



Integrated Nature Conservation and Sustainable Resource Management

C/O Bualapha District Office
for Natural Resources and Environment



On behalf of:



Plant Inventory Survey In the Hin Nam No National Protected Area: Botanical Report

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Executive summary:

Background: Biodiversity Conservation is the most important goal of the Hin Nam No NPA and also of the German supported project. The NPA management unit needs mechanisms that allow it to measure whether the biodiversity values of the NPA are getting better or worse. The diversity of plants in the Hin Nam No area is still little known. A total of 4xx species were identified during a flora survey in 1998 (Walston, 1999). A list of 67 indicator species was drawn up and 6 forest types were distinguished by a recent flora survey (Lamxay, 2014). To arrive at verifiable indicators for the maintenance of plant biodiversity, density measurements are needed through sample plot surveys. Secondly, the spatial distribution of the six forest types should be estimated through a combination of analysis of satellite imagery with ground trothing in selected locations¹. Last but not least, the largest potential for income generation through NTFPs was estimated to be in the sustainable use of ‘mak tao’ sugar palm trees (*Arenga westerhoutii*). An estimate of the resource quantity is needed to develop village based business plans for producer groups.

For plant inventory, the team from the NUOL implemented the sampling study in the area of Bane Chalou from 25–28 February 2015. Thirty four sampling plots were studied for vegetation composition survey at Nong chong area of Kouan Ka Ane and the dense forest of Phou Changking.

The objectives: The aim of the study was to develop the database of plant species distribution in some important plant areas in Chalou Area (HNN-NPA) by carrying out field works with a method using sample plots with a radius of 17.85 meters (or 0.1 ha) that are: (1) to investigate species diversity,

distribution, abundance, and status of indicator plant species and determine ecological characteristic of forest types, (2) to Assess the economic value of timber in the Chalou areas, (3) to evaluate impacts on forest resources, (4) Train villagers and district staff in survey methods and (5) Work with the international GIS adviser to define sample plots in Ban Chalou of each of the forest types and map occurrence of forest types by combining satellite image analysis and field observation

Method: A sampling plot study was made at Phouchanking and Nongchong area of Bane Chalou N 17° 17' 08.5" E 105° 56' 51.6". Boualapha district, Khammouane province in the Hin Nam No NPA. In this study, ground walking for sampling plot study with semi-structure interview to record local name, use and status of plant species, also, the plant samples were collected, photographed and diameter of tree were measured.

Result: Two study sites of Bane Chalou that are Nongchong area of Khouan Ka An and Phou chang king area were observed. Thirty four sampling plots were studied, Five forest types were found and surveyed as evergreen forest (EF) 12 plots, semi-evergreen forest (SEF), mixed deciduous forest (MDF), bamboo forest (BF) and karts forest (KF) are 9,8,3, and 2 plots respectively. The composition of key tree species of each forest type were recorded that are: EF 302 records, SEF, MDF, BF and KF are 264, 276, 40 and 43 records respectively. For plant distribution and density in this area, nine hundred twenty five tree records belonging 36 families and 81 tree species were classified and recorded. The important quantitative such as density of tree, sapling and seedling, timber volume, basal area, relative density, relative dominant, relative frequency and important value index were analyzed. Statistical analysis were used by Microsoft Excel and were determined as per Curtis and McIntosh (1950).

The five high density trees in this area are ກົກຍາງແດງ *Dipterocarpus costatus* C.F.Gaertn. (Dipterocarpaceae), ກົກເປືອຍດອກຂາວ *Lagerstroemia calyculata* Kurz (Lythraceae), ກົກເປືອຍເປືອກແດງ *Lagerstroemia floribunda* Jack (Lythraceae), ໄມ້ຫວ້າດົງ *Syzygium* sp. (Myrtaceae) and ໄມ້ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae). In the other hand, the five high density family are ຕະກຸນໄມ້ຍາງ Dipterocarpaceae, ຕະກຸນໄມ້ເປືອຍ Lythraceae, ຕະກຸນຖົ່ວ Fabaceae, ຕະກຸນໄມ້ຫວ້າ Myrtaceae and ຕະກຸນໄມ້ໝຸນ Ebenaceae respectively.

Other observations and Recommendations: In this study, threats which are illegal logging of valuable timber trees inside the NPA is the high threat with road construction through dance forest at Phou Changking, the forest fires which seem to occur in small area, Almost all these fires are set by people for providing grazing and facilitate hunting.

For follow-up it is recommended to do more develop baseline data on the densities of indicator species, secondly, satellite image interpretation is very important tool to combined with field observations to determine the distribution of the forest types throughout the Hin Nam No NPA and thirdly, more plant inventory studies and more botany surveys are desired to capture all the unknown plant species likely to be hiding inside Hin Nam No NPA.

