BIODIVERSITY IN PHONG NHA - KE BANG AND HIN NAM NO

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The Nature Conservation and Sustainable Natural Resource Management in Phong Nha – Ke Bang National Park Region Project

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This is an output of the Nature Conservation and Sustainable Natural Resource Management in Phong Nha-Ke Bang National Park Region Project, Quang Binh Province, Vietnam (Phong Nha - Ke Bang Region Project)

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CONTENT

ABBREVIATION

asl	Above sea level
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DARD	Department of Agriculture and Rural Development
DBH	Diametre at breast hight of tree
DoFRM	Department of Forest Resources Management (in Laos)
FFI	Fauna & Flora International
GIZ	*Deutsche Gesellschaft fuer Internationale Zusammenarbeit* (GIZ)-GmbH-German Technical Cooperation
HNN NCA	Hin Nam No National Conservation Area
HNN Region Project	The Integrated Nature conservation and Sustainable resources Management in the Hin Nam No Region Project
IBA	Important Bird Area
IUCN	The World Conservation Union (International Union for Conservation of nature)
KfW	*Kredit Anstalt für Wiederaufbau*-German Development Bank
MARD	Ministry of Agriculture and Rural Development
NCA	National Conservation Area
NR	Nature Reserve
NP	National park
NTFP	Non-timber forest product
PDR	People's Democratic Republic
PNKB NP	Phong Nha - Ke Bang National Park
PNKB-HNN Region	Phong Nha Ke Bang - Hin Nam No Region (Phong Nha - Ke Bang National Park and Hin Nam No National Conservation Area)
PNKB Region Project	The Nature Conservation & Sustainable Natural Resource Management in Phong Nha – Ke Bang Region Project, Vietnam
PPMU	Provincial Project Management Unit
RRS	Restricted Range Species
UNESCO	United Nations Educational, Scientific and Cultural Organization
VNRB	Red Data Book of Vietnam (2007)
VRTC	Vietnam - Russian Tropical Centre
WCS	Wildlife Conservation Society
WWF	World Wide Fund for Nature

INTRODUCTION

Phong Nha Ke Bang - Hin Nam No Region (PNKB-HNN region) comprises Phong Nha - Ke Bang National Park (PNKB NP) in Quang Binh Province, Vietnam and Hin Nam No National Conservation Area (HNN NCA) in Khammouane Province, Lao PDR. The region is among the world largest limestone conservation landscapes. The total area of landscape reaches about 317,754 ha and most of which is covered by primary forests (https://en.wikipedia.org/...). The PNKB-HNN region is recognized as the most important global ecoregion within Great Annamite Range (Batzer et al. 2001). It contains the universal outstanding values on biodiversity and high diversity of flora and fauna including many karst-specialist species, endemic species and large quantity of globally endangered species.

PNKB NP (123,326 ha) was first recognized as a World Heritage Site by the UNESCO World Heritage Committee in 2003 under category VIII: outstanding universal geological, geomorphic and geographic values. In 2015, PNKB NP was second time inscribed on the World Heritage List for its outstanding universal values on on-going ecological and biological processes (category IX) and biodiversity conservation importance (category X). HNN NCA (88,500 ha) also has an outstanding universal values on geomorphology, biodiversity and high potential of ecotourism development in near future. The area can meet all criteria to be designated as an UNESCO Natural World Heritage Site and the Lao Government is seeking this recognition to underscore the national and international significance of this conservation area (DoFRM, 2015).

The Nature Conservation & Sustainable Natural Resource Management in PNKB NP Region Project, Vietnam, KfW component (PNKB Region Project), aims to improve the management of PNKB NP and reduce the pressure on its natural resources. The Project is cooperation between Quang Binh Provincial People Committee (PPC) and Germany. The project owner is the Quang Binh PPC. It is funded through the German Development Bank KfW (financial cooperation) and GIZ (technical cooperation). On behalf of the Project owner, the Project Management Unit (PMU) manages the Project. The two components of KfW and GIZ jointly support the PMUt in project coordination and implementation. GIZ's responsibility is mainly in technical cooperation, leading buffer zone and tourism planning. KfW's responsibility is largely investment, complementing and scaling up GIZ's pilot projects and plans, in addition to leading the development of a management plan for PNKB NP, investments in park infrastructure, equipment, law enforcement training, etc., and complementary technical assistance to improve management, in particular law enforcement. The Project has already produced several planning documents such as "National Park Strategic Management Plan 2013-2025", "National Park Operational Management Plan 2013-2020", "Buffer Zone Development Plan 2013-2025" etc. In 2010 – 2011, the PNKB Region Project supported PNKB NP to conduct biodiversity surveys at the extension area of the park with the participation of international and national scientists and conservationists. These surveys provided relevant biodiversity information including distribution of precious species and maps of biodiversity hotspots in the PNKB NP.

