was extracted from 26 out of 44 species, while 12 species can produce leaves for using. When considering the number of different uses per plant family, the Euphorbiaceae represented the most important, with five species, followed by the Burseraceae, Lauraceae and Moraceae (four species each).

Table 5 Diversity of tree species producing NTFPs classified by parts used

Local name	Scientific name	Family	Part(s) used
Ba bét	*Mallotus decipiens*	Euphorbiaceae	Leaves
Ba bét đỏ	*Mallotus metcalfianus*	Euphorbiaceae	Leaves
Bã đậu	*Croton tiglium*	Euphorbiaceae	Stem
Ba gạc lá xoan	*Rauvolfia verticillata*	Apocynaceae	Leaves
Bồ kết	*Gleditsia australis*	Caesalpiniaceae	Fruit
Bứa	*Garcinia oblongifolia*	Clusiaceae	Leaves
Bưởi bung	*Acronychia pedunculata*	Rutaceae	Leaves
Chân chim	*Schefflera octophylla*	Araliaceae	Leaves
Chay bắc bộ	*Artocarpus tonkinensis*	Moraceae	Bark
Chay lá bồ đề	*Artocarpus styracifolius*	Moraceae	Bark
Chay rừng	*Artocarpus tonkinensis*	Moraceae	Bark
Cò ke	*Grewia paniculata*	Tiliaceae	Fruit
Dâu da đất	*Baccaurea sapida*	Phyllanthaceae	Edible fruit
Dâu da xoan	*Spondias lakoensis*	Anacardiaceae	Edible fruit
Dẻ	*Castanopsis annamensis*	Fagaceae	Fruit
Dẻ ăn quả	*Quercus platycalyx*	Fagaceae	Edible fruit
Dẻ gai	*Castanopsis lecomtei*	Fagaceae	Fruit
Đẻn	*Vitex leptobotrys*	Verbenaceae	Stem
Đẻn 3 lá	*Vitex trifolia*	Verbenaceae	Stem
Đẻn 5 lá	*Vitex quinata*	Verbenaceae	Stem
Găng	*Canthium horridum*	Rubiaceae	Fruit
Giổi ăn quả	*Michelia tonkinensis*	Magnoliaceae	Edible fruit
Kháo	*Machilus sp.*	Lauraceae	Bark
Khế	*Averrhoa sp.*	Oxalidaceae	Edible fruit
Khế rừng	*Averrhoa carambola*	Oxalidaceae	Edible fruit
Nhội	*Bischofia javanica*	Euphorbiaceae	Leaves
Quế lợn	*Cinnamomum bejolghota*	Lauraceae	Bark
Rau sắng	*Melientha suavis*	Opiliaceae	Leaves
Re gừng	*Cinnamomum ovatum*	Lauraceae	Leaves, bark
Sảng nhung	*Sterculia lanceolata*	Sterculiaceae	Fruit
Sấu tía	*Lagerstroemia tomentosa*	Lythraceae	Edible fruit
Sung rừng	*Ficus sp.*	Moraceae	Edible fruit
Trám chim	*Canarium parvum*	Burseraceae	Edible fruit

Trám đen	*Canarium tramdenum*	Burseraceae	Edible fruit
Trám hồng	*Canarium littorale*	Burseraceae	Edible fruit
Trám trắng	*Canarium album*	Burseraceae	Edible fruit
Trẩu	*Vernicia montana*	Euphorbiaceae	Fruit
Trường vải	*Paranephelium spirei*	Sapindaceae	Fruit
Ươi	*Sterculia tonkinensis*	Sterculiaceae	Fruit
Vối thuốc	*Schima wallichii*	Theaceae	Leaves
Vối thuốc răng cưa	*Schima superba*	Theaceae	Leaves
Vù hương	*Cinamomum blansae*	Lauraceae	Whole plant
Vú sữa	*Chrysophyllum cainito*	Sapotaceae	Edible fruit
Xoài rừng	*Mangifera minitifolia*	Anacardiaceae	Edible fruit

Fig.8: Collecting and sharing information about tree species producing non-timber forest products with park ranger.

Fig. 9: Collecting information from local men and elderly person

Fig. 10: Collecting information from local women

Fig. 11: Collecting information from the whole group

7.7. Population density of tree species producing NTFPs classified by parts used

Density of 44 species producing NTFPs is shown in Table 6. Overall, density was comparatively higher in successional forests than undisturbed one. The majority of the species occur with maximum densities of 0-5 stems/ha. Many species have even less than one producing individual per hectare. Only few species occur in higher densities (> 20 stems/ha) in specific habitat types. 11 out of 44 species producing NTFFs had only one individual, while 17 species were found at density of greater than two individuals and smaller than 5. The density of tree species producing NTFPs was highest in the first phase (330 individuals/ha), followed by the second phase (202 stems/ha), the third one (199 stems/ha) and undisturbed forest (72 individuals/ha).

The NTFP abundances were different in four forest sites. As indicated in Table 6, the lowest number of tree species producing NTFPs were found in the first phase (17 species), while the highest was counted in the third one (27). In the former phase, *Vernicia Montana* had the highest mean population of ha^{-1} (258 indiviudals) and six tree species had only 1-2 individuals/ha. In the second phase, out of 26 species, *Vernicia Montana* had the highest mean population per ha (90 individuals), while the lowest, one per ha, was noted each for *Rauvolfia verticillata, Rauvolfia verticillata, Artocarpus tonkinensis, Grewia paniculata, Baccaurea sapida, Castanopsis annamensis, Vitex leptobotrys, Vitex quinata, Canthium horridum, Averrhoa sp., Canarium tramdenum*. Ten out of 27 species counted in the third phase had one individual, while almost species with only stem/ha were found in the undisturbed forest.

The floristic composition of successional and undisturbed forests was different (Table 6). Pioneer species are clearly favoured in the former forest since the logging operations create apparently optimal growing conditions, as can be concluded from the maximum densities found in these logged-over forests, such as *Vernicia Montana, Mallotus decipiens,* and *Mallotus metcalfianus,* whilst the densities of shade-bearers as *Castanopsis annamensis* and *Quercus platycalyx* was lower, even they were absent.

Table 6: Density of tree species producing NTFPs classified by parts used in the four forest sites in Ben En National Park, Vietnam

Local name	Scientific name	Density of species collected in				Total
		Phase 1 (ha)	Phase 2 (ha)	Phase 3 (ha)	UD (ha)	
Ba bét	*Mallotus decipiens*	5	2	-	-	7
Ba bét đỏ	*Mallotus metcalfianus*	2	-	-	-	2
Bã đậu	*Croton tiglium*	-	23	5	-	28
Ba gạc lá xoan	*Rauvolfia verticillata*	1	1	1	-	3
Bồ kết	*Gleditsia australis*	-	-	1	-	1
Bứa	*Garcinia oblongifolia*	6	1	6	1	14
Bưởi bung	*Acronychia pedunculata*	2	3	-	-	5
Chân chim	*Schefflera octophylla*	-	-	4	2	6
Chay bắc bộ	*Artocarpus tonkinensis*	-	2	-	1	3
Chay lá bồ đề	*Artocarpus styracifolius*	-	-	1	-	1
Chay rừng	*Artocarpus tonkinensis*	-	1	1	-	2
Cò ke	*Grewia paniculata*	-	1	-	-	1
Dâu da đất	*Baccaurea sapida*	-	1	1	3	5
Dâu da xoan	*Spondias lakoensis*	1	-	-	1	2
Dẻ	*Castanopsis annamensis*	2	1	4	4	11
Dẻ ăn quả	*Quercus platycalyx*	-	-	-	1	1
Dẻ gai	*Castanopsis lecomtei*	-	-	1	3	4
Đẻn	*Vitex leptobotrys*	-	1	3	-	4
Đẻn 3 lá	*Vitex trifolia*	11	12	8	3	34
Đẻn 5 lá	*Vitex quinata*	-	1	3	-	4
Găng	*Canthium horridum*	-	1	-	-	1
Giổi ăn quả	*Michelia tonkinensis*	-	-	-	1	1
Kháo	*Machilus sp.*	-	-	1	-	1
Khế	*Averrhoa sp.*	7	1	1	-	9
Khế rừng	*Averrhoa carambola*	-	-	-	1	1
Nhội	*Bischofia javanica*	1	-	-	2	3
Quế lợn	*Cinnamomum bejolghota*	-	-	1	-	1
Rau sắng	*Meliantha suavis*	-	-	-	2	2
Re gừng	*Cinnamomum ovatum*	-	-	2	3	5
Sảng nhung	*Sterculia lanceolata*	-	3	5	-	8
Sấu tía	*Lagerstroemia tomentosa*	2	-	-	3	5
Sung rừng	*Ficus sp.*	9	3	3	-	15
Trám chim	*Canarium parvum*	7	17	29	7	60
Trám đen	*Canarium tramdenum*	2	2	-	-	4
Trám hồng	*Canarium littorale*	-	10	9	4	23

Trám trắng	*Canarium album*	7	11	23	2	43
Trẩu	*Vernicia montana*	258	90	28	-	376
Trường vải	*Paranephelium spirei*	-	3	4	3	10
Ươi	*Sterculia tonkinensis*	-	1	4	-	5
Vối thuốc	*Schima wallichii*	-	-	-	1	1
Vối thuốc răng cưa	*Schima superba*	-	6	48	21	75
Vù hương	*Cinamomum blansae*	7	-	2	1	10
Vú sữa	*Chrysophyllum cainito*	-	-	-	1	1
Xoài rừng	*Mangifera minitifolia*	-	4	-	1	5
Total of tree species		**17**	**26**	**27**	**24**	**44**

UD: Undisturbed forest

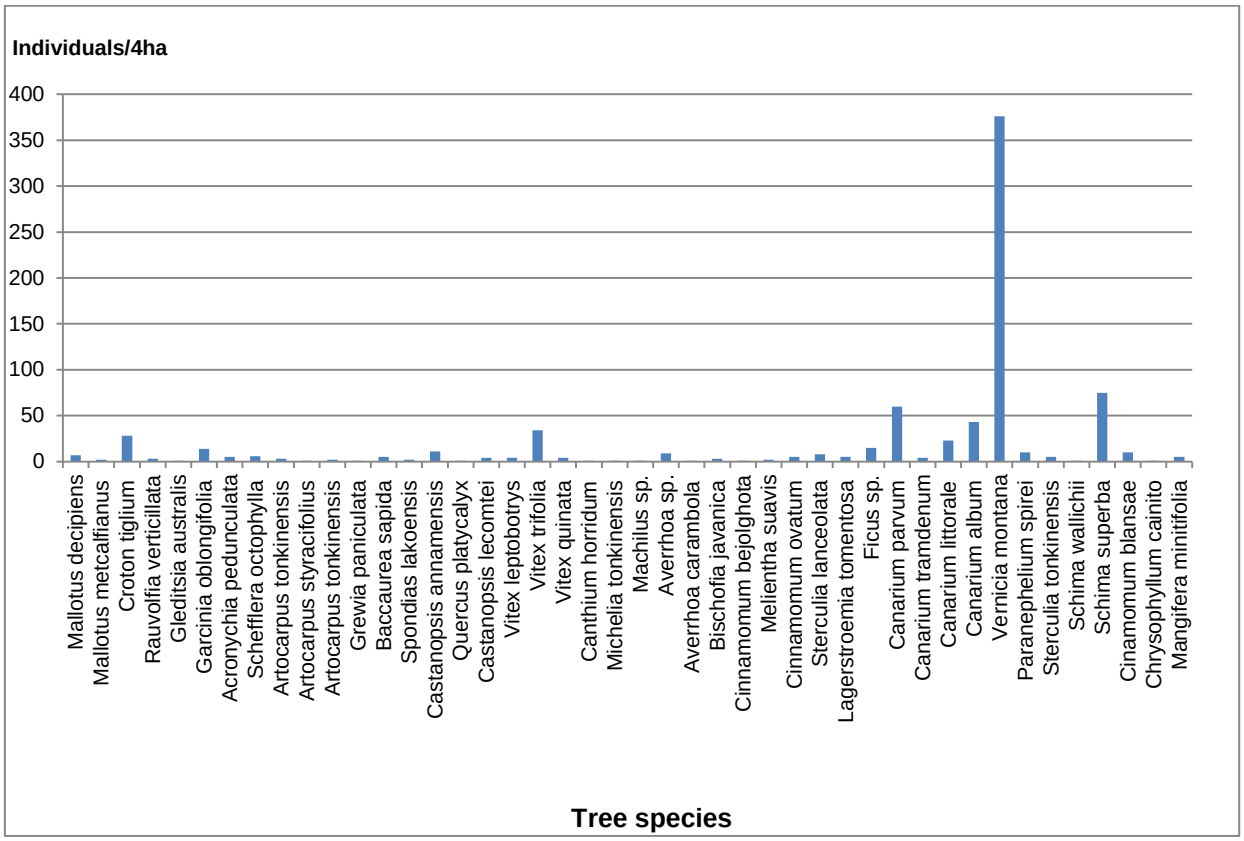

Fig. 12: Total density of tree species producing NTFPs classified by parts used

7.8 Diversity of tree species classified by different uses

The results show that non-timber products identified by the local inhabitants and park rangers were used for fuelwood, building materials, food, medicine, resins, furnitune, flavor, and spice (Table 7). The family with the largest number of uses was Euphorbiaceae with seven documented uses, followed by Amaranthaceae (six uses), and Lamiaceae (five), while