Table of Content

List of acronyms

NPA	National Protected Area
CITES	Convention on International Trade in Endangered Species
FAO	Food and Agriculture Organization of the United Nations
GIZ	Deutsche Gesellschaft fuer Internationale Zusammenarbeit
GPS	Global Positioning Satellite
IUCN	International Union for Conservation of Nature
MAF	Ministry of Agriculture and Forestry
MONRE	Ministry of Natural Resources and Environment
NBCA	National Biodiversity Conservation Area (old term, now: NPA)
NHL	National Herbarium of Laos
NTFP	Non-Timber Forest Product
NUOL	National University of Laos
PDR	People's Democratic Republic
PRA	Participatory Rural Appraisal
SNV	The Netherlands Development Organization
STEa	Science, Technology and Environment Agency (old term, now: MONRE)

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1. Introduction:

Biodiversity Conservation is the most important goal of the Hin Nam No NPA and also of the German supported project. The NPA management unit needs mechanisms that allow it to measure whether the biodiversity values of the NPA are getting better or worse. The diversity of plants in the Hin Nam No area is still little known. A total of >450 species were identified during a flora survey in 1998 (Walston, 1999). A list of 67 indicator species was drawn up and 6 forest types were distinguished by a recent flora survey (Lamxay, 2014). To arrive at verifiable indicators for the maintenance of plant biodiversity, density measurements are needed through sample plot surveys. Secondly, the spatial distribution of the six forest types should be estimated through a combination of analysis of satellite imagery with ground trothing in selected locationsⁱⁱ. Last but not least, the largest potential for income generation through NTFPs was estimated to be in the sustainable use of ‘mak tao’ sugar palm trees (*Arenga westerhoutii*). An estimate of the resource quantity is needed to develop village based business plans for producer groups.

For plant inventory, the team from the NUOL implemented the sampling study in the area of Bane Chalou from 25–28 February 2015. Thirty four sampling plots were studied for vegetation composition survey from Nong chong area of Kouan Ka ane and the dense forest of Phou Changking.

In Lao PDR, Forest ecosystems are generally classified according to altitude (e.g. lowland vs. Upper), dominant species of trees, types of plant communities (the composition of plant species), and whether the majority of tree species are deciduous, semi-evergreen or evergreen. The ecosystems of the Lao PDR are presently classified on the basis of the forest types. The study “Forest Habitats and Flora in Lao PDR, Vietnam and Cambodia” by Rundel (1999) reported that forest habitats in the Lao PDR can be broadly divided into three groups, lowland, montane and azonal habitats. The criteria of forest classification were mainly based on floristic structure and species composition (MAF & STEA, 2003) and (FAO, 2010)

Several forest classification schemes have been proposed for the Lao PDR. The classification of forest types for this study is based on the classification used by the Forest Inventory and Planning Division, Department of Forestry since 1982, and the preliminary national forest record. The definition below shows the classification and definition of each forest or land use type. The definition of forest is belong to the Report on the Assessment of Forest Cover and Land Use (MAF, DOF, 2003) In Laos, eight type of forest were classified based on floristic structure and species composition and according their distribution in different altitude range within southern, central and northern region. Dry Dipterocarp forest, lower dry evergreen, upper evergreen, lower mixed deciduous, upper mixed deciduous, Gallery forest, coniferous and mixed conifer/broadleaf forest were described (MAF & STEA, 2003).

All plant species must be required special laboratory work and identification. Those species will be prepared for voucher specimens. Botanists have collected part of stem with leave including flowers and fruits (if possible), alcohol method of samples collection were done in the field, then all collections were prepared, dried, mounted, labeled, data-basing identified and botanical described at the herbarium of Biology department, National University of Laos, Vientiane.

Botanist team have determined plant species using standard references in this region such as Flora of Thailand, Flora of Vietnam, Flora of Malaysia, Flore du Cambodge, du Laos et du Vietnam and also Flore General de l' Indo-Chine and other botanical related books, journals, bulletins and others. Lao botanist team have asked specialist or specific experts as Thailand, Vietnamese and international botanical experts for helping to determine and identify unknown species. All voucher specimens were taken at the Herbarium of Biology department, Faculty of Science, National University of Laos and will be distributed to the National Herbarium of Laos.

2. The goals

To strengthen the capacity of the Biodiversity Monitoring and Livelihood Teams within the Hin Nam No National Protected Area (NPA) Management Unit working with village women to define baseline indicators on plant biodiversity through forest inventories for selected threatened NTFPs and timber tree species.

3. The objectives

The objectives of the Botanical activities proposed develop the database of plant species distribution in some important plant areas in Chalou Area (HNN-NPA) by carrying out field works with a method using sample plots with a radius of 17.85 meters (or 0.1 ha) that are:

- 1) Investigate species diversity, distribution, abundance, and status of indicator plant species and determine ecological characteristic of forest types
- 2) Assess the economic value of timber in the Chalou areas.
- 3) Evaluate impacts on forest resources.
- 4) Train villagers and district staff in survey methods

5) Work with the international GIS adviser to define sample plots of at least 100x100m in Ban Chalou of each of the six forest types and map occurrence of forest types by combining satellite image analysis and field observation

4. Methods

1) Study area:

The Area of Bane Chalou, Boualapha district, Khammouane province. At range 200-500 m elevation the names of survey major and minor localities, way points with elevation and general of habitat and ecosystems were recorded. Coordinates of representative vegetation types and general habitats obtainment with a GPS meter (Garmin 12XL) were taken.

Teams of botanists and local staffs/villagers will access to study sites by walking. The team will spend approximately at least 1 hours/plot, except in the priority areas will effort more than 1 hrs/plot. Local people/villagers as a guides/ informants will be employed for security reason, site navigation, and data interview.