A book of Meijboom and Ho Thi Ngoc Lanh (2002) entitled "*Flora and Fauna of Phong Nha Ke Bang and Hin Nam No*" published by WWF funded Project "Linking Hin Nam No and Phong Nha Ke Bang through parallel conservation" compiled scientific data/information obtained by biodiversity surveys in PNKB-HNN region before 2000. The content of the book is relatively simple, lacks many scientific information and now mainly outdated. Updating and re-editing this book based on the biodiversity survey results in PNKB-HNN region conducted after 2000 is very crucial and necessary for both protected areas and science.

New book "*Biodoversity in Phong Nha - Ke Bang and Hin Nam No*" inherited still useful biodiversity data from the book of Meijboom and Ho Thi Ngoc Lanh (2002) and updated new data from biodiversity surveys conducted in PNKB NP and HNN NCA during period of 2000-2015. This document will be used by two protected areas in activities relevant to transboundary cooperation programme and other separate activities in each protected area. The book provides abundant data/information on biodiversity including many species the first described for science.

As the book compilers, Associate Prof. Dr. Nguyen Xuan Dang and MSc. Nguyen Xuan Nghia are responsible for compiling fauna related content, while Dr. Nguyen Tien Hiep and Dr. Nguyen Quoc Dzung are responsible for compiling vegetation and flora related content. Important contribution to the book editing are given by Dr. Vu Dinh Thong, Dr. Nguyen Quang Truong from Institute of Ecology and Biological Resources, Mr. Le Trong Trai from Viet Nature Conservation Centre, Associate Prof. Dr. Nguyen Huu Duc from Centre for Resources, Environment and Climate Change, Mr. Nguyen Trung Thuc, Director of the PNKB Region Project, Mr. Bernd Unger, Chief Technical Advisor KfW component, Mr. Nguyen Van Tri Tin, Deputy Chief Technical Advisor KfW component, Mr. Dinh Huy Tri, Deputy Director of PNKB NP and Mr. Sisomphone Southichack, Director of HNN BCA.

For the book compilation, we selectively use biodiversity data/information from various sources including un-published and published reports, books and articles from various scientific journals. Out of which published documents, especially most recent publications are more preferred.

An important part of the book are the lists of plant and animal species recorded in PNKB-HNN region which present as annexes. On the lists of animal species, the animal records are divided into 2 types: confirmed (C) and un-confirmed (U) records. Confirmed records include records by animal specimens or animal parts, direct sighting of the animals in the wild and observation of un-mistakenly identifiable activity signs (tracks, feces, dens, etc.) of some species. Other records such as interview data, observation of animal specimens in markets or in villages etc. are treated as un-confirmed record. Similarly, on the lists of plant species, the records are divided into two types: records accompanied by museum vouchers (S) and records without museum specimens (+).

Conservation status of each species are identified using following documents: for globally threatened status use: 1) IUCN Red List of Threatened Species (IUCN, 2015) with four threatened categories: Critically endangered (CR), Endangered (EN), Vulnerable (VU) and Near Threatened (NT); 2) CITES Appendices I and II valid from 5 February 2015. Appendix I includes species threatened with extinction; trade in specimens of these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival (https://cites.org/eng/disc/how.php).

For the national threatened status in Vietnam use: 1) Red Data Book of Vietnam in 2007 with four threatened categories: Critically endangered (CR), Endangered (EN), Vulnerable (VU) and Low Risk (LR); 2) Decree 32/2006/NĐ-CP, dated 30 March 2006 of Vietnam Government on management of endangered, rare and precious species of plant and animal species. The Decree includes two groups I and II: group IA includes plant species and group IB include animal species in strict ban of their utilization for commercial purposes. Group IIA includes plant species and group IIB includes animal species in restrictive utilization for commercial purposes. 3) Decree 160/2013/NĐ-CP, dated 12/11/2013 of Vietnam Government on the criteria for selection and management regulations of species under the List of endangered, rare and precious species of protection priority. The Decree includes Appendix I - List of endangered, rare and precious species of conservation priority.