11 families were recorded with one use only. For medicinal uses, Theaceae and two species *Mallotus decipiens* and *Mallotus metcalfianus* of Euphorbiaceae were the most important families in terms of medicinal uses, while Moraceae was particularly important for resin. Lauraceae had many species producing flavor, while a high number of family (Anacardiaceae, Araliaceae, Clusiaceae, Fagaceae, Lauraceae, Magnoliaceae, Oxalidaceae, and Phyllanthaceae) produced spice.

Table 7 Diversity of tree species classified by different uses

Vietnamese name	Scientific name	Family name	Purpose Uses
Ba bét	*Mallotus decipiens*	Euphorbiaceae	Medicinal; firewood
Ba bét đỏ	*Mallotus metcalfianus*	Euphorbiaceae	Medicinal; firewood
Bã đậu	*Croton tiglium*	Euphorbiaceae	Resin
Ba gạc lá xoan	*Rauvolfia verticillata*	Apocynaceae	Resin
Ban ban	*Hypericum japonicum*	Hypericaceae	Firewood
Bồ kết	*Gleditsia australis*	Caesalpiniaceae	Firewood
Bời lời	*Litsea griffithii*	Lauraceae	Furniture and oil
Bời lời vòng	*Litsea verticillata*	Lauraceae	Furniture
Bứa	*Garcinia oblongifolia*	Clusiaceae	Furniture and spice
Bưởi bung	*Acronychia pedunculata*	Rutaceae	Medicinal and firewood
Cà ổi	*Castanopsis indica*	Fagaceae	Furniture
Chân chim	*Schefflera octophylla*	Araliaceae	Firewood and spice
Chay bắc bộ	*Artocarpus tonkinensis*	Moraceae	Firewood and resin
Chay lá bồ đề	*Artocarpus styracifolius*	Moraceae	Firewood and resin
Chay rừng	*Artocarpus tonkinensis*	Moraceae	Firewood and resin
Chè đuôi	*Camellia caudata*	Theaceae	Firewood
Chò nâu	*Dipterocarpus retusus*	Dipterocarpaceae	Furniture
Chòi mòi	*Antidesma acidum*	Euphorbiaceae	Firewood
Chua khét	*Dosoxylum acutangulum*	Meliaceae	Furniture
Cò ke	*Grewia paniculata*	Tiliaceae	Firewood
Cơi	*Pterocarya tonkinensis*	Juglandaceae	Furniture
Côm tầng	*Elaeocarpus griffithii*	Elaeocarpaceae	Street tree
Đa gừ	*Ficus curtipes*	Moraceae	Furniture
Đa quả xanh	*Ficus annulata*	Moraceae	Firewood
Đa tía	*Ficus altissima*	Moraceae	Firewood
Dâu da đất	*Baccaurea sapida*	Phyllanthaceae	Firewood and spice
Dâu da xoan	*Spondias lakoensis*	Anacardiaceae	Firewood and spice
Dẻ	*Castanopsis annamensis*	Fagaceae	Furniture
Dẻ ăn quả	*Quercus platycalyx*	Fagaceae	Furniture
Dẻ cau	*Quercus sp.*	Fagaceae	Furniture
Dẻ đỏ	*Castanopsis hystrix*	Fagaceae	Furniture
Dẻ gai	*Castanopsis lecomtei*	Fagaceae	Furniture and spice
Đẻn	*Vitex leptobotrys*	Verbenaceae	Furniture
Đẻn 3 lá	*Vitex trifolia*	Verbenaceae	Furniture

Đẻn 5 lá	*Vitex quinata*	Verbenaceae	Furniture
Dền cơm	*Amaranthus spinosus*	Amaranthaceae	Furniture
Đẻn đỏ	*Vitex leptobotrys*	Verbenaceae	Furniture
Dền tía	*Amaranthus tricolor*	Amaranthaceae	Furniture
Đinh dại	*Markhamia stipulata*	Bignoniaceae	Firewood
Đinh hương	*Dysoxylum cauliflorum*	Meliaceae	Furniture
Đinh thối	*Fernandoa brilletii*	Bignoniaceae	Furniture
Dọc vàng	*Garcinia multiflora*	Clusiaceae	Furniture
Dung đen	*Symplocos lauria*	Symplocaceae	Firewood
Dung giấy	*Symplocos atriolivacea*	Symplocaceae	Firewood
Dung nam	*Symplocos cochinchinensis*	Symplocaceae	Firewood
Đuôi chồn	*Uraria crinita*	Fabaceae	Furniture
Đuôi trâu	*Mellettia lasiopetala*	Fagaceae	Furniture
Găng	*Canthium horridum*	Rubiaceae	Flavor
Giổi ăn quả	*Michelia tonkinensis*	Magnoliaceae	Furniture and spice
Giổi bà	*Michelia banlanse*	Magnoliaceae	Furniture and firewood
Giổi bắc bộ	*Michelia tonkinensis*	Magnoliaceae	Furniture
Giổi nhung	*Paramechelia braianensis*	Magnoliaceae	Furniture
Giổi xanh	*Michelia mediocris*	Magnoliaceae	Furniture
Gội	*Aphanamixis silvestris*	Meliaceae	Furniture
Gội đỏ	*Aglaia dasyclada*	Meliaceae	Furniture
Gội gà	*Aglaia silvestric*	Meliaceae	Furniture
Gội gác	*Aphanamixis polystachya*	Meliaceae	Furniture
Gội nếp	*Aglaia spectabilis*	Meliaceae	Furniture
Gội núi	*Aglaia roxburghiana*	Meliaceae	Furniture
Gội tẻ	*Aglaia perviridis*	Meliaceae	Furniture
Gội trắng	*Aphanamixis grandifolia*	Meliaceae	Furniture
Hu đay	*Trema orientalis*	Ulmaceae	Firewood
Hu lông	*Trema politoria*	Ulmaceae	Firewood
Kè đuôi dông	*Markhamia cauda-felina*	Bignoniaceae	Furniture
Kháo	*Machilus sp.*	Lauraceae	Furniture and flavor
Kháo lá to	*Phoebe tavoyana*	Lauraceae	Furniture and flavor
Kháo nước	*Phoebe paniculata*	Lauraceae	Furniture and flavor
Kháo vàng	*Machilus bonii*	Lauraceae	Furniture and flavor
Khế	*Averrhoa sp.*	Oxalidaceae	Firewood and spice
Khế rừng	*Averrhoa carambola*	Oxalidaceae	Firewood and spice
Lim xanh	*Erythrophleum fordii Oliv*	Caesalpiniaceae	Furniture
Lim xẹt	*Peltophorum tonkinensis*	Caesalpiniaceae	Firewood and Furniture
Lõi thọ	*Gmelina arborea*	Lamiaceae	Furniture
Lọng bàng	*Dillenia heterosepala*	Dilleniaceae	Furniture
Lòng mang	*Pterospermum hetrophyllum*	Sterculiaceae	Furniture
Long não	*Cinnamomum camphora*	Lauraceae	Furniture; oil and flavor
Lòng trứng	*Lindera racemosa*	Lauraceae	Furniture
Mãi táp	*Aidia oxyodonta*	Rubiaceae	Furniture
Mán đỉa	*Archidendron clypearia*	Mimosaceae	Firewood

Mán đỉa trâu	*Archidendron lucidum*	Mimosaceae	Firewood
Máu chó lá nhỏ	*Knema globularia*	Myristicaceae	Furniture
Máu chó lá to	*Knema pierrei Warb*	Myristicaceae	Furniture
Mé cò ke	*Grewia paniculata Roxb.*	Tiliaceae	Firewood and spice
Mít rừng	*Cryptocarya sp*	Lauraceae	Furniture and spice
Mò lá lớn	*Cryptocarya annanmensis*	Lauraceae	Firewood
Mò lá tròn	*Cryptocarya impressa*	Lauraceae	Firewood
Nanh chuột	*Cryptocarya lenticellata*	Lauraceae	Furniture
Ngát	*Gironniera cuspidata*	Ulmaceae	Furniture
Ngát lông	*Gironniera mollissima*	Ulmaceae	Furniture
Ngát vàng	*Gironniera subaequalis*	Ulmaceae	Furniture
Ngô đồng	*Firmiana simplex*	Sterculiaceae	Furniture
Nhọ nồi	*Diospyros apiculata*	Ebenaceae	Firewood
Nhọc lá to	*Polyalthia laui*	Annonaceae	Furniture
Nhội	*Bischofia javanica*	Euphorbiaceae	Furniture and street tree
Nhựa ruồi	*Ilex rotunda*	Aquifoliaceae	Furniture and flavor
Quế lợn	*Cinnamomum bejolghota*	Lauraceae	Furniture and flavor
Ràng ràng xanh	*Ormosia pinnata*	Fabaceae	Firewood
Rau sắng	*Melientha suavis*	Opiliaceae	Firewood and food
Re đá	*Cinnamomum mairei*	Lauraceae	Furniture
Re đỏ	*Cinnamomum tetragonum*	Lauraceae	Furniture
Re gân lõm	*Cinnamomum impressimeurium*	Lauraceae	Furniture
Re gừng	*Cinnamomum ovatum*	Lauraceae	Furniture and flavor
Re hương	*Cinnamomum iners*	Lauraceae	Firewood
Re mới	*Cinnamomum burmannii*	Lauraceae	Furniture
Re mới lá to	*Cinnamomum subavenium*	Lauraceae	Furniture
Re nhớt	*Cinnamomum sp.*	Lauraceae	Furniture
Re sâu	*Machilus bonii*	Lauraceae	Furniture
Re thơm	*Cinnamomum sp1.*	Lauraceae	Furniture
Re xanh	*Cinnamomum parthenoxylon*	Lauraceae	Furniture
Săng lẻ	*Lagerstroemiatomentsa Presl.*	Lythraceae	Furniture
Sảng nhung	*Sterculia lanceolata*	Sterculiaceae	Firewood and food
Sấu tía	*Dracontomelum duperreanum*	Anacardiaceae	Furniture and foods (fruits)
Sến đất	*Sinosideroxylon racemosum*	Sapotaceae	Furniture
Sến mật	*Madhuca pasquieri*	Sapotaceae	Furniture
Sổ	*Dillenia scabrella*	Dilleniaceae	Furniture
Sồi bắc giang	*Lithocarpus bacgiangnenis*	Fagaceae	Furniture
Sồi đỏ	*Lithocarpus elegans*	Fagaceae	Furniture
Sòi núi	*Balakata baccata*	Euphorbiaceae	Furniture
Sồi phảng	*Lithocarpus areca*	Fagaceae	Furniture
Sòi tía	*Sapium discolor*	Euphorbiaceae	Firewood
Sơn rừng	*Rhus rhetsoides*	Anacardiaceae	Firewood and flavor
Sơn ta	*Rhus succedanea*	Anacardiaceae	Firewood
Song xanh	*Actinodaphne obovata*	Lauraceae	Furniture
Sụ lá kiếm	*Phoebe angustifolia*	Lauraceae	Furniture