2) Data collection

2.1) Species diversity survey: A sampling plot study was made at Phouchanking and Nongchong area of Bane Chalou N 17° 17' 08.5" E 105° 56' 51.6". Boualapha district, Khammouane province in the Hin Nam No NPA. In this study, ground walking for sampling plot study with semi-structure interview to record local name, use and status of plant species that occur in the plot, also, the plant sample were collected, photographed and diameter of tree and its high were measured.

The floristic survey were focused on indicator species of tree plants. The intensive survey were conducted on the transect lines covered in all vegetation types, including special zone such as limestone forest where mostly hosts of endemic species. For those of plants both known and unknown were collected at least 4 duplicates of leave with flowers or fruits for further analysis in the laboratory. Botanists were recorded necessary information i.e. minor localities, waypoints, date, Tree species names, its dbh, its high, species and number of sapling and seedling also the number of species and clump of bamboo. (Annex 1. Form of forest inventory sheet)

2.2) Forest inventory: Primary data of plant diversity was collected from sampling plots that were set randomly covering the Chalou Area (HNN-NPA) area according to ecology, geographic conditions and forest types. The sampling plots were set in the dominant areas or good representation of forest types. The sampling plot consists of 3 types of temporary plots as indicate in the Figure 3-3 which are: (1) A circular sample plots with a radius of 17.85 meters (or 0.1 ha): data of trees which are diameter at breast height (130 cm high) (DBH) \geq 30 centimeters will be recorded. Other significant information will be measured such as tree species, DBH, total height, timber quality, number of log (1 log = 5 m timber), and bamboo species, including number of clumps and stems per clump. (2) Square plots of 5x5 meters (25 square meters or 0.0025 ha) will be established in the middle of the circular plots.

Information of small trees and/or saplings (trees whose DBH < 30 centimeters and whose height >1.3 meters), tree species, number of tree, and height, as well as Non Timber Forest Products species will recorded from these plots and (3) Square plots of 2x2 meters will established within the larger square plots of 5x5 meters. Data concerning plant species, number of seedling, and undergrowth vegetation will recorded.

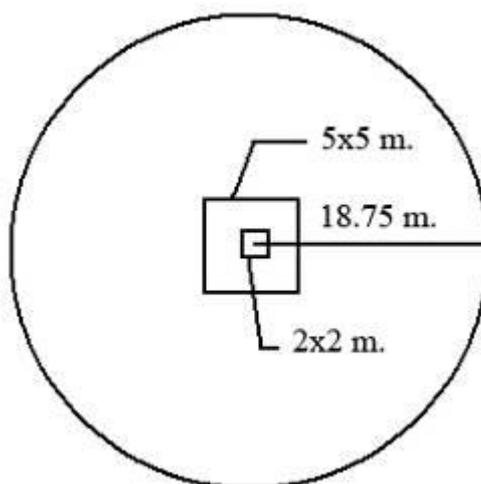


Figure 1. The temporary sampling plot for forest inventory

2.3. Forest and Vegetation Classification: Forest ecosystems are generally classified according to altitude (e.g. lowland vs. Upper), dominant species of trees, types of plant communities (the composition of plant species), and whether the majority of tree species are deciduous, semi-evergreen or evergreen. The ecosystems of the Lao PDR are presently classified on the basis of the forest types. The study “Forest Habitats and Flora in Lao PDR, Vietnam and Cambodia” by Rundel (1999) reported that forest habitats in the Lao PDR can be broadly divided into three groups, lowland, montane and azonal habitats. The criteria of forest classification were mainly based on floristic structure and species composition (MAF & STEA, 2003) and (FAO, 2010). Several forest classification schemes have been proposed for the Lao PDR. The classification of forest types for this study is based on the classification used by the Forest Inventory and Planning Division, Department of Forestry since 1982, and the preliminary national forest record. The definition below shows the classification and definition of each forest or land use type. The definition of forest is belong to the Report on the Assessment of Forest Cover and Land Use (MAF, DOF, 2003)

3. Data analysis

3.1) Plant Identification: Some plant species may be required special laboratory work and identification. Those species will be prepared for voucher specimens. Botanists will collect part of leave including flowers and fruits (if possible), then put into the plastic bag (Using alcohol method in the field), then will preparing, drying, mounting, labeling, data-basing identifying and botanical

describing at the herbarium of Biology department, NUoL, Vientiane. Botanist team will determine plant species using standard references in this region such as Flora of Thailand, Flora of Vietnam, Flore du Cambodge, du Laos et du Vietnam and also Flore General de l' Indo-Chine and other botanical books, journals, bulletins and others. Botanist team might be invited specialist from oversea as Thailand and Vietnam for help to identify unknown species (if needed).