For the nationally threatened status in Laos, we use status ranking system developed for wildlife in Lao by Duckworth et al. (1999) Wildlife in Lao PDR: 1999 status report. Vientiane, Bangkok. This system comprises 4 threatened categories: ARL: At Risk in Laos, CARL: Conditionally At Risk in Laos (used only for reptiles and mammals), LKL: Little Known in Laos, PARL: Potentially At Risk in Laos.

Finally, we would like to note that PNKB-HNN region is very large with very complicated and restrictively accessible terrain. To date, available biodiversity surveys have not yet accessed to many remote areas of rich biodiversity in the region. Therefore, this document is not a comprehensive database of biodiversity in PNKB-HNN region. It is expected that future biodiversity surveys will reveal more abundant data on the Region's biodiversity, and then, this book must be updated to provide more comprehensive database of PNKB-HNN biodiversity.

PART 1

BRIEF BIO-PHYSICAL AND SOCIO-ECONOMIC FEATURES IN PHONG NHA KE BANG AND HIN NAM NO

1.1 PHONG NHA - KE BANG NATIONAL PARK

Phong Nha Protected Forest (5,000 ha) was established in 1986. The Protected Forest was revised to Phong Nha Nature Reserve (41,132 ha) in 1993 and to PNKB NR (85,754 ha) in 2001. In 2013, the Park boundary was again revised to enlarge the Park's area to 123,326 ha. At the 27 meeting of the World Heritage Committee, dated 5 July 2003, PNKB NP was recognized as an UNESCO World Heritage Site because it satisfies World Heritage Natural Criterion VIII on Geomorphology and Earth History (as an outstanding example representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features). At the 39 meeting of the World Heritage Committee, dated 3 July 2015, PNKB NP was second time inscribed on the UNESCO World Heritage List for satisfying Criterion IX (as an outstanding example representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals) and Criterion X (as containing the most important and significant natural habitats for *in-situ* conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation).

Following description of bio-physical and Socio-economic features of PNKB NP are taken from "Operational management plan 2013 to 2020 - Phong Nha - Ke Bang NP, The Nature World Heritage Site" (Le Trong Trai et al. 2012).

1.1.1 Bio-physical features

The PNKB NP is located in western part of Bo Trach and Minh Hoa Districts, close to international border with Laos, covering administrative territory of 13 communes of 3 districts (Bo Trach, Minh Hoa and Quang Ninh districts). The Park's headquarter is located in Son Trach commune, Bo Trach District, Quang Binh Province, 50 km north east of Dong Hoi Provincial Town. The PNKB NP has coordinates bound within: $17^0$44.671' N; $105^0$49.381'E to $17^0$22.334' N, $106^0$04.555' E; and $17^0$27.002' N; $106^0$23.250' E to $17^0$40.522' N; $105^0$46.731' E.

PNKB NP is situated in one of the largest continuous limestone karst areas in Indochina which also includes Hin Nam No NCA in Laos - the Central Indochinese Limestone. This limestone massif is located in a transitional zone between northern and central Annamite Mountains. The topography of the NP is characterized by precipitous karst ridges, which rise to elevations of around 400 m. Scattered among these ridges are narrow valleys and pockets of igneous rock formations.

PNKB NP comprises a wide deeply dissected plateau of some 200,000 ha, extending into HNN area in Laos. Its geological history is traced back to the late Ordovician-early Silurian period around 460-400 million years ago. The limestone is discontinuous, being interblended with shales and sandstones and capped by schists and granites, rising to a number of unexplored peaks over 1,000 m high. The extensive transitional landforms derive from an extremely complicated intercalation of limestone massifs and terrigenous terrain which has produced three distinctive types of topography. Two third of PNKB NP is Cenozoic karst. A small main area is of mainly Mesozoic karst. A third area is a non-karstic landscape of low

round-topped mountains of intrusive rock with planation surfaces and abrasion-accumulation terraces along the valleys of the Son, and Chay rivers and on the margins of the central limestone massif.