Sữa	*Alstonia scholaris*	Apocynaceae	Furniture and street tree
Sui	*Antiaris toxicaria*	Moraceae	Furniture
Sung	*Ficus racemosa*	Moraceae	Furniture and food (fruit)
Sung rừng	*Ficus sp.*	Moraceae	Furniture and food (fruit)
Táu muối	*Vatica odorata*	Dipterocarpaceae	Firewood
Thành ngạnh	*Cratoxylum polyanthum*	Clusiaceae	Firewood
Thẩu tấu	*Aporosa dioica*	Euphorbiaceae	Furniture
Thị lông	*Diospyros hirsuta*	Ebenaceae	Firewood
Thị rừng	*Diospyros montana*	Ebenaceae	Firewood
Thôi ba	*Alangium chinense*	Alangiaceae	Furniture
Thừng mực lông	*Wrightia pubscens*	Apocynaceae	Furniture
Thừng mực mỡ	*Wrightia laevis*	Apocynaceae	Furniture
Trâm	*Syzygium brachiatum*	Myrtaceae	Furniture
Trâm bắc bộ	*Syzygium tonkinensis*	Myrtaceae	Furniture
Trám chim	*Canarium parvum*	Burseraceae	Furniture and food
Trám đen	*Canarium tramdenum*	Burseraceae	Furniture and food
Trâm đỏ	*Syzygium zeylanicum*	Myrtaceae	Furniture
Trám hồng	*Canarium littorale*	Burseraceae	Furniture and food
Trâm khế	*Syzygium sp*	Myrtaceae	Furniture
Trâm lá bóng	*Syzygium parviflorum*	Myrtaceae	Furniture
Trâm núi	*Syzygium levinei*	Myrtaceae	Furniture
Trám trắng	*Canarium album*	Burseraceae	Furniture and food
Trâm trắng	*Syzygium chanlos*	Myrtaceae	Furniture
Trám trẩu	*Mytilaria laosensis*	Burseraceae	Furniture
Trẩu	*Vernicia montana*	Euphorbiaceae	Firewood and flavor
Trường kẹn	*Mischocarpus oppositifolius*	Sapindaceae	Furniture
Trường mật	*Pometia pinnata*	Sapindaceae	Furniture
Trường sâng	*Amesiodendron chinense*	Sapindaceae	Furniture
Trường vải	*Paranephelium spirei*	Sapindaceae	Furniture
Ươi	*Sterculia tonkinensis*	Sterculiaceae	Furniture, flavor and food
Vàng tâm	*Manglietia dandyi*	Magnoliaceae	Furniture
Vạng trứng	*Endospermum sinensis*	Euphorbiaceae	Furniture
Vỏ mãn	*Ficus vasculosa*	Moraceae	Furniture
Vối thuốc	*Schima wallichii*	Theaceae	Firewood and medicinal
Vối thuốc răng cưa	*Schima superba*	Theaceae	Firewood and medicinal
Vù hương	*Cinamomum blansae*	Lauraceae	Furniture
Vú sữa	*Chrysophyllum cainito*	Sapotaceae	Furniture and food
Xoài rừng	*Mangifera minitifolia*	Anacardiaceae	Furniture and food
Xoan đào	*Prunus arborea*	Rosaceae	Furniture
Xoan nhừ	*Spondias axillaris*	Anacardiaceae	Furniture

A total of 164 species covering 43 families were recorded from the four forest sites (Table 7). The majority of species recorded in the sampled plots were used either as furniture or as firewood (Fig. 3). Of these, 42 species were utilized for firewood; 115 for furniture, 45 species

were classes into two utilization categories (furniture and oil, firewood and flavor, firewood and medicinal, furniture and flavor, furniture and food, furniture and spice), only five were medicinal species, including *Schima wallichii, Schima superba, Acronychia pedunculata, Mallotus decipiens, Mallotus metcalfianus*.

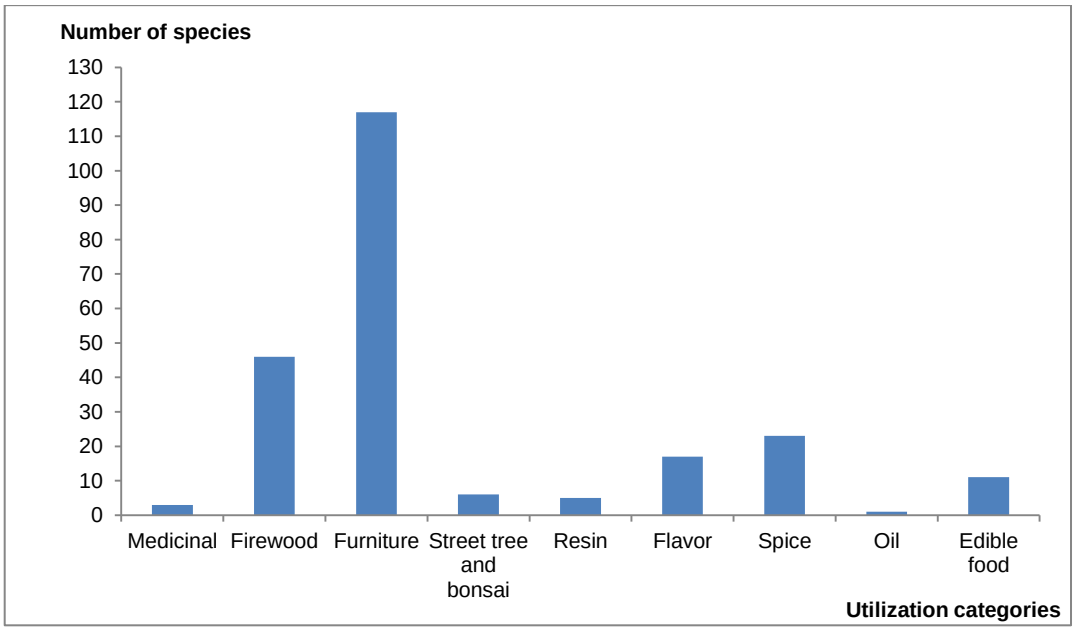

Fig. 13: The number of tree species classified into a single utilization category (mixed utilization were not mentioned in this figure)

7.9 Diversity of tree species producing NTFPs preffered by local people

Of the 164 tree species recorded in the four forest sites, three spcies (*Quercus platycalyx, Michelia tonkinensis*, and *Melientha suavis*) were extremely preffered by local people (Table 8). Of these three species, the first two species produced edible fruits and the third species' leaves were used for cooking. 29 species were mentioned by local people as "like", while they had no comments on the remaining species.

Table 8: Diversity of tree species preferred by local people (X means: Local people's choice)

Local name	Scientific name	Extremly like	Like	Dislike	Note
Ba bét	*Mallotus decipiens*				N/A
Ba bét đỏ	*Mallotus metcalfianus*				N/A
Bã đậu	*Croton tiglium*				N/A
Ba gạc lá xoan	*Rauvolfia verticillata*				N/A

Ban ban	*Hypericum japonicum*				N/A
Bồ kết	*Gleditsia australis*				N/A
Bời lời	*Litsea griffithii*				N/A
Bời lời vòng	*Litsea verticillata*				N/A
Bứa	*Garcinia oblongifolia*			X	
Bưởi bung	*Acronychia pedunculata*				N/A
Cà ổi	*Castanopsis indica*				N/A
Chân chim	*Schefflera octophylla*			X	
Chay bắc bộ	*Artocarpus tonkinensis*			X	
Chay lá bồ đề	*Artocarpus styracifolius*			X	
Chay rừng	*Artocarpus tonkinensis*			X	
Chè đuôi	*Camellia caudata*				N/A
Chò nâu	*Dipterocarpus retusus*				N/A
Chòi mòi	*Antidesma acidum*			X	
Chua khét	*Dosoxylum acutangulum*				N/A
Cò ke	*Grewia paniculata*			X	
Cơi	*Pterocarya tonkinensis*				N/A
Côm tầng	*Elaeocarpus griffithii*				N/A
Đa gừ	*Ficus curtipes*				N/A
Đa quả xanh	*Ficus annulata*				N/A
Đa tía	*Ficus altissima*				N/A
Dâu da đất	*Baccaurea sapida*			X	
Dâu da xoan	*Spondias lakoensis*			X	
Dẻ	*Castanopsis annamensis*			X	
Dẻ ăn quả	*Quercus platycalyx*		X		
Dẻ cau	*Quercus sp.*				N/A
Dẻ đỏ	*Castanopsis hystrix*				N/A
Dẻ gai	*Castanopsis lecomtei*			X	
Đẻn	*Vitex leptobotrys*				N/A
Đẻn 3 lá	*Vitex trifolia*				N/A
Đẻn 5 lá	*Vitex quinata*				N/A
Dền cơm	*Amaranthus spinosus*				N/A
Đẻn đỏ	*Vitex leptobotrys*				N/A
Dền tía	*Amaranthus tricolor*				N/A
Đinh dại	*Markhamia stipulata*				N/A
Đinh hương	*Dysoxylum cauliflorum*				N/A
Đinh thối	*Fernandoa brilletii*				N/A
Dọc vàng	*Garcinia multiflora*				N/A
Dung đen	*Symplocos lauria*				N/A
Dung giấy	*Symplocos atriolivacea*				N/A
Dung nam	*Symplocos cochinchinensis*				N/A
Đuôi chồn	*Uraria crinita*				N/A
Đuôi trâu	*Mellettia lasiopetala*				N/A
Găng	*Canthium horridum*				N/A

Giổi ăn quả	*Michelia tonkinensis*	X			
Giổi bà	*Michelia banlanse*				N/A
Giổi bắc bộ	*Michelia tonkinensis*				N/A
Giổi nhung	*Paramechelia braianensis*				N/A
Giổi xanh	*Michelia mediocris*				N/A
Gội	*Aphanamixis silvestris*				N/A
Gội đỏ	*Aglaia dasyclada*				N/A
Gội gà	*Aglaia silvestric*				N/A
Gội gác	*Aphanamixis polystachya*				N/A
Gội nếp	*Aglaia spectabilis*				N/A
Gội núi	*Aglaia roxburghiana*				N/A
Gội tẻ	*Aglaia perviridis*				N/A
Gội trắng	*Aphanamixis grandifolia*				N/A
Hu đay	*Trema orientalis*				N/A
Hu lông	*Trema politoria*				N/A
Kè đuôi giông	*Markhamia cauda-felina*				N/A
Kháo	*Machilus sp.*				N/A
Kháo lá to	*Phoebe tavoyana*				N/A
Kháo nước	*Phoebe paniculata*				N/A
Kháo vàng	*Machilus bonii*				N/A
Khế	*Averrhoa sp.*			X	
Khế rừng	*Averrhoa carambola*			X	
Lim xanh	*Erythrophleum fordii Oliv*				N/A
Lim xẹt	*Peltophorum tonkinensis*				N/A
Lõi thọ	*Gmelina arborea*				N/A
Lọng bàng	*Dillenia heterosepala*				N/A
Lòng mang	*Pterospermum hetrophyllum*				N/A
Long não	*Cinnamomum camphora*				N/A
Lòng trứng	*Lindera racemosa*				N/A
Mãi táp	*Aidia oxyodonta*				N/A
Mán đỉa	*Archidendron clypearia*				N/A
Mán đỉa trâu	*Archidendron lucidum*				N/A
Máu chó lá nhỏ	*Knema globularia*				N/A
Máu chó lá to	*Knema pierrei*				N/A
Mé cò ke	*Grewia paniculata*			X	
Mít rừng	*Cryptocarya sp*			X	
Mò lá lớn	*Cryptocarya annanmensis*				N/A
Mò lá tròn	*Cryptocarya impressa*				N/A
Nanh chuột	*Cryptocarya lenticellata*				N/A
Ngát	*Gironniera cuspidata*				N/A
Ngát lông	*Gironniera mollissima*				N/A
Ngát vàng	*Gironniera subaequalis*				N/A
Ngô đồng	*Firmiana simplex*				N/A
Nhọ nồi	*Diospyros apiculata*				N/A