4.2) Quantitative analysis: The important quantitative analysis such as density, frequency, volume, etc., of tree species will use Statistical Package for Social Sciences (SPSS), Microsoft Excel and be determined as per Curtis and McIntosh (1950), which are:

4.2.1) *Density:* Total density of a plants (D) was calculated from the following equation:

(1) Density of trees:

$$D_i = \frac{10n_i}{n}$$

D_i = density of a particular species)no/ha(

n_i = numbers of a particular species

n = total numbers of sampling plots

$$D = \sum_{i=1}^n D_i$$

D = total density of trees (no/ha)

(2) Density of saplings:

$$D_i = \frac{400n_i}{n}$$

D_i = density of a particular species (no/ha(

n_i = numbers of a particular species

n = total numbers of sampling plots

$$D = \sum_{i=1}^n D_i$$

D = total density of saplings (no/ha)

(3) Density of seedlings:

$$D_i = \frac{2500n_i}{n}$$

D_i = density of a particular species)no/ha(

n_i = numbers of a particular species

n = numbers of sampling plots

$$D = \sum_{i=1}^n D_i$$

D = total density of saplings (no/ha)

4.2.2) *Basal area*: Total basal area of trees (B) was obtained from this formula:

$$B_i = \pi \frac{25(D_i)^2}{n}$$

B_i = basal area of a particular tree)m²/ha(

D_i = diameter of a particular tree

n = numbers of sampling plots

$$B = \sum_{i=1}^n B_i$$

B = total basal area of trees

4.2.3) *Timber volume*: Calculation of an average timber volume (\bar{V}) was follow Samart and Thannarin (1996) as equation: $\ln(V_i) = \ln(2.110246) + 2.266056 \ln(dbh_i)$

dbh_i = diameter at breast height of a particular timber (m)

V_i = timber volume of a particular tree)m³/ha(

$$\bar{V} = \sum_{i=1}^n V_i$$

\bar{V} = average timber volume)m³/ha(

n = numbers of sampling plots

4.2.4) *Relative density*: Relative density of a given species (RD_i) was calculated from the following equation:

$$RD_i = \frac{100N_i}{N}$$

N_i = numbers of a particular tree species

N = numbers of total trees

4.2.5) *Relative dominant*: Relative dominant of a given species (RB_i) was calculated from the following equation:

$$RB_i = \frac{100B_i}{B}$$

B_i = basal area of a particular tree species)m²/ha(

B = total basal area of trees (m²/ha(

4.2.6) *Relative frequency*: Relative frequency of a given species (RF_i) was calculated from the

following equation:

$$RF_i = \frac{100n_i}{n}$$

n_i = numbers of sampling plots that a particular species occurs

n = total numbers of sampling plots

4.2.7) *Important value Index*: This index is used to determine the overall importance of each species in the community structure. Important value index of a given species (IVI_i) was calculated from the (Curtis, 1959)

$$IVI_i = RD_i + RB_i + RF_i$$

RD_i = relative density of a particular species

RB_i = relative dominant of a particular species

RF_i = relative frequency of a particular species

5. Result:

5.1 *Site study*: Two main study sites of Bane Chalou consisted of Nongchong area at the Khouan Ka An valley inside HNN NPA and the range of Phou Chang king area were observed. (see Maps) and the GPS data points of all sampling plots are presented in the Table 1.

We need help to create the map from GIS specialist (Ronny?)

5.2 Data collection:

Thirty four sampling plots were studied and five forest types were sampling surveyed as evergreen forest (EF) 12 plots, semi-evergreen forest (SEF), mixed deciduous forest (MDF), bamboo forest (BF) and karts forest (KF) are 9,8,3, and 2 plots respectively. The waypoints, major locations, manor location/habitat/ecosystem, forest types and elevations of each sampling plot were supplied. (Annex 2)

5.3 Plant density:

The composition of key tree species in each forest type were recorded which are: EF 302 records, SEF, MDF, BF and KF are 264, 276, 40 and 43 records respectively. Total of 36 families and 81 tree species were classified. Nine hundred twenty five records were noted. In total of 34 plots and 625 plant records, plant records which are 630 records of tree and 200, 63 and 32 records of sapling, seedling and bamboo/Graminae respectively were classified. Its waypoints, elevations, collection dates, major locations, habitats or minor locations, forest types, number of plant species in each plot, local names, scientific names, family names and its habit were supplied (Annex 3 and table 2). The important quantitative such as density of tree, sapling and seedling, timber volume, basal area, relative density, relative dominant, relative frequency and important value index were analyzed and supplied. Statistical analysis was used by Microsoft Excel and were determined as per Curtis and McIntosh (1950).

5.3.1 *Species density*: In Chalou area, density of tree species which are the high top ten density species consisted ເປືອຍດອກຂາວ *Lagerstroemia calyculata* Kurz (Lythraceae); ຍາງແດງ *Dipterocarpus costatus* C.F.Gaertn. (Dipterocarpaceae); ໄມ້ຫວ້າດົງ *Sygygium* sp. (Myrtaceae); ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae); ເປືອຍເປືອກແດງ *Lagerstroemia floribunda* Jack (Lythraceae); ຂີ້ໝູ *Callerya atropurpurea* (Wall.) Schot (Fabaceae); ແຄນຫີນ *Hopea ferrea* Pierre (Dipterocarpaceae); ຂີ້ໜອນຄວາຍ *Gironniera nervosa* Planch. (Ulmaceae); ໄມ້ຊີ *Shorea thorelii* Pierre (Dipterocarpaceae) and ຄາຍໂສ້ *Schima wallichii* (DC.) Korth. (Theaceae) respectively. The values of number of records, number of sampling plots that the particular species occur, density of particular species, relative density and relative frequency of 81 tree species were supplied (Annex 4)