Son Doong cave, on the Son river, running underground at least 5 km by 150 m wide and 200 m high is now famous as the world's largest cave. It possesses beautiful sand beaches and spectacular spleothems. Phong Nha cave, with surveyed length of 7.73 km and 14 grottoes, is the best known. Its entrance is the last stretch of the underground Chay river, a tributary of the Son which itself flows underground for 20 km. Two beautiful caves, Thien Duong and Tien Son, are nearby. Other extensive caves include Vom cave system, 15 km long and the Hang Khe Rhy cave system,18.9 km long.

Phong Nha - Ke Bang also contains two dozens of mountain peaks with over 1,000 m in height (https://en.wikipedia.org/...). The highest of them are Peak Co Preu with a height of 1213 m asl., Phu Tao (1174 m), Co Unet (1150 m) and Peak Co Rilata (1128 m). Mountains of karstic area of the Park rise at typical height of above 800 m constitute a continuous range along Laotian-Vietnamese border. Notable summits here above 1000 m are: Phu Canh (1095 m), Phu Mun (1078 m), Phu Tu En (1078 m), Phu On Chinh (1068 m), Phu Dung (1064 m), Phu Tu Oc (1053 m), Phu Long (1015 m), Phu Oc (1015 m) and Phu Dong (1002 m). Inserting into these summits are many lowest peaks 800 - 1000 m high, like summits of Phu Sinh (965 m), Phu Co Tri (949 m), Phu On Boi (933 m), Phu Tu (956 m), Phu Toan (905 m), Phu Phong (902 m) and Phu Ma Ma (835 m). Non-karstic area consists a smallest portion of the PNKB NP territory, distributing mainly in outer circle of limestone in the north, northeast and southeast of the national park. The height of these summits usually varies from 500-1000 m. Here there are narrow valleys along streams and rivers, such as Am, Cha Lo, Chut Ngut and Rao Thuong river valley in the southernmost edge. In the north-south direction, there exist notable summits: Phu Toc Vu (1000 m), Ma Tac (1068 m), Co Khu (886 m), U Bo (1009 m) and Co Rilata (1128 m). The highest summit in the non-limestone area and also the highest summit of PNKB NP is Co Preu (1213 m), a summit in the southernmost edge of the park.

The climate in PNKB NP is tropical, hot and humid. The annual mean temperature ranges between 23°C and 25°C. Summer maximum temperature is 41ºC and winter minimum of 6°C. The hotest months are from June to August, with a mean of 28°C; the coldest months are from December to February with a mean of 18°C. The high annual rainfall averages 2,000 - 2.,500 mm, 88% falling between July and December, though there is rain in every month and on 160 days a year. The mean annual relative humidity is 84%.

PNKB NP contains the catchment area of many but not all of the streams and rivers that feed the Gianh river. Flooding of the valleys occurs between September and November, but in the dry season from February to August almost all of the streams dry up. Because of the limestone topography, drainage is complex and there are few permanent water courses. There are, however, the Chay and Trooc rivers, all of which are fed by underground streams, which emerge from the En, Vom, Toi and Phong Nha Cave systems. All three rivers flow into the Gianh river, which empties into the East Sea. The whole catchment might be generated in HNN NCA area in Laos.

PNKB NP is an important part of Global 200 priority ecoregion, The Greater Annamites. This is a large intact area with rich biodiversity of global conservation importance (Baltzer et al., 2001). PNKB NP also lies within the Indo-Burma Biodiversity Hotspot. The Park covers territory of 2 Important Bird Areas: Phong Nha and Ke Bang. It is also situated in the Annamese Lowlands Endemic Bird Area (Stattersfield et al. 1998). The forest coverage of PNKB NP is very high. The results of the interpretation of remote sensing data show that the forest coverage is 96.2% of the total area of the Park (Le Xuan Canh et al. 1997). The

limestone karst is almost entirely forested, apart from steep cliff faces. The only clearance of forest has been in flat valleys within the limestone massif, and in lowland areas bordering it. The most widespread forest type is limestone forest, but there are also significant areas of lowland evergreen forest distributed on non-calcareous substrates in valleys among the limestone karst. Limestone karst of PNKB NP supports an area of 500 ha of limestone forest above 700 m with dominant unique plant formation of *Calocedrus macrolepis*, a large coniferous tree that is endemic species to limestone areas (Averyanov et al. 2004) and enlisted in 2015 IUCN Red List.