Nhọc lá to	*Polyalthia laui*				N/A
Nhội	*Bischofia javanica*		X		
Nhựa ruồi	*Ilex rotunda*				N/A
Quế lợn	*Cinnamomum bejolghota*		X		
Ràng ràng xanh	*Ormosia pinnata*				N/A
Rau sắng	*Melientha suavis*	X			
Re đá	*Cinnamomum mairei*				N/A
Re đỏ	*Cinnamomum tetragonum*				N/A
Re gân lõm	*Cinnamomum impressimeurium*				N/A
Re gừng	*Cinnamomum ovatum*				N/A
Re hương	*Cinnamomum iners*				N/A
Re mới	*Cinnamomum burmannii*				N/A
Re mới lá to	*Cinnamomum subavenium*				N/A
Re nhớt	*Cinnamomum sp.*				N/A
Re sâu	*Machilus bonii*				N/A
Re thơm	*Cinnamomum sp1.*				N/A
Re xanh	*Cinnamomum parthenoxylon*				N/A
Săng lẻ	*Dracontomelon duperreanum*				N/A
Sảng nhung	*Sterculia lanceolata*		X		
Sấu tía	*Lagerstroemia tomentosa*		X		
Sến đất	*Sinosideroxylon racemosum*				N/A
Sến mật	*Madhuca pasquieri*				N/A
Sổ	*Dillenia scabrella*				N/A
Sồi bắc giang	*Lithocarpus bacgiangnenis*				N/A
Sồi đỏ	*Lithocarpus elegans*				N/A
Sòi núi	*Balakata baccata*				N/A
Sồi phảng	*Lithocarpus areca*				N/A
Sòi tía	*Sapium discolor*				N/A
Sơn rừng	*Rhus rhetsoides*				N/A
Sơn ta	*Rhus succedanea*				N/A
Song xanh	*Actinodaphne obovata*				N/A
Sụ lá kiếm	*Phoebe angustifolia*				N/A
Sữa	*Alstonia scholaris*				N/A
Sui	*Antiaris toxicaria*				N/A
Sung	*Ficus racemosa*				N/A
Sung rừng	*Ficus sp.*		X		
Táu muối	*Vatica odorata*				N/A
Thành ngạnh	*Cratoxylum polyanthum*				N/A
Thẩu tấu	*Aporosa dioica*				N/A
Thị lông	*Diospyros hirsuta*				N/A
Thị rừng	*Diospyros montana*				N/A
Thôi ba	*Alangium chinense*				N/A
Thừng mực lông	*Wrightia pubscens*				N/A
Thừng mực mỡ	*Wrightia laevis*				N/A

Trâm	*Syzygium brachiatum*				N/A
Trâm bắc bộ	*Syzygium tonkinensis*				N/A
Trám chim	*Canarium parvum*			X	
Trám đen	*Canarium tramdenum*	X			
Trâm đỏ	*Syzygium zeylanicum*				N/A
Trám hồng	*Canarium littorale*			X	
Trâm khế	*Syzygium sp*				N/A
Trâm lá bóng	*Syzygium parviflorum*				N/A
Trâm núi	*Syzygium levinei*				N/A
Trám trắng	*Canarium album*			X	
Trâm trắng	*Syzygium chanlos*				N/A
Trám trẩu	*Mytilaria laosensis*				N/A
Trẩu	*Vernicia montana*				N/A
Trường kẹn	*Mischocarpus oppositifolius*				N/A
Trường mật	*Pometia pinnata*				N/A
Trường sâng	*Amesiodendron chinense*				N/A
Trường vải	*Paranephelium spirei*			X	
Ươi	*Sterculia tonkinensis*				N/A
Vàng tâm	*Manglietia dandyi*				N/A
Vạng trứng	*Endospermum sinensis*				N/A
Vỏ mãn	*Ficus vasculosa*			X	
Vối thuốc	*Schima wallichii*				N/A
Vối thuốc răng cưa	*Schima superba*			X	
Vù hương	*Cinamomum blansae*				N/A
Vú sữa	*Chrysophyllum cainito*			X	
Xoài rừng	*Mangifera minitifolia*			X	
Xoan đào	*Prunus arborea*			X	
Xoan nhừ	*Spondias axillaris*				N/A

7.10 Population structure of tree species producing NTFPs

Figure 14 presents population structure of 44 tree species producing NTFPs recorded in four forest sites. With regard to the changes in the forest structure of the NTFP species, the overall population structure does not differ between proximal and distant sites and the distribution pattern of NTFP s in diameter-class was the inverted-J shape (Fig. 14). It is shown that merely the smaller size classes (10-30 cm dbh) are successional forests compared to undisturbed one. All the 44 NTFP species exhibit asymmetrical normal distribution with reduced recruitment in smaller size-classes and increased mortality in bigger size classes. In the lower classes (below 30 cm DBH), the most abundant species were *Vernicia Montana, Garcinia oblongifolia,* and *Croton tiglium*, while in the upper classes

(above 60 cm DBH), *Canarium littorale, Lagerstroemia tomentosa,* and *Cinamomum blansae* were the most abundant in undisturbed forests and absent in the three successional phases.

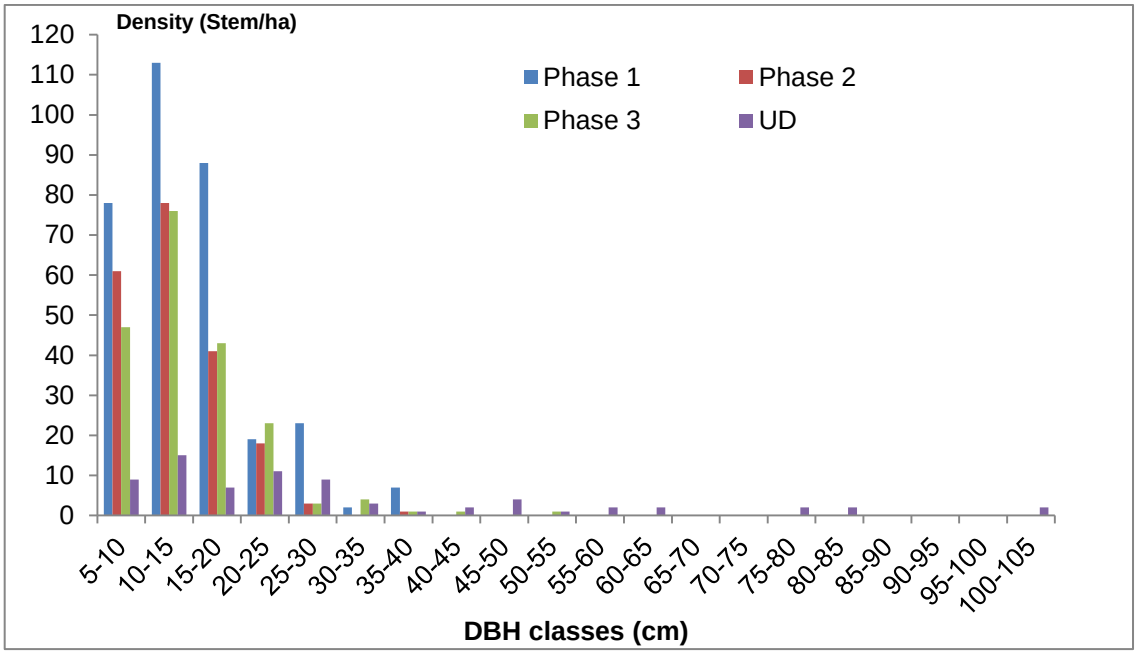

Fig. 14: Population structure of tree species producing NTFPs

8 Results of regeneration

8.1 The abundance of seedling and sapling

A description of the tree abundance of seedling, sapling, species and families sampled in the four forest sites are listed in Tables 9. The abundance of two different regeneration categories varied among the four forest sites. The highest abundance of seedlings and saplings was found in the phase 3 (386 individuals and 499 stems per 0.2 ha, respectively). Across all sites, the abundance of saplings was higher than that of seedlings; this abundance respectively contributed approximately 74.6%, 60.6%, 56.3% and 68.2% of the total regeneration counted in the first, second, third phases, and undisturbed forest. It can be said that a greater number of saplings revealed better regeneration potential for the forest stands.

At each forest site, the species number of seedlings and saplings was highest in the third phase, while the earliest phase and undisturbed forest held the lowest species richness of seedlings and saplings. Of these, the former site was particularly low, with recorded seedlings representing only 22 species from 16 families; comparatively, the later site contained 51 species representing 21 families as seedlings.

Table 9 The number of the stems, species, and families of the seedlings and saplings found in the four forest types in Ben En National Park, Vietnam.

Forest site	Abundance [n/0.2 ha]	Species [n/0.2 ha]	Family [n/0.2 ha]
Phase 1			
Seedlings	91	22	16
Saplings	268	49	26
Total	**359**	**55**	**30**
Phase 2			
Seedlings	235	57	22
Saplings	362	78	32
Total	**597**	**85**	**33**
Phase 3			
Seedlings	386	66	28
Saplings	499	80	29
Total	**885**	**95**	**31**
Undisturbed forest			
Seedlings	167	51	21
Saplings	359	65	22
Total	**526**	**79**	**26**

As was the case for the species richness, a similar trend was evidenced at the same sites for the family number of regeneration. The second and third phases had the highest family number in terms of saplings with 32 and 29 families respectively. The first phase held the smallest family number of seedlings (16 families).

8.2 Diversity of regeneration (seedlings and saplings)

Table 10 shows the diversity pattern of seedlings and saplings across the four forest sites. The values of the three diversity indices of the regenerated trees varied greatly among the sites, with the results indicating that the highest values of the Shannon-Wiener diversity indices were recorded in the second and third phases, and followed by the undisturbed forest and first phase. A trend that was likewise was found for the Evenness index. It is thus clear

that of the four forest sites, the second phase was the most diverse, as evidenced by the Shannon and Simpson diversity indices.

Table 10 The Shannon-Wiener, Simpson's diversity, and Evenness indices of seedlings and saplings of the four forest types in Ben En National Park, Vietnam.

Forest site	**Shannon-Wiener index** (H')	**Simpson's diversity index** (D)	**Evenness index** [%]
The first phase			
Seedlings [0.2 ha]	2.61	0.09	84.4
Saplings [0.2 ha]	2.69	0.16	69.1
All regeneration	**2.86**	**0.12**	**71.3**
The second phase			
Seedlings [0.2 ha]	3.51	0.04	86.8
Saplings [0.2 ha]	3.72	0.04	85.4
All regeneration	**3.78**	**0.04**	**85.1**
The third phase			
Seedlings [0.2 ha]	3.6	0.04	85.9
Saplings [0.2 ha]	3.64	0.04	83
All regeneration	**3.75**	**0.04**	**82.3**
Undisturbed forest			
Seedlings [0.2 ha]	3.56	0.03	90.6
Saplings [0.2 ha]	3.74	0.03	89.6
All regeneration	**3.63**	**0.03**	**83**

8.3 Species composition of seedlings and saplings

Table 11 indicates that a majority of species were represented by different individuals which in turn varied from site to site. The structure of seedling and sapling populations was characterized by numerous species that occurred at low abundance in similar fashion to the adult population. With respect to species abundance, significant differences can be observed among the four forest sites. A total of 144 species were recorded in these four sites, of which 23 species were common and 50 species appeared only in one of four sites. Numerous species, inclduing, *Mallotus paniculatus, Mallotus floribundus*, and *Engelhardtia chrysolepsis*

were only present in the first phase, while *Litsea griffithii, Vitex leptobotrys*, and *Symplocos lauria* only appeared in the other forest sites (Appendix 5).