5.3.2. *Family density*: The high top ten density family are ຕະກຸນໄມ້ຍາງ Dipterocarpaceae; ຕະກຸນໄມ້ເປືອຍ Lythraceae; ຕະກຸນຖົ່ວ Fabaceae; ຕະກຸນຫວ້າ Myrtaceae; ຕະກຸນໄມ້ໝູນ Ebenaceae; ຕະກຸນຫຍ້າ Graminae; ຕະກຸນກົກຫານ Ulmaceae; ຕະກຸນຄາຍໂສ້ Theaceae; ຕະກຸນລໍາໄຍ Sapindaceae and ຕະກຸນໝາກຍົມ Euphorbiaceae. The values of number species, number of records, number of sampling plots that the particular family occur, density of particular family, relative density and relative frequency of 33 tree families were supplied (Annex 5)

5.3.3. *Plant density* in the five forest types was defined base on species composition and its density.

a) *Evergreen Forest* were noted. This type of forest were found at the hill of Phou Chang king area. Total of 12 sampling plots were studied , 302 tree species records of 24 families and 49 species. The high density species are ຍາງແດງ *Dipterocarpus costatus* C.F.Gaertn. (Dipterocarpaceae); ໄມ້ຫວ້າດົງ *Sygygium* sp. (Myrtaceae); ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae); ໄມ້ຊີ *Shorea thorelii* Pierre (Dipterocarpaceae) and ຄາຍໂສ້ *Schima wallichii* (DC.) Korth. (Theaceae). In the other hand the high relative frequency are ຍາງແດງ *Dipterocarpus costatus* C.F.Gaertn. (Dipterocarpaceae); ໄມ້ຫວ້າດົງ *Sygygium* sp. (Myrtaceae); ໄມ້ເຮັຍ *Schizostachum virgatum* (Munro) H.B.Nathani & Bennet (Graminae); ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae); ໄມ້ບາກ *Anisoptera costata* Korth. (Dipterocarpaceae) and ມ່ວງປ່າ *Mangifera caloneura* Kurz. (Anacardaceae) which its value are 100; 75; 66.66, 50; 50 and 50 respectively. For the high density families are Dipterocarpaceae; Myrtaceae; Fabaceae; Theaceae; Anacardaceae and Graminae with the value of density of particular family are 77.5; 43.33; 32.5; 19.16; 10.83 and 10.00 (Annex 6a and Annex 6b)

b) *Semi-Evergreen Forest*: this type of forest were found at both sites as at Nong chong area, on the top of Phou Chang king and in the hill of Phou chang king along the verside of Xebangfai. Total of 9 sampling plots were studied , 264 tree species records of 30 families and 56 species. The top ten high density of tree species are ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae); ຍາງແດງ *Dipterocarpus costatus* C.F.Gaertn. (Dipterocarpaceae); ແຄນຫີນ *Hopea ferrea* Pierre (Dipterocarpaceae); ຂີ້ໝູ *Callerya atropurpurea* (Wall.) Schot (Fabaceae); ໄມ້ຫວ້າດົງ *Sygygium* sp. (Myrtaceae); ຂີ້ໜອນຄວາຍ *Gironniera nervosa* Planch. (Ulmaceae); ໄມ້ບາກ *Anisoptera costata* Korth. (Dipterocarpaceae); ໄມ້ຊີ *Shorea thorelii* Pierre (Dipterocarpaceae); ມັນປາ *Fagraea fragrans* Roxb.

(Gentianaceae) and ເປືອຍດອກຂາວ *Lagerstroemia calyculata* Kurz (Lythraceae) with the value of density of particular species are 41.1; 28.8; 24.4; 18.8; 17.7; 12.2; 8.88; 7.77; 7.77 and 6.66 respectively. However, the high relative frequency are ໄມ້ຫວ້າດົງ *Sygygium* sp. (Myrtaceae); ຍາງແດງ *Dipterocarpus costatus* C.F.Gaertn. (Dipterocarpaceae); ຂີ້ໝູ *Callerya atropurpurea* (Wall.) Schot (Fabaceae); ລຳໂຍປ່າ *Dimocarpus longan* Lour. (Sapindaceae) and ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae) with its value 88.88; 55.55; 55.55; 55.55 and 44.44 respectively. Density of plant families in this type of forest shows that the families of Dipterocarpaceae; Fabaceae; Myrtaceae; Graminae; Sapindaceae; Ulmaceae; Gentianaceae; Guttiferae; Anacardaceae and Ebenaceae are the high density with the value of 71.11; 70.00; 18.88; 13.33; 12.22; 12.22; 7.77; 7.77; 6.66 and 6.66 respectively (Annex 7)

C) Mixed Deciduous Forest: this type of forest were found at along Houay Ka an and Houay Khai in Nong Chong area. Total of 8 sampling plots were studied , 276 tree species records of 25 families and 51 species. The top ten high density of tree species are ເປືອຍດອກຂາວ *Lagerstroemia calyculata* Kurz (Lythraceae); ເປືອຍເປືອກແດງ *Lagerstroemia floribunda* Jack (Lythraceae); ຂີ້ໝູ *Callerya atropurpurea* (Wall.) Schot (Fabaceae); ນົມຍານ *Barringtonia longipes* Gagnep. (Lecythidaceae); ຂີ້ໜອນຄວາຍ *Gironniera nervosa* Planch. (Ulmaceae); ແດງນ້ຳ *Pometia pinnata* J.R.Forst. & G.Forst. (Sapindaceae); ສົ້ມຝາດ *Bischofia javanica* Blume (Euphorbiaceae); ໝາກຄອມ *Microcos tomentosa* Sm. (Tiliaceae); ຄຳມ່າ *Saraca indica* L. (Fabaceae) and ຫຳອາວ *Pterospermum diversifolium* Blume (Sterculiaceae) with value of density 102.50; 71.25; 30.00; 12.50; 8.75; 8.75; 7.50; 6.25; 5.00 and 5.00 respectively. However, the most high relative frequency are the same as species as density. In this forest type the family of Lythraceae is the highest density with value 173.75 that it is higher than other families around 3 times. Other high density of tree families are Fabaceae; Euphorbiaceae; Lecythidaceae; Sapindaceae; Meliaceae; Dipterocarpaceae; Ulmaceae; Ebenaceae and Moraceae with the value of density 41.25; 15.00; 12.50; 12.50; 11.25; 8.75; 8.75; 7.50 and 6.25 respectively. (Annex 8)