Up to date, 2,804 species of vascular plants were recorded from PNKB NP, of which 116 species are at national and 84 species at globally threatened categories and many endemic plant species to PNKB area or Indochina. A total of 725 species of vertebrate animals were recorded from PBKN NP including 143 mammal species, 303 bird species, 107 reptile species, 56 amphibian species and 117 fish species (see part 3 for details). Out of 725 recorded animal species, 75 species are listed in Red Data Book of Vietnam in 2007, 68 species are listed in 2015 IUCN Red List of Threatened Species (IUCN, 2015) and 30 species are endemic species to Vietnam, Indochina or restricted range species.

1.1.2 Socio-economic features

In core zone of PNKB NP there are 2 villages of Tan Trach commune, Bo Trach district. Ban Doong (Doong village) is the smallest village of 6 households and Doong community belongs to ethnic Van Kieu group. Second village is of Arem community, Vietnam's smallest ethnic minority group numbering some 307 individuals in 79 households and that making up the smallest ethnic minority groups in Vietnam. The buffer zone of PNKB NP consists of 13 communes, and is a home of over 15,000 households of 65,000 individuals. The population density is varied: along the main road, villages or communes are more populated than in the remote areas adjacent to Vietnam-Laos border. All communes in buffer zone are very poor and listed as a priority for various economic development programmes such as: programme 135 (infrastructure upgrading), programme 661 (forest plantation and regeneration), Central Poverty Reduction Project (supported by the Asian Development Bank), etc. At present, the Nature conservation and Sustainable Management of Natural Resources in Phong Nha - Ke Bang NP Region Project funded by Vietnamese Government and the German Bank (KfW) is supporting the commune economic development.

PNKB NP is not only famous for its cave system, beautiful landscape and high biodiversity but it is also famous for the minority groups living in the area. Besides the Kinh (Majority Vietnamese) ethnic group, there area 2 main ethnic groups: Van Kieu and Chut. Bru-Van Kieu ethnic group has the largest population of all the ethnic groups living in the Northern Annamite Mountain Range (except Kinh group). The Bru - Van Kieu belongs to the Mon - Kho Me language group, a group native to Indochina, which includes groups such as the Van Kieu, Khua, Ma Coong, Tri and So. Among them, the Van Kieu is largest and most widely distributed in the Annamite Mountain Range. The Tri and Ma Coong ethnic groups are distributed in Thuong Trach and Tan Trach communes, Bo Trach district and Laos. The Khua ethnic group is mostly distributed in Dan Hoa commune, Minh Hoa district. Chut ethnic group includes many ethnic sub-groups such as Sach, May, Ruc and Arem. The Arem are located inside the Park in Village 39, Tan Trach Commune while the Ruc are located in the Bufffer zone, Thuong Hoa Commune. The Arem and Ruc are not only the smallest groups of the Chut ethnic minority but also 2 smallest groups in Vietnam. They live isolated from other communities in the limestone karst area. In 2006, the Arem groups consisted of only 202 people and Ruc group consisted of only 322 people. The Arem and Ruc have their own distinct languages, which are parts of Viet-Muong branch of the Mon-Khmer language family. Since 1992, the Arem and Ruc people started to live in houses. In the past, they

preferred to move around deeply within the forest, dwelling in caves, trees or temporary shacks. The Ruc and Arem were the last groups of people to start building houses in the 1960's.

1.2 HIN NAM NO NATIONAL CONSERVATION AREA

HNN NCA was established in 1993, total area of 88,500 ha. HNN NCA together with PNKB NP forms a sizable proportion of the largest karst landscapes in Southeast Asia. Due to its high geological and biodiversity value of international significance, the absence of villages inside the protected area boundary, and its high medium-term potential for tourism development within a complex of protected areas within Khammouane province, Hin Nam No meets criteria to be designated as an UNESCO natural World Heritage Site and the Lao Government is seeking this recognition from UNESCO. The following information on bio-physical and Socio-economic features are cited from "Hin Nam No National Protected Area Co-management Plan (2016-2020)" (DoFRM, 2015).