Table 11 The 34 most abundant tree species of regeneration collected in the four forest types in Ben En National Park, Vietnam, as ranked in descending order of the total abundance of seedlings and saplings.

Species	**Family**	**The abundance of regeneration** [n/0.2 ha]				**Total**
		P1	P2	P3	UD	
Pometia pinnata	Sapindaceae	-	80	65	25	170
Schima superba	Theaceae	1	22	96	19	138
Cinnamomum parthenoxylon	Lauraceae	3	17	88	26	134
Vernicia montana	Euphorbiaceae	102	4	-	-	106
Gironniera cuspidata	Ulmaceae	15	28	31	27	101
Syzygium chanlos	Myrtaceae	31	32	9	23	95
Syzygium zeylanicum	Myrtaceae	5	22	37	18	82
Alangium chinense	Alangiaceae	61	8	-	4	73
Wrightia laevis	Apocynaceae	14	18	22	16	70
Antidesma acidum	Euphorbiaceae	2	11	44	12	69
Peltophorum pterocarpum	Caesalpiniaceae	12	25	18	3	58
Hypericum japonicum	Hypericaceae	12	29	14	-	55
Knema globularia	Myristicaceae	-	3	32	19	54
Cinnamomum subavenium	Lauraceae	-	6	23	21	50
Canarium parvum	Burseraceae	4	17	17	8	46
Cinnamomum tetragonum	Lauraceae	1	10	20	13	44
Erythrophleum fordii	Caesalpiniaceae	-	10	14	17	41
Vitex trifolia	Verbenaceae	5	18	7	4	34
Paranephelium spirei	Sapindaceae	-	10	14	10	34
Ficus vasculosa	Moraceae	1	8	20	5	34
Acronychia pedunculata	Rutaceae	2	14	16	-	32
Aglaia dasyclada	Meliaceae	2	8	1	19	30
Mellettia lasiopetala	Fagaceae	-	3	18	8	29
Castanopsis annamensis	Fagaceae	1	17	6	2	26
Gironniera subaequalis	Ulmaceae	1	-	-	25	26
Canarium album	Burseraceae	3	10	7	6	26
Aphanamixis grandifolia	Meliaceae	-	2	1	21	24
Garcinia oblongifolia	Clusiaceae	3	3	7	10	23
Vatica odorata	Dipterocarpaceae	1	-	20	1	22
Mischocarpus oppositifolius	Sapindaceae	2	6	10	4	22

Michelia banlanse	Magnoliaceae	1	5	6	9	21
Wrightia pubscens	Apocynaceae	5	9	4	3	21
Amesiodendron chinense	Sapindaceae	-	4	4	13	21
Michelia tonkinensis	Magnoliaceae	11	4	5	-	20

P1: Phase 1; P2: Phase 2; P3: Phase 3; and UD: Undisturbed forest

The regeneration of the *Vernicia montana* (Euphorbiaceae) and *Hypericum japonicum* (Hypericaceae) species was absent in the undisturbed forest; however, they dominated in the successional forests. The abundance of seedlings and saplings was numerous for former species, with a respective 102 and 4 individuals counted in the first and second phases, while the latter species had 12, 29 and 14 stems in the first, second and third phase, respectively. A similar pattern was observed for the regeneration of *Acronychia pedunculata* (Rutaceae) which was rare in the first site (with 2 individuals counted), absent in the undisturbed site, and in abundance in the two remaining sites (12 and 14 stems in the second and third, respectively).

8.4 Family composition of regeneration (seedlings and saplings)

In the course of this study, a total of 31 tree families of seedlings and saplings were recorded in the four forest site (Table 12). Most families (Lauraceae, Burseraceae, and Sapindaceae) were common to all the forest sites. Several families (Hypericaceae and Rutaceae) were recorded in the forest sites of succession, but they were absent from the undisturbed forest. In terms of tree abundance, the family with the greatest number of individuals was Lauraceae with 360 stems, followed by Sapindaceae (247), Myrtaceae (207) and Euphorbiaceae (200). Across all sites, 15 out of 39 families were represented by a single species, and only six had species number greater than five.

Table 12 The family of regeneration collected in the four forest types in Ben En National Park, Vietnam.

No.	**Family**	**The abundance of regeneration (n/0.2 ha)**				**Total**
		P1	P2	P3	UD	
1	Alangiaceae	61	8	-	4	73
2	Amaranthaceae	-	1	-	-	1
3	Anacardiaceae	-	2	2	-	4
4	Apocynaceae	20	32	26	19	97

5	Araliaceae	-	1	-	1	2
6	Bignoniaceae	-	2	6	6	14
7	Burseraceae	10	31	28	20	89
8	Caesalpiniaceae	12	36	32	22	102
9	Clusiaceae	8	5	8	15	36
10	Dilleniaceae	1	-	1	-	2
11	Dipterocarpaceae	1	-	20	1	22
12	Ebenaceae	-	-	2	2	4
13	Elaeocarpaceae	1	1	6	3	11
14	Euphorbiaceae	112	28	45	15	200
15	Fabaceae	4	1	1		6
16	Fagaceae	2	23	31	24	80
17	Hypericaceae	12	29	14	-	55
18	Juglandaceae	1	-	-	-	1
19	Lamiaceae	1	-	-	-	1
20	Lauraceae	6	60	189	105	360
21	Loganiaceae	-	1	-	-	1
22	Magnoliaceae	12	9	12	19	52
23	Meliaceae	3	17	22	57	99
24	Mimosaceae	1	8	10	1	20
25	Moraceae	9	18	30	7	64
26	Myristicaceae	-	5	45	21	71
27	Myrtaceae	38	65	60	44	207
28	Oxalidaceae	3	-	4	-	7
29	Phyllanthaceae	2	4	7	2	15
30	Rosaceae	3	1	-	-	4
31	Rubiaceae	-	1	-	-	1
32	Rutaceae	2	14	22	-	38
33	Sapindaceae	2	100	93	52	247
34	Sterculiaceae	3	10	2	2	17
35	Symplocaceae	-	2	5	1	8
36	Theaceae	1	22	101	25	149
37	Tiliaceae	2	8	1	-	11
38	Ulmaceae	21	32	47	52	152
39	Verbenaceae	5	20	13	6	44

P1: Phase 1; P2: Phase 2; P3: Phase 3; and UD: Undisturbed forest

8.5 Regeneration of tree species producing NTFPs

Table 13 indicates total density of regeneration species producing NTFPs collected in four forest sites. Species of *Garcinia oblongifolia; Acronychia pedunculata; Baccaurea sapida; Castanopsis annamensis; Vitex trifolia; Machilus sp.; Machilus bonii; Grewia paniculata; Sterculia lanceolata; Canarium parvum; Canarium album; Vernicia Montana; Paranephelium spirei; Schima superba* presented good regeneration (number of individuals ≥ 10), while *Mallotus paniculatus; Schefflera octophylla; Artocarpus sp.; Vitex quinata; Canthium horridum; Michelia tonkinensis; Phoebe tavoyana; Cinnamomum camphora; Canarium tramdenum; Mangifera minitifolia* showed poor regeneration abilities (individuals of each species ≤ 2). *Schima superba* was observed to produce the highest number of medicinal individuals (138) and 106 individuals of *Vernicia Montana* produced flavor.

Table 13 Total density of regeneration species producing NTFPs in four forest sites

Scientific name	P 1	P 2	P 3	UD	Total	Uses	Parts used
Mallotus paniculatus	2	-	-	-	2	Medicinal	Leaves
Euodia tepta	-	-	6	-	6	Medicinal	-
Croton tiglium	-	4	-	-	4	Resin	Stem
Rauvolfia verticillata	1	5	-	-	6	Resin	Leaves
Litsea griffithii	-	1	3	1	5	Oil	-
Garcinia oblongifolia	3	3	7	10	23	Spice	Leaves
Acronychia pedunculata	2	14	16	-	32	Medicinal	Leaves
Schefflera octophylla	-	1	-	1	2	Spice	Leaves
Artocarpus tonkinensis	-	2	5	-	7	Resin	Bark
Artocarpus styracifolius	-	-	2	-	2	Resin	Bark
Artocarpus sp.	-	-	1	-	1	Resin	Bark
Baccaurea sapida	2	4	7	2	15	Spice	Fruit
Castanopsis annamensis	1	17	6	2	26	-	Fruit
Castanopsis lecomtei	-	-	1	2	3	Spice	Fruit
Vitex leptobotrys	-	2	6	1	9	-	Stem
Vitex trifolia	5	18	7	4	34	-	Stem
Vitex quinata	-	-	-	1	1	-	Stem
Canthium horridum	-	1	-	-	1	Flavor	Fruit
Michelia tonkinensis	-	-	-	2	2	Spice	Fruit
Machilus sp.	-	2	8	-	10	Flavor	Bark
Phoebe tavoyana	-	1	-	-	1	Flavor	-
Machilus bonii	-	2	2	7	11	Flavor	-
Averrhoa carambola	3	-	4	-	7	Spice	Fruit
Cinnamomum camphora	-	-	1	-	1	Oil and flavor	-
Grewia paniculata	2	8	1	-	11	Spice	-

Cinnamomum ovatum	-	-	-	5	5	Flavor	Leaves and bark
Sterculia lanceolata	-	9	1	-	10	Food	Fruit
Ficus racemosa	4	2	-	-	6	Food	Fruit
Canarium parvum	4	17	17	8	46	Food	Fruit
Canarium tramdenum	1	-	-	-	1	Food	Fruit
Canarium littorale	-	4	2	5	11	Food	Fruit
Canarium album	3	10	7	6	26	Food	Fruit
Vernicia montana	102	4	-	-	106	Flavor	Fruit
Paranephelium spirei	-	10	14	10	34	-	Fruit
Schima wallichii	-	-	-	6	6	Medicinal	Leaves
Schima superba	1	22	96	19	138	Medicinal	Leaves
Mangifera minitifolia	-	-	2	-	2	Food	Fruit

P1: Phase 1; P2: Phase 2; P3: Phase 3; and UD: Undisturbed forest

9 Constraints for biodiversity conservation and use of NTFP resource

Recently, the efforts of biodiversity on ecosystem process have received much attention because of the growing concern that loss of biodiversity may impair ecosystem functioning. Ben En National Park has prohibited the harvesting of non-timber forest products according to special forest management regulations. However, there are several challenges limiting their implementation, as follows:

1) Limited species-specific information such as availability, distribution, productivity, and regeneration potentials;
2) A main concern for the conservation and sustainability is that there exists unsustainable harvesting practices and habitat loss;
3) Threats to NTFPs from deforestation and illegally harvesting;
4) Traditional grazing is available in forest areas resulting in the deterioration of the vegetation cover and disappearance of trees.
5) Lack of capacity with the communities for the better management of NTFPs, and
6) Poor management of natural resources and wood lands leading to the fact that policymakers are unaware of the extent of the uses or the values of NTFPs in these natural forests and the magnitudes of dependence of the rural poor on the resource for food security and income.

10 Recommendations for improving effective forest management of NTFPs and benefit-sharing mechanisms

Based on the present study, a better understanding of conservation status and sustainable use were obtained and some management suggestions consist of:

1. A link is needed between research and management procedures adopted by the government, research institutions and relevant conservation organisations. Up-to-date information from the threatened areas should be updated and new strategies for conservation should be planned regularly.
2. The goal for the management of species diversity and richness should focus on indigenous wildlife species. The objectives of the forest management should be redefined to highlight the important role of biodiversity conservation.
3. Site-specific conservation policies are urgently needed, over-harvests or exploits the natural resources of the area (especially floral biodiversity) should be taken care of.
4. A study of economically important, vulnerable and endangered species should be a priority project in future efforts.
5. More information about biology, resource assessment methods, harvesting strategies, and market value of potential promising species should be addressed.
6. Assess sustainable use, sustainable levels of harvesting and the management practices for the conservation of NTFPs species.
7. Create public awareness about conservation and sustainable management of NTFPs.
8. Provide locals with training to harvest plant resources for use in a sustainable way and provide conservation education to the villagers and in the schools.
9. Encourage local people to cultivate NTFPs.