d) Bamboo Forest: the both tables below show the density of tree species and tree families in the Bamboo forest that was found on the hill of Phou Changking and along the houay Kaan and Houay Khai of Nong Chong area. Total of 3 sampling plots were studied and 43 tree species records of 14 families and 21 species. (Table 3a and table 3b)

Table 3a The density of plant species of the Bamboo Forest

# / plot	Local name	Scientific name	Family name	No records	No plot	Di	RDi	RFi
1	ຂີ້ໜອນຄວາຍ	<i>Girromiera nervosa</i> Planch.	Ulmaceae	9	3	30.00000	20.93023	100.00000
2	ຍາງແດງ	<i>Dipterocarpus costatus</i> C.F.Gaertn.	Dipterocarpaceae	5	2	16.66667	11.62791	66.66667
3	ໄມ້ເຮັຍ	<i>Schizostachum virgatum</i> (Munro) H.B.Nathani & Bennet	Graminae	3	3	10.00000	6.97674	100.00000
4	ລົງໄຍປ່າ	<i>Dimocarpus longan</i> Lour.	Sapindaceae	2	2	6.66667	4.65116	66.66667
5	ໄມ້ຍົມ	<i>Toona ciliata</i> M.Roem.	Meliaceae	2	2	6.66667	4.65116	66.66667
6	ແຄຫອມ	<i>Cinnamomum</i> sp.	Lauraceae	2	2	6.66667	4.65116	66.66667
7	ດັງດຳ	<i>Diospyros variegata</i> Kurz	Ebenaceae	2	2	6.66667	4.65116	66.66667
8	ນົມຍານ	<i>Barringtonia longipes</i> Gagnep.	Lecythidaceae	2	2	6.66667	4.65116	66.66667
9	ຕາເສືອ	<i>Aglaia lawii</i> (Wight) C.J.Saldanha ex Ramamoorthy	Meliaceae	2	2	6.66667	4.65116	66.66667
10	ຂີ້ໝູ	<i>Callerya atropurpurea</i> (Wall.) Schot	Fabaceae	2	2	6.66667	4.65116	66.66667
11	ຫ້າອາວ	<i>Pterospermum diversifolium</i> Blume	Sterculiaceae	2	2	6.66667	4.65116	66.66667
12	ໄໝກປ່າ	<i>Wrightia tomentosa</i> Roem. & Schult.	Apocynaceae	1	1	3.33333	2.32558	33.33333
13	ຫ້າອາວ	<i>Pterospermum semisagittatum</i> Buch.-Ham.	Sterculiaceae	1	1	3.33333	2.32558	33.33333
14	ກໍ່ໜາມ	<i>Castanopsis</i> sp.	Fagaceae	1	1	3.33333	2.32558	33.33333
15	ໄມ້ບາກ	<i>Anisoptera costata</i> Korth.	Dipterocarpaceae	1	1	3.33333	2.32558	33.33333
16	ປີ້ເກັດແຂ້	<i>Balakata baccata</i> (Roxb.) H.-J.Esser	Euphorbiaceae	1	1	3.33333	2.32558	33.33333
17	ດັງດຳ	<i>Diospyros</i> cf. <i>wallichii</i> King & Camble ex King	Ebenaceae	1	1	3.33333	2.32558	33.33333
18	ເປືອຍດອກຂາວ	<i>Lagerstroemia calyculata</i> Kurz	Lythraceae	1	1	3.33333	2.32558	33.33333
19	ໄມ້ຊີ້	<i>Shorea thorelii</i> Pierre	Dipterocarpaceae	1	1	3.33333	2.32558	33.33333
20	ປັດອງເຂົ້າສານ	<i>Macaranga denticulata</i> (Blume) Müll.Arg.	Euphorbiaceae	1	1	3.33333	2.32558	33.33333
21	ໄມ້ແທ້	<i>Dinochloa malayana</i> S.Dransf.	Graminae	1	1	3.33333	2.32558	33.33333
TOTAL		21 species		43		143.33333	100.00	1133.33333

Table 3b The density of plant families of the Bamboo Forest

No	Family name	No species	No records	Di	RDi
1	Ulmaceae	1	9	30.00000	20.93023
2	Dipterocarpaceae	3	7	23.33333	16.27907
3	Graminae	2	4	13.33333	9.30233
4	Sapindaceae	1	2	6.66667	4.65116
5	Meliaceae	2	4	13.33333	9.30233
6	Lauraceae	1	2	6.66667	4.65116
7	Ebenaceae	2	3	10.00000	6.97674
8	Lecythidaceae	1	2	6.66667	4.65116
9	Fabaceae	1	2	6.66667	4.65116
10	Sterculiaceae	2	3	10.00000	6.97674
11	Apocynaceae	1	1	3.33333	2.32558
12	Fagaceae	1	1	3.33333	2.32558
13	Euphorbiaceae	2	2	6.66667	4.65116
14	Lythraceae	1	1	3.33333	2.32558
TOTAL	14 families	21	43	143.33333	100

e) *Karts Forest*: the both tables below show the density of tree species and tree families in the kart forest that was found on the top hill of Phou Changking. Total of 2 sampling plots were studied and 40 tree species records of 8 families and 11 species. (Table 4a and table 4b)

Table 4a the plant species density of karts forest

Ref. #	Local name	Scientific name	Family name	No records	No plot	Di	RDi	RFi
1	ແຄນຫິນ	<i>Hopea ferrea</i> Pierre	Dipterocarpaceae	14	2	70	35	700
2	ໄມ້ໝູນ	<i>Diospyros cf. curranii</i> Merr.	Ebenaceae	13	2	65	32.5	650
3	ໄມ້ໝູນ	<i>Diospyros malabarica</i> (Desr.) Merr.	Ebenaceae	4	2	20	10	200
4	ໄມ້ນ້ຳກຽງ	<i>Mangifera longipetiolata</i> King	Anacardaceae	2	2	10	5	100
5	ຍາງຂາວ	<i>Dipterocarpus alatus</i> Roxb.	Dipterocarpaceae	1	1	5	2.5	50
6	ຍາງແດງ	<i>Dipterocarpus costatus</i> C.F.Gaertn.	Dipterocarpaceae	1	1	5	2.5	50
7	ຄຳມ່າ	<i>Saraca indica</i> L.	Fabaceae	1	1	5	2.5	50
8	ກີ່ກຽງ	<i>Lithocarpus elegans</i> (Blume) Hatus. ex	Fagaceae	1	1	5	2.5	50
9	ດູກໄກ່	<i>Prismatomelis tetandra</i> (Roxb.) Merr.	Rubiaceae	1	1	5	2.5	50
10	ໝາມຂີ້ແຮ	<i>Streblus taxoides</i> (Roth) Kurz	Moraceae	1	1	5	2.5	50
11	ໝາກແງວ	<i>Nephelium lappaceum</i> L.	Sapindaceae	1	1	5	2.5	50
TOTAL			11 species	40	15	200	100	2000

Table 4b the plant family density of karts forest

No	Family name	No species	No records	Di	RDi
1	Ebenaceae	2	17	85	42.5
2	Dipterocarpaceae	3	16	80	40
3	Anacardaceae	1	2	10	5
4	Fabaceae	1	1	5	2.5
5	Fagaceae	1	1	5	2.5
6	Rubiaceae	1	1	5	2.5
7	Moraceae	1	1	5	2.5
8	Sapindaceae	1	1	5	2.5
TOTAL	8 Families	11	40	200	100

5.4 Plant habit density:

The composition of key tree species in Bane Chalou Area which are 630 records of tree, and that of sapling, seedling and Bamboo are 200, 63 and 32 records respectively were recorded. For tree species diversity in this area, nine hundred twenty five tree records that are 36 families and 81 tree species were classified and recorded. Their important quantitative such as density of trees, density of saplings, density of seedlings, basal areas, timber volumes, relative densities, relative dominants, relative frequencies and important value indexes were analyzed.

Table 5 Plant habit density at Chalou area.

Item	Number of records	Number of families	Number of species	Number of records of tree habits			
				Tree	Sapling	Seedling	Bamboo
TOTAL	925	36	81	630	200	63	32

5.4.1 Tree density: Six hundred thirty records of tree species in Bane Chalou area were noted. Twenty four families and 47 species were identified and density analyzed. The top five high density of tree species are ກີ່ກຽງ *Dipterocarpus costatus* C.F.Gaertn. (Dipterocarpaceae), ກີ່ເປືອຍດອກຂາວ *Lagerstroemia calyculata* Kurz (Lythraceae), ກີ່ເປືອຍເປືອກແດງ *Lagerstroemia floribunda* Jack (Lythraceae), ໄມ້ຫວ້າດົງ *Sygygium* sp. (Myrtaceae) and ໄມ້ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae) with its densities value 23.82; 23.82; 16.47; 15.58 and 12.94 respectively. Their local names, scientific names, family names, Ni = number of number records of particular tree species,

Np: number of plots that particular tree species occur, Di : Density of particular tree species (no/ Ha), SUM Vi : Total of basal area of particular tree species (m²/Ha), SUM Bi: Total of timber volume of particular tree species (m³/Ha), RD_i = Relative Density, RB_i = Relative Dominant, RF_i: Relative Frequency and their IVI_i : Important value Index were supplied in Annex 9a-9b

In the other hand, the five high density tree family are ຕະກູນໄມ້ຍາງ Dipterocarpaceae, ຕະກູນໄມ້ເປືອຍ Lythraceae, ຕະກູນຖົ່ວ Fabaceae, ຕະກູນໄມ້ຫວ້າ Myrtaceae and ຕະກູນໄມ້ຄາຍໂສ້ Theaceae respectively. Their local names, scientific names, number of species, number (records) of particular tree families, number of plots that particular tree families occur, density of particular families (no/ Ha), relative density and their relative frequency were supplied in Annex 9c.