In terms of benefit-sharing mechanisms, the following suggestions should be concerned in the future time:

1. It is a fact that the financial outcome can motivate local people to conserve NTFPs plant species, thus an appropriate policy environment and collective cooperation strategies need to be developed that would involve many local people;
2. The management of NTFPs must use the local indigenous knowledge, the ecological impacts of NTFPs extraction for collecting, monitoring, and sharing of rights and benefits;
3. The capacity building programmes for the local people are very important. The abundance of the species in the forests offers better opportunity for the development of the NTFPs and holds a potential for poverty alleviation;

4. A comprehensive NTFP policy is needed to strike a balance between biodiversity conservation and provision of livelihood security to the forest dwellers;
5. Prohibiting NTFPs harvest is likely ineffective conservation policy, in order to conserve forest resources and NTFPs species, people living in adjoining villages to the forests should be incorporated into the conservation program, which would prevent the exploitation of these tree species for timber and ensure sustainable production of their valuable non-timber products;
6. The research activities should contribute to the development of NTFP species and exploitation systems should be ecologically sustainable and socially and economically attractive for the local communities.

11 Management implications for conservation and more sustainable use of NTFP species

This study has revealed the abundance of woody tree species and ecologically valuable non-timber tree species in the study area. Sustainable management of forest reserves requires holistic approach in which both timber and non-timber tree species are managed in accordance with their ecological attributes. To achieve a balance between conservation and sustainable use of non-timber forest resources, the following activities should be carried out by the park, as follows:

1. Identifying currently unprotected sites that are a priority for conservation of biological diversity and ecosystem processes;
2. Development and implementation of effective conservation and resource management plans may need legislative reform before managed use of non-timber forest resources provides incentive for conservation as a form of land-use;
3. Enhancing the role of local people in inventory, research, monitoring and impact assessment processes, and management;
4. Non-timber forest resources uses should be placed into forest management and land use plannings, while silvicultural prescriptions need to be developed that consider and incorporate NTFR;
5. Conservation policies and education must be directed to reducing the various disturbance factors identified here;
6. Research should be carried out on methods of their sustainable harvest to provide clearer insight on best forest management and conservation strategies;
7. Much attention should be undertaken in forest management plans for regeneration and conservation of these ecosystems.

TÀI LIỆU THAM KHẢO

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Appendices

App. 1 Important value index of Species calculated in the Phase 1

No	Latin name	Abundance (n/ha)	Dominance (m2/ha)	Frequency (%)	IVI (%)
1	*Vernicia montana*	258	5.261	100	86.83
2	*Alangium chinense*	169	2.440	100	51.46
3	*Hypericum japonicum*	24	0.474	55	11.69
4	*Gironniera cuspidata*	15	0.426	50	9.65
5	*Sapium discolor*	14	0.373	40	8.27
6	*Ficus racemosa*	9	0.433	25	6.84
7	*Trema orientalis*	9	0.268	40	6.71
8	*Wrightia laevis*	17	0.125	35	6.24
9	*Ficus annulata*	10	0.114	45	6.00
10	*Cinamomum blansae*	7	0.254	35	5.92
11	*Cratoxylum polyanthum*	14	0.079	40	5.85
12	*Pterospermum hetrophyllum*	11	0.168	35	5.76
13	*Syzygium chanlos*	12	0.064	40	5.46
14	*Mischocarpus oppositifolius*	11	0.113	25	4.49
15	*Michelia tonkinensis*	8	0.063	35	4.49
16	*Peltophorum pterocarpum*	9	0.089	30	4.43
17	*Vitex trifolia*	11	0.139	20	4.29
18	*Canarium album*	7	0.030	35	4.08
19	*Garcinia oblongifolia*	6	0.052	30	3.72
20	*Cinnamomum tetragonum*	7	0.064	25	3.54
21	*Endospermum sinensis*	8	0.123	15	3.34
22	*Averrhoa carambola*	7	0.065	20	3.14
23	*Canarium parvum*	7	0.043	20	2.95
24	*Cinnamomum parthenoxylon*	4	0.084	20	2.88
25	*Syzygium zeylanicum*	5	0.035	20	2.61
26	*Elaeocarpus griffithii*	4	0.044	20	2.55
27	*Aphanamixis grandifolia*	4	0.030	20	2.43
28	*Dillenia scabrella*	2	0.141	10	2.25
29	*Grewia paniculata*	4	0.040	15	2.11
30	*Alstonia scholaris*	3	0.035	15	1.93
31	*Knema pierrei*	3	0.033	15	1.91
32	*Prunus arborea*	3	0.032	15	1.90
33	*Canarium tramdenum*	2	0.051	10	1.51
34	*Mallotus paniculatus*	5	0.047	5	1.48
35	*Mallotus metcalfianus*	2	0.035	10	1.38
36	*Knema globularia*	2	0.023	10	1.28
37	*Symplocos lauria*	2	0.019	10	1.25
38	*Gmelina arborea*	2	0.016	10	1.22
39	*Lagerstroemia tomentosa*	2	0.016	10	1.22

40	*Acronychia pedunculata*	2	0.062	5	1.20
41	*Fernandoa brilletii*	2	0.012	10	1.19
42	*Wrightia pubscens*	2	0.011	10	1.19
43	*Castanopsis annamensis*	2	0.010	10	1.18
44	*Ficus curtipes*	3	0.034	5	1.10
45	*Aglaia spectabilis*	2	0.015	5	0.81
46	*Antidesma acidum*	2	0.010	5	0.77
47	*Aporosa dioica*	1	0.022	5	0.72
48	*Michelia banlanse*	1	0.015	5	0.67
49	*Uraria crinite*	1	0.015	5	0.67
50	*Machilus bonii*	1	0.013	5	0.66
51	*Spondias lakoensis*	1	0.012	5	0.65
52	*Vatica odorata*	1	0.007	5	0.61
53	*Aglaia perviridis*	1	0.006	5	0.60
54	*Ormosia pinnata*	1	0.006	5	0.60
55	*Rauvolfia verticillata*	1	0.006	5	0.59
56	*Bischofia javanica*	1	0.005	5	0.59
57	*Litsea verticillata*	1	0.004	5	0.58
58	*Mytilaria laosensis*	1	0.003	5	0.57
Total		**726**	**12.21**		

App. 2 Important value index of Species calculated in the Phase 2

No	Latin name	Abundance (n/ha)	Dominance (m2/ha)	Frequency (%)	IVI (%)
1	*Hypericum japonicum*	340	3.73	100	68.97
2	*Alangium chinense*	99	1.61	90	27.73
3	*Vernicia montana*	90	1.48	95	26.20
4	*Gironniera cuspidate*	27	0.73	55	11.59
5	*Sapium discolor*	23	0.81	50	11.41
6	*Peltophorum pterocarpum*	29	0.52	45	9.70
7	*Croton tiglium*	23	0.33	55	8.35
8	*Aglaia dasyclada*	16	0.41	50	7.88
9	*Canarium parvum*	17	0.26	60	7.58
10	*Wrightia laevis*	19	0.35	45	7.46
11	*Erythrophleum fordii*	10	0.43	20	5.38
12	*Ficus vasculosa*	15	0.30	25	5.33
13	*Canarium littorale*	10	0.23	40	5.31
14	*Ficus annulata*	14	0.18	35	5.03
15	*Pometia pinnata*	13	0.19	35	5.01
16	*Vitex trifolia*	12	0.15	40	4.96
17	*Canarium album*	11	0.19	25	4.15
18	*Mischocarpus oppositifolius*	12	0.12	30	4.10
19	*Endospermum sinensis*	7	0.15	30	3.79
20	*Amesiodendron chinense*	7	0.09	30	3.35
21	*Pterospermum hetrophyllum*	8	0.08	25	3.09
22	*Trema orientalis*	5	0.19	15	2.83
23	*Wrightia pubscens*	7	0.06	25	2.80
24	*Markhamia caudafelina*	7	0.05	25	2.78
25	*Grewia paniculat*	8	0.08	20	2.74
26	*Gironniera mollissima*	6	0.15	15	2.67
27	*Schima superba*	6	0.07	20	2.44
28	*Canarium album*	4	0.06	20	2.14
29	*Ficus racemosa*	3	0.07	15	1.81
30	*Acronychia pedunculata*	3	0.06	15	1.72
31	*Elaeocarpus griffithii*	4	0.04	15	1.71
32	*Cinnamomum iners*	4	0.03	15	1.64
33	*Knema globularia*	3	0.04	15	1.59
34	*Paranephelium spirei*	3	0.04	15	1.57
35	*Phoebe angustifolia*	5	0.05	10	1.55
36	*Cinnamomum camphora*	3	0.03	15	1.52
37	*Cinnamomum tetragonum*	2	0.08	10	1.42
38	*Castanopsis indica*	2	0.08	10	1.41
39	*Mangifera minitifolia*	4	0.04	10	1.34
40	*Sterculia lanceolata*	3	0.05	10	1.33
41	*Prunus arborea*	4	0.03	10	1.32
42	*Machilus bonii*	2	0.04	10	1.15

43	*Canarium tramdenum*	2	0.04	10	1.12
44	*Neocinnamomum lecomtei*	2	0.03	10	1.07
45	*Syzygium zeylanicum*	2	0.03	10	1.05
46	*Vatica odorata*	2	0.02	10	1.03
47	*Symplocos lauria*	2	0.01	10	0.95
48	*Mellettia lasiopetala*	2	0.01	10	0.93
49	*Artocarpus tonkinensis*	2	0.01	10	0.93
50	*Artocarpus sp.*	1	0.06	5	0.84
51	*Cryptocarya sp.*	1	0.05	5	0.81
52	*Mallotus decipiens*	2	0.03	5	0.74
53	*Antidesma acidum*	2	0.02	5	0.68
54	*Castanopsis annamensis*	1	0.03	5	0.64
55	*Castanopsis hystrix*	1	0.03	5	0.62
56	*Grewia paniculata*	1	0.02	5	0.60
57	*Cinnamomum subavenium*	1	0.02	5	0.59
58	*Michelia mediocris*	1	0.02	5	0.58
59	*Alstonia scholaris*	1	0.02	5	0.56
60	*Syzygium levinei*	1	0.02	5	0.55
61	*Mytilaria laosensis*	1	0.02	5	0.55
62	*Vitex leptobotrys*	1	0.01	5	0.54
63	*Uraria crinite*	1	0.01	5	0.52
64	*Cinnamomum mairei*	1	0.01	5	0.52
65	*Cryptocarya annanmensis*	1	0.01	5	0.52
66	*Michelia banlanse*	1	0.01	5	0.51
67	*Diospyros apiculata*	1	0.01	5	0.51
68	*Archidendron clypearia*	1	0.01	5	0.50
69	*Syzygium sp.*	1	0.01	5	0.50
70	*Litsea griffithii*	1	0.01	5	0.50
71	*Averrhoa carambola*	1	0.01	5	0.49
72	*Garcinia oblongifolia*	1	0.01	5	0.48
73	*Sterculia tonkinensis*	1	0.01	5	0.47
74	*Baccaurea sapida*	1	0.00	5	0.47
75	*Rauvolfia verticillata*	1	0.00	5	0.47
76	*Camellia caudate*	1	0.00	5	0.46
77	*Vitex quinata*	1	0.00	5	0.46
78	*Canthium horridum*	1	0.00	5	0.46
79	*Michelia tonkinensis*	1	0.00	5	0.46
80	*Polyalthia laui*	1	0.00	5	0.46
Total		**937**	**14.28**		

App. 3 Important value index of Species calculated in the Phase 3

No	Latin name	Abundance (n/ha)	Dominance (m2/ha)	Frequency (%)	IVI (%)
1	*Cinnamomum tetragonum*	72	2.25	80	19.47
2	*Pometia pinnata*	46	1.54	65	13.40
3	*Gironniera cuspidata*	42	1.44	70	12.80
4	*Ficus vasculosa*	44	0.82	85	11.26
5	*Gironniera mollissima*	34	1.15	70	10.86
6	*Gironniera subaequalis*	26	1.49	55	10.67
7	*Schima superba*	48	0.75	65	10.60
8	*Alangium chinense*	49	1.04	30	10.39
9	*Sapium discolor*	22	1.25	70	9.95
10	*Mellettia lasiopetala*	29	0.80	55	8.36
11	*Canarium parvum*	29	0.35	90	8.11
12	*Peltophorum pterocarpum*	22	0.96	40	7.64
13	*Endospermum sinensis*	17	0.89	40	6.84
14	*Cinnamomum parthenoxylon*	24	0.46	55	6.57
15	*Vernicia montana*	28	0.60	30	6.50
16	*Canarium album*	23	0.32	50	5.71
17	*Pterocarya tonkinensis*	13	0.67	40	5.58
18	*Cinnamomum subavenium*	13	0.48	50	5.25
19	*Erythrophleum fordii*	16	0.38	50	5.18
20	*Machilus bonii*	14	0.28	45	4.38
21	*Wrightia laevis*	12	0.33	40	4.17
22	*Syzygium chanlos*	10	0.42	35	4.09
23	*Michelia banlanse*	13	0.16	45	3.82
24	*Knema globularia*	11	0.16	45	3.64
25	*Amesiodendron chinense*	9	0.23	40	3.45
26	*Michelia tonkinensis*	7	0.36	30	3.35
27	*Cinnamomum mairei*	10	0.27	25	3.10
28	*Vitex trifolia*	8	0.21	30	2.88
29	*Cinnamomum subavenium*	9	0.12	35	2.85
30	*Canarium littorale*	9	0.17	30	2.83
31	*Markhamia stipulata*	8	0.17	30	2.71
32	*Mytilaria laosensis*	9	0.14	30	2.71
33	*Mischocarpus oppositifolius*	8	0.31	15	2.66
34	*Schefflera octophylla*	4	0.42	15	2.65
35	*Firmiana simplex*	6	0.24	25	2.56
36	*Aglaia dasyclada*	8	0.13	30	2.56
37	*Syzygium zeylanicum*	8	0.06	35	2.53
38	*Syzygium levinei*	7	0.10	30	2.35
39	*Cryptocarya annanmensis*	10	0.11	20	2.30
40	*Quercus platycalyx*	5	0.18	25	2.23
41	*Garcinia oblongifolia*	6	0.07	30	2.14
42	*Dipterocarpus retusus*	1	0.46	5	2.06
43	*Castanopsis indica*	4	0.26	15	2.04
44	*Elaeocarpus griffithii*	5	0.16	20	1.95
45	*Vitex leptobotrys*	3	0.23	15	1.83
46	*Hypericum japonicum*	6	0.10	20	1.82
47	*Dosoxylum acutangulum*	4	0.13	20	1.74
48	*Paranephelium spirei*	4	0.09	20	1.58
49	*Sterculia lanceolata*	5	0.09	15	1.48

50	*Archidendron clypearia*	4	0.05	20	1.44
51	*Grewia paniculata*	5	0.07	15	1.41
52	*Pterospermum hetrophyllum*	5	0.07	15	1.40
53	*Aphanamixis silvestris*	4	0.09	15	1.40
54	*Rhus rhetsoides*	4	0.09	15	1.38
55	*Knema pierrei*	4	0.04	20	1.38
56	*Castanopsis annamensis*	4	0.08	15	1.34
57	*Croton tiglium*	5	0.10	10	1.33
58	*Actinodaphne obovata*	4	0.04	15	1.18
59	*Aglaia roxburghiana*	4	0.03	15	1.14
60	*Sterculia tonkinensis*	4	0.06	10	1.06
61	*Syzygium parviflorum*	3	0.03	15	1.05
62	*Cinnamomum burmannii*	1	0.19	5	1.04
63	*Cinamomum blansae*	2	0.11	10	1.04
64	*Ficus racemosa*	3	0.03	15	1.04
65	*Cinnamomum ovatum*	2	0.08	10	0.93
66	*Vitex quinata*	3	0.05	10	0.91
67	*Prunus arborea*	2	0.07	10	0.88
68	*Markhamia caudafelina*	3	0.03	10	0.83
69	*Sinosideroxylon racemosum*	1	0.13	5	0.82
70	*Lithocarpus areca*	3	0.02	10	0.81
71	*Paramechelia braianensis*	2	0.05	10	0.80
72	*Aphanamixis grandifolia*	2	0.04	10	0.78
73	*Balakata baccata*	1	0.11	5	0.75
74	*Michelia mediocris*	2	0.03	10	0.74
75	*Uraria crinita*	2	0.02	10	0.70
76	*Aporosa dioica*	2	0.02	10	0.70
77	*Trema orientalis*	1	0.10	5	0.68
78	*Ficus annulata*	2	0.01	10	0.66
79	*Castanopsis hystrix*	2	0.01	10	0.66
80	*Cratoxylum polyanthum*	2	0.01	10	0.66
81	*Trema politoria*	1	0.06	5	0.55
82	*Madhuca pasquieri*	1	0.06	5	0.54
83	*Camellia caudata*	2	0.03	5	0.54
84	*Gleditsia australis*	1	0.05	5	0.51
85	*Artocarpus tonkinensis*	1	0.05	5	0.49
86	*Garcinia multiflora*	1	0.04	5	0.47
87	*Symplocos cochinchinensis*	1	0.03	5	0.41
88	*Averrhoa carambola*	1	0.02	5	0.40
89	*Castanopsis lecomtei*	1	0.02	5	0.40
90	*Cinnamomum burmannii*	1	0.02	5	0.40
91	*Cinnamomum camphora*	1	0.02	5	0.39
92	*Rhus succedanea*	1	0.02	5	0.39
93	*Artocarpus styracifolius*	1	0.02	5	0.38
94	*Lindera racemosa*	1	0.02	5	0.37
95	*Ficus curtipes*	1	0.01	5	0.37
96	*Lithocarpus elegans*	1	0.01	5	0.36
97	*Phoebe tavoyana*	1	0.01	5	0.36
98	*Symplocos lauria*	1	0.01	5	0.36
99	*Litsea griffithii*	1	0.01	5	0.36
100	*Aidia oxyodonta*	1	0.01	5	0.36
101	*Archidendron lucidum*	1	0.01	5	0.36
102	*Cinnamomum bejolghota*	1	0.01	5	0.35
103	*Rauvolfia verticillata*	1	0.01	5	0.35

104	*Phoebe paniculata*	1	0.01	5	0.35
105	*Lithocarpus bacgiangnenis*	1	0.01	5	0.35
106	*Ormosia pinnata*	1	0.01	5	0.34
107	*Machilus sp.*	1	0.01	5	0.34
108	*Cryptocarya lenticellata*	1	0.01	5	0.34
109	*Ilex rotunda*	1	0.01	5	0.34
110	*Diospyros hirsuta*	1	0.01	5	0.34
111	*Syzygium brachiatum*	1	0.01	5	0.34
112	*Polyalthia laui*	1	0.00	5	0.33
113	*Antiaris toxicaria*	1	0.00	5	0.33
114	*Baccaurea sapida*	1	0.00	5	0.32
115	*Aglaia perviridis*	1	0.00	5	0.32
	Total	**944**	**26.29**		

App. 4 Important value index of Species calculated in the undisturbed forest

No	Latin name	Abundance (n/ha)	Dominance (m2/ha)	Frequency (%)	IVI (%)
1	*Pometia pinnata*	31	2.90	80	17.26
2	*Mischocarpus oppositifolius*	22	2.93	50	13.99
3	*Gironniera subaequalis*	30	1.42	80	13.49
4	*Erythrophleum fordii*	18	2.02	55	11.30
5	*Cinnamomum subavenium*	18	1.85	60	11.14
6	*Cinnamomum tetragonum*	22	1.48	45	10.22
7	*Gironniera cuspidata*	21	0.67	60	8.89
8	*Schima superba*	21	0.50	60	8.47
9	*Mellettia lasiopetala*	22	0.70	45	8.34
10	*Wrightia laevis*	17	0.57	60	7.87
11	*Syzygium chanlos*	18	0.75	45	7.68
12	*Cinnamomum mairei*	16	0.64	55	7.57
13	*Castanopsis hystrix*	11	1.19	35	6.86
14	*Sinosideroxylon racemosum*	8	1.08	40	6.27
15	*Aglaia silvestric*	7	1.22	30	5.88
16	*Aglaia dasyclada*	6	1.37	25	5.79
17	*Castanopsis indica*	5	1.38	20	5.37
18	*Canarium littorale*	4	1.42	20	5.28
19	*Cinnamomum parthenoxylon*	10	0.32	45	5.09
20	*Canarium parvum*	7	0.79	30	4.85
21	*Michelia mediocris*	7	0.71	25	4.39
22	*Dipterocarpus retusus*	5	0.86	25	4.37
23	*Castanopsis annamensis*	4	1.03	20	4.33
24	*Aphanamixis grandifolia*	6	0.54	25	3.80
25	*Michelia banlanse*	6	0.36	30	3.62
26	*Peltophorum tonkinensis*	6	0.44	25	3.57
27	*Garcinia multiflora*	7	0.28	25	3.36
28	*Dosoxylum acutangulum*	2	0.94	10	3.20
29	*Dysoxylum cauliflorum*	5	0.48	20	3.20
30	*Paranephelium spirei*	3	0.67	15	3.00
31	*Lagerstroemia tomentosa*	3	0.78	10	2.99
32	*Knema globularia*	6	0.09	30	2.97
33	*Ficus vasculosa*	7	0.09	25	2.91
34	*Amesiodendron chinense*	5	0.31	20	2.77
35	*Ficus annulata*	5	0.11	25	2.55
36	*Knema pierrei*	4	0.27	20	2.49
37	*Lithocarpus areca*	5	0.18	20	2.47
38	*Sapium discolor*	1	0.79	5	2.37
39	*Vitex trifolia*	3	0.28	15	2.05
40	*Grewia paniculata*	4	0.09	20	2.04
41	*Madhuca pasquieri*	3	0.25	15	1.99
42	*Castanopsis lecomtei*	3	0.24	15	1.95

43	*Dracontomelon duperreanum*	1	0.57	5	1.83
44	*Quercus platycalyx*	4	0.09	15	1.78
45	*Schefflera octophylla*	2	0.28	10	1.61
46	*Markhamia stipulata*	3	0.09	15	1.60
47	*Canarium album*	2	0.28	10	1.60
48	*Machilus bonii*	3	0.08	15	1.58
49	*Baccaurea sapida*	3	0.07	15	1.54
50	*Cinnamomum ovatum*	3	0.07	15	1.54
51	*Syzygium zeylanicum*	3	0.06	15	1.51
52	*Aglaia perviridis*	2	0.21	10	1.44
53	*Bischofia javanica*	2	0.32	5	1.43
54	*Firmiana simplex*	2	0.19	10	1.37
55	*Cinnamomum iners*	2	0.18	10	1.35
56	*Elaeocarpus griffithii*	2	0.15	10	1.28
57	*Machilus bonii*	2	0.13	10	1.24
58	*Amaranthus tricolor*	2	0.12	10	1.21
59	*Phoebe paniculata*	2	0.11	10	1.19
60	*Spondias axillaris*	2	0.11	10	1.19
61	*Uraria crinita*	2	0.10	10	1.17
62	*Cinamomum blansae*	1	0.28	5	1.14
63	*Prunus arborea*	2	0.07	10	1.10
64	*Michelia tonkinensis*	1	0.26	5	1.08
65	*Fernandoa brilletii*	2	0.07	10	1.08
66	*Melientha suavis*	2	0.06	10	1.06
67	*Cinnamomum subavenium*	2	0.05	10	1.04
68	*Syzygium levinei*	2	0.05	10	1.04
69	*Symplocos lauria*	2	0.04	10	1.02
70	*Vatica odorata*	1	0.23	5	1.01
71	*Symplocos atriolivacea*	2	0.04	10	1.01
72	*Mytilaria laosensis*	2	0.04	10	1.01
73	*Alangium chinense*	2	0.03	10	1.00
74	*Aphanamixis polystachya*	1	0.20	5	0.95
75	*Pterospermum hetrophyllum*	1	0.18	5	0.89
76	*Quercus platycalyx*	1	0.16	5	0.84
77	*Lithocarpus bacgiangnenis*	1	0.12	5	0.76
78	*Cryptocarya sp*	1	0.10	5	0.69
79	*Averrhoa carambola*	1	0.09	5	0.67
80	*Spondias lakoensis*	1	0.08	5	0.65
81	*Cinnamomum impressimeurium*	1	0.08	5	0.65
82	*Artocarpus tonkinensis*	1	0.07	5	0.64
83	*Ficus curtipes*	1	0.07	5	0.63
84	*Michelia tonkinensis*	1	0.07	5	0.63
85	*Diospyros apiculata*	1	0.07	5	0.62
86	*Ficus altissima*	1	0.06	5	0.62
87	*Archidendron clypearia*	1	0.06	5	0.62
88	*Ficus racemosa*	1	0.06	5	0.62