5.4.2 *Sapling density*: Three hundred ninety six records of tree sapling species in Bane Chalou area were noted. Thirty families and 56 species were identified and density analyzed. The top five high density of tree species are ນົມຍານ *Barringtonia longipes* Gagnep. (Lecythidaceae); ຂີ້ໜອນຄວາຍ *Gironniera nervosa* Planch. (Ulmaceae); ໄມ້ໝູນ *Diospyros malabarica* (Desr.) Kostel. (Ebenaceae); ຫວ້າດົງ *Sygygium* sp. (Myrtaceae); ຂີ້ໝູ *Callerya atropurpurea* (Wall.) Schot (Fabaceae); ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae); ແຄຫອມ *Cinnamomun* sp. (Lauraceae); ແຄນຫີນ *Hopea ferrea* Pierre (Dipterocarpaceae); ຕາເສືອ *Aglaia lawii* (Wight) C.J.Saldanha ex Ramamoorthy (Meliaceae) with its densities value 10.00; 7.05; 6.76; 6.17; 6.17; 5.29, 4.41; 3.82 and 3.82 respectively. Their local names, scientific names, family names, Ni = number of number records of particular tree species, Np: number of plots that particular tree species occur, Di : Density of particular tree species (no/ Ha), RD_i = Relative Density and their RF_i: Relative Frequency were supplied in Annex 10a

In the other hand, the five high density tree family are Fabaceae, Ebenaceae; Lecythidaceae; Euphorbiaceae and Meliaceae respectively. Their local names, scientific names, number of species, number (records) of particular tree families, number of plots that particular tree families occur, density of particular families (no/ Ha), relative density and their relative frequency were supplied in Annex 10b.

5.4.3 *Seedling density*: 202 records of tree sapling species in Bane Chalou area were noted. 18 families and 27 species were identified and density analyzed. The highest density of seedling is ກະຈະ *Erythrophleum fordii* Oliv. (Fabaceae) with large value of density 4852.94 that is more than other species 3 times. The other high density are ເປືອຍຄອກຂາວ *Lagerstroemia calyculata* Kurz (Lythraceae); ແຄນຫີນ *Hopea ferrea* Pierre (Dipterocarpaceae), ຍາງແດງ *Dipterocarpus costatus* C.F.Gaertn. (Dipterocarpaceae), ໄມ້ໝູນ *Diospyros malabarica* (Desr.) Kostel. (Ebenaceae) with its density value 1470.58; 1323.52; 1176.47 and 1102.94 respectively. Their local names, scientific names, family names, Ni = number of number records of particular tree species, Np: number of plots that particular tree species occur, Di : Density of particular tree species (no/ Ha), RD_i = Relative Density and their RF_i: Relative Frequency were supplied in Annex 11a

In the other hand, the five high density tree family are Fabaceae; Dipterocarpaceae; Lythraceae; Ebenaceae and Sapindaceae respectively. Their local names, scientific names, number of species, number (records) of particular tree families, number of plots that particular tree families occur, density of particular families (no/ Ha), relative density and their relative frequency were supplied in Annex 11b.

5.4.4. *Bamboo density*: Of total 5 species of bamboo were found in Bane Chalou area. Number of clumps and number of stems per clump were noted. The highest density is ໄມ້ເຮັຍ *Schizostachum virgatum* (Munro) H.B.Nathani & Bennet with its density value 57.35 clumps/Ha or at 1681.01 stems / Ha (Table 6)

Table 6 the density of bamboo in Bane Chalou area

No	Name	Scientific Name	Family	No. of clump	Everage No. of stems/culm	Total no. of stems of particular bamboo species	Di Density of particular species (No clumps/Ha)	Dii. Density of particular species (No stems/Ha)
1	ໄມ້ເຮັຍ	<i>Schizostachum virgatum</i> (Munro) H.B.Nathani & Bennet	Graminae	195	29.31	5715.45	57.35294	1681.01471
2	ໄມ້ແທ້	<i>Dinochloa malayana</i> S.Dransf.	Graminae	36	4.8	172.8	10.58824	50.82353
3	ໄມ້ກາຍແສນ	<i>Neohouzeana mekongensis</i> Buse	Graminae	32	12.5	400	9.41176	117.64706
4	ໄມ້ຊອດ	<i>Pseudostachyum polymorphum</i> Munro	Graminae	29	12.75	369.75	8.52941	108.75000
5	ໄມ້ພາງ	<i>Dendrocalamus longifimbriatus</i> Gamble	Graminae	9	13	117	2.64706	34.41176
TOTAL			5 species	301	14.472	4356.072	88.52941	1992.64706

6. Other observations and Recommendations:

Threats are illegal logging of valuable timber trees inside the NPA, the forest fires which seem to occur in small area, Almost all these fires are set by people for providing grazing and facilitate hunting.

For follow-up it is recommended to do more develop baseline data on the densities of indicator species, secondly, satellite image interpretation is very important tool to combined with field observations to determine the distribution of the forest types throughout the Hin Nam No NPA and thirdly, more plant inventory studies and more botany surveys are desired to capture all the unknown plant species likely to be hiding inside Hin Nam No NPA.

Vientiane, 2 April 2015

Dr. Vichit Lamxay