89	*Syzygium tonkinensis*	1	0.06	5	0.62
90	*Diospyros montana*	1	0.06	5	0.61
91	*Mangifera minitifolia*	1	0.06	5	0.61
92	*Dillenia heterosepala*	1	0.04	5	0.55
93	*Manglietia dandyi*	1	0.04	5	0.55
94	*Paramechelia braianensis*	1	0.03	5	0.54
95	*Dillenia scabrella*	1	0.03	5	0.54
96	*Wrightia pubscens*	1	0.03	5	0.53
97	*Litsea griffithii*	1	0.03	5	0.53
98	*Chrysophyllum cainito*	1	0.03	5	0.52
99	*Phoebe angustifolia*	1	0.02	5	0.52
100	*Vitex leptobotrys*	1	0.02	5	0.51
101	*Cratoxylum polyanthum*	1	0.02	5	0.51
102	*Garcinia oblongifolia*	1	0.02	5	0.50
103	*Aglaia spectabilis*	1	0.02	5	0.50
104	*Diospyros hirsuta*	1	0.01	5	0.50
105	*Cryptocarya annanmensis*	1	0.01	5	0.49
106	*Aglaia roxburghiana*	1	0.01	5	0.49
107	*Ormosia pinnata*	1	0.01	5	0.49
108	*Gironniera mollissima*	1	0.01	5	0.48
109	*Amaranthus spinosus*	1	0.01	5	0.47
110	*Schima wallichii*	1	0.00	5	0.47
	Total	**516**	**41.46**		

App. 5 Tree species of regeneration collected in the four forest types in Ben En National Park, Vietnam

No	Scientific name	Family	Phase 1	Phase 2	Phase 3	Undisturbed forest	Total
1	Pometia pinnata	Sapindaceae		80	65	25	170
2	Schima superba	Theaceae	1	22	96	19	138
3	Cinnamomum parthenoxylon	Lauraceae	3	17	88	26	134
4	Vernicia montana	Euphorbiaceae	102	4			106
5	Gironniera cuspidata	Ulmaceae	15	28	31	27	101
6	Syzygium chanlos	Myrtaceae	31	32	9	23	95
7	Syzygium zeylanicum	Myrtaceae	5	22	37	18	82
8	Alangium chinense	Alangiaceae	61	8		4	73
9	Wrightia laevis	Apocynaceae	14	18	22	16	70
10	Antidesma acidum	Euphorbiaceae	2	11	44	12	69
11	Peltophorum pterocarpum	Caesalpiniaceae	12	25	18	3	58
12	Hypericum japonicum	Hypericaceae	12	29	14		55
13	Knema globularia	Myristicaceae		3	32	19	54
14	Cinnamomum subavenium	Lauraceae		6	23	21	50
15	Canarium parvum	Burseraceae	4	17	17	8	46
16	Cinnamomum tetragonum	Lauraceae	1	10	20	13	44
17	Erythrophleum fordii	Caesalpiniaceae		10	14	17	41
18	Vitex trifolia	Verbenaceae	5	18	7	4	34
19	Paranephelium spirei	Sapindaceae		10	14	10	34
20	Ficus vasculosa	Moraceae	1	8	20	5	34
21	Acronychia pedunculata	Rutaceae	2	14	16		32
22	Aglaia dasyclada	Meliaceae	2	8	1	19	30
23	Mellettia lasiopetala	Fagaceae		3	18	8	29
24	Castanopsis annamensis	Fagaceae	1	17	6	2	26
25	Gironniera subaequalis	Ulmaceae	1			25	26
26	Canarium album	Burseraceae	3	10	7	6	26
27	Aphanamixis grandifolia	Meliaceae		2	1	21	24
28	Garcinia oblongifolia	Clusiaceae	3	3	7	10	23
29	Vatica odorata	Dipterocarpaceae	1		20	1	22
30	Mischocarpus oppositifolius	Sapindaceae	2	6	10	4	22
31	Michelia banlanse	Magnoliaceae	1	5	6	9	21
32	Wrightia pubscens	Apocynaceae	5	9	4	3	21
33	Amesiodendron chinense	Sapindaceae		4	4	13	21
34	Michelia tonkinensis	Magnoliaceae	11	4	5		20
35	Gironniera mollissima	Ulmaceae		3	16		19
36	Machilus bonii	Lauraceae		3	6	9	18
37	Knema pierrei	Myristicaceae		2	13	2	17
38	Archidendron clypearia	Mimosaceae	1	8	6	1	16
39	Baccaurea sapida	Phyllanthaceae	2	4	7	2	15
40	Actinodaphne obovata	Lauraceae			10	4	14
41	Dysoxylum cauliflorum	Meliaceae		1	7	5	13

42	Markhamia stipulata	Bignoniaceae		2	5	5	12
43	Elaeocarpus griffithii	Elaeocarpaceae	1	1	6	3	11
44	Castanopsis hystrix	Fagaceae			2	9	11
45	Machilus bonii	Lauraceae		2	2	7	11
46	Grewia paniculata	Tiliaceae	2	8	1		11
47	Canarium littorale	Burseraceae		4	2	5	11
48	Machilus sp.	Lauraceae		2	8		10
49	Cinnamomum mairei	Lauraceae			3	7	10
50	Cinnamomum subavenium	Lauraceae	1	4	5		10
51	Sterculia lanceolata	Sterculiaceae		9	1		10
52	Syzygium levinei	Myrtaceae		2	7	1	10
53	Ficus sp.	Moraceae	3	6			9
54	Vitex leptobotrys	Verbenaceae		2	6	1	9
55	Sapium discolor	Euphorbiaceae	3	6			9
56	Phoebe angustifolia	Lauraceae		4	4	1	9
57	Aglaia silvestric	Meliaceae		4	1	3	8
58	Aglaia spectabilis	Meliaceae	1	1		6	8
59	Artocarpus tonkinensis	Moraceae		2	5		7
60	Michelia mediocris	Magnoliaceae			1	6	7
61	Averrhoa carambola	Oxalidaceae	3		4		7
62	Pterospermum hetrophyllum	Sterculiaceae	3	1	1	2	7
63	Cratoxylum polyanthum	Clusiaceae	5	2			7
64	Euodia tepta	Rutaceae			6		6
65	Rauvolfia verticillata	Apocynaceae	1	5			6
66	Aphanamixis silvestris	Meliaceae			6		6
67	Trema orientalis	Ulmaceae	5	1			6
68	Neolitsea poilanei	Lauraceae		1		5	6
69	Ficus racemosa	Moraceae	4	2			6
70	Endospermum sinensis	Euphorbiaceae	2	3		1	6
71	Schima wallichii	Theaceae				6	6
72	Litsea griffithii	Lauraceae		1	3	1	5
73	Aglaia perviridis	Meliaceae		1	1	3	5
74	Cryptocarya annanmensis	Lauraceae			5		5
75	Cinnamomum impressimeurium	Lauraceae		4		1	5
76	Cinnamomum ovatum	Lauraceae				5	5
77	Syzygium tonkinensis	Myrtaceae		4		1	5
78	Mytilaria laosensis	Burseraceae	2		2	1	5
79	Syzygium cumini	Myrtaceae		3	2		5
80	Croton tiglium	Euphorbiaceae		4			4
81	Litsea lancifolia	Lauraceae			4		4
82	Symplocos lauria	Symplocaceae		1	2	1	4
83	Uraria crinita	Fabaceae	2	1	1		4
84	Archidendron lucidum	Mimosaceae			4		4
85	Endiandra hainanensis	Lauraceae			1	3	4
86	Cryptocarya lenticellata	Lauraceae		2	2		4
87	Neocinnamomum lecomtei	Lauraceae			3	1	4

88	Lithocarpus areca	Fagaceae		1	2	1	4
89	Garcia cowa	Clusiaceae				4	4
90	Prunus arborea	Rosaceae	3	1			4
91	Camellia sinensis	Theaceae			3		3
92	Castanopsis lecomtei	Fagaceae			1	2	3
93	Symplocos atriolivacea	Symplocaceae		1	2		3
94	Aglaia roxburghiana	Meliaceae			3		3
95	Cinnamomum iners	Lauraceae		1		2	3
96	Lithocarpus sp.	Fagaceae			1	2	3
97	Syzygium parviflorum	Myrtaceae		1	2		3
98	Syzygium polyanthum	Myrtaceae			3		3
99	Mallotus paniculatus	Euphorbiaceae	2				2
100	Castanopsis indica	Fagaceae		2			2
101	Schefflera octophylla	Araliaceae		1		1	2
102	Artocarpus styracifolius	Moraceae			2		2
103	Fernandoa brilletii	Bignoniaceae			1	1	2
104	Garcinia multiflora	Clusiaceae			1	1	2
105	Michelia tonkinensis	Magnoliaceae				2	2
106	Paramechelia braianensis	Magnoliaceae				2	2
107	Phoebe platycarpa	Lauraceae		2			2
108	Koilodepas longifolium	Euphorbiaceae				2	2
109	Ormosia pinnata	Fabaceae	2				2
110	Dillenia scabrella	Dilleniaceae	1		1		2
111	Rhus succedanea	Anacardiaceae		2			2
112	Antiaris toxicaria	Moraceae			2		2
113	Diospyros hirsuta	Ebenaceae			2		2
114	Syzygium brachiatum	Myrtaceae	2				2
115	Saraca dives	Caesalpiniaceae		1		1	2
116	Mangifera minitifolia	Anacardiaceae			2		2
117	Mallotus floribundus	Euphorbiaceae	1				1
118	Litsea verticillata	Lauraceae	1				1
119	Beilschmiedia ferruginea	Lauraceae			1		1
120	Artocarpus tonkinensis	Moraceae				1	1
121	Artocarpus sp.	Moraceae			1		1
122	Camellia caudata	Theaceae			1		1
123	Engelhardtia chrysolepsis	Juglandaceae	1				1
124	Diospyros pilosula	Ebenaceae				1	1
125	Dosoxylum acutangulum	Meliaceae			1		1
126	Ficus annulata	Moraceae				1	1
127	Quercus platycalyx	Fagaceae	1				1
128	Lithocarpus pseudosundaicus	Fagaceae			1		1
129	Vitex quinata	Verbenaceae				1	1
130	Amaranthus tricolor	Amaranthaceae		1			1
131	Symplocos glauca	Symplocaceae			1		1
132	Canthium horridum	Rubiaceae		1			1
133	Phoebe tavoyana	Lauraceae		1			1

134	Gmelina arborea	Lamiaceae	1				1
135	Cinnamomum camphora	Lauraceae			1		1
136	Strychnos angustifolia	Loganiaceae		1			1
137	Ficus vasculosa	Moraceae	1				1
138	Cassia sp.	Caesalpiniaceae				1	1
139	Chisocheton chinensis	Meliaceae			1		1
140	Eurya tonkinensis	Theaceae			1		1
141	Aporosa dioica	Euphorbiaceae			1		1
142	Diospyros montana	Ebenaceae				1	1
143	Canarium tramdenum	Burseraceae	1				1
14	Syzygium cumini	Myrtaceae		1			1
	Total		**359**	**597**	**885**	**526**	**2367**