1.2.1 Bio-physical features

HNN NCA (88,500 ha) is one of three national protected areas situated in Khammouane Province, Lao PDR. The NCA itself is situated some 135 km due east from Thakhek City along Route 12. The south-western boundary is partially defined by the Xe Bang Fai River. The south-eastern boundary is defined by Route 20. The NCA is also contiguous with PNKB NP on the east, along Vietnam-Laos border. HNN NCA is situated between latitude 17º 14' 28.14" and 17º40'35.15" N and between longitude 105° 42'28.66" and 106° 1'20.87" E.

The characteristic landscape style of the Hin Nam No karst is that of a dissected plateau of karst massifs that are almost completely bordered by bare limestone walls or cliffs rising up to 500 m above intervening alluvial plains and flat-bottomed basins. The limestone massifs have been eroded into a classic fengcong karst of clustered cones, with steep cones and pinnacles together with deep fissures and dolines on the summit surfaces, making them virtually inaccessible. The highest peak in HNN NCA is Phou Chuang mountain (1492 m asl), which is located in the north of the NCA. The limestone of HNN NCA is not totally bare rock; mostly it is forested, particularly from the mid-level of the limestone mountains down to the foothills. Limestone characters are observed as bare rocks on top, and with some bushes. Small and medium trees can be found at the mid-level, depending upon the gradient. However, large trees can be found in the high mountains, where there is more soil. In the foothill areas, there are large trees with an average height of 25 m (highest at 45m). Limestone formations are found connecting to each other at various densities and at different sizes and height levels. Generally, all areas in Hin Nam No are forested except for the upper limestone hills and a block of 10 by 10 km of pure karst rocks in the north-western corner of the NCA. The allochtonous water of the Xe Bang Fai River has cut a 6.4 km underground course through the limestone karst, creating one of the largest active river cave passages in the world. The active river passage averages 76 m in width and 53 m in height, with a maximum width of 200 m and a maximum height of 120 m.

HNN NCA is in the Southeast Asia monsoon climate regime. The southwest monsoon begins in May, reaches its maximum strength in August with very frequent and heavy rain. The southwest monsoon disappears about mid-October and the climate then cycles through a transition period to mid-November when the northeast monsoon appears. Rainfall becomes very infrequent and light. The rainfall accounts for about 4% of annual rainfall, the air is cool, and the humidity lower. The northeast monsoon lasts until the end of February when the hot and dry transition period begins. In 2007, the annual rainfall was 1,480 mm, following the general pattern of the Southeast Asia monsoon. The average annual temperature is 25.7°C (with temperature ranging from 11 – 40°C). In addition to the monsoons, the HNN NCA is

occasionally visited by typhoons and tropical depressions. The peak of the typhoon season in the central region of Lao is generally September and October. The typhoons form over the East Sea and move westward to Vietnam, lift over the Annamite mountains and pass on to the Hin Nam No massif.

Most rivers in Hin Nam No are seasonal and considered inactive streams during the dry season. Nevertheless, the areas which have water sources throughout the year include Phou Chuang (height of over 1,400m asl), Pa Xong, Khoun Ka-arn, Nam Masai, and Nam Kaloc. The Xe Bang Fai River itself is the south western boundary of HNN NCA, not the watershed boundary to the west. Upper catchment of the Xe Bang Fai River lies outside of the NCA boundary.

HNN NCA is of global significance for the conservation of biodiversity because its variety of habitats and forest types provided by the landscape geomorphology support a high diversity of animals and plants, including a number of globally threatened species, endemic species and karst specialist species. HNN NCA is situated where the Central Indochina Limestone meets the Annamite Mountains. The property lies within the boundaries of the Northern Annamites Rain Forest Ecoregion, one of the Global 200 Ecoregions considered most crucial to the conservation of global biodiversity. More specifically, within this ecoregion, the Central Indochina Limestone has been identified as a priority landscape which is critical and globally significant for the conservation of primate species and limestone specialist species (Baltzer et al. 2001).

HNN NCA has many forested areas (about 70%). However, so far little information is available on the spatial distribution of the various forest types. Forests are not well developed only in those areas where the limestone is at the surface or the cliffs are too steep; these localities have a negative impact on the number of indicator species recorded in those areas. In total, 11 major habitat types have been identified in HNN NCA, including seven forest habitats, bare rock (or sparse, stunted forest on limestone), two wetland habitats, and cave habitats.

Little is known about the diversity of plants in the HNN NCA. Surveys of surface habitats in Hin Nam No have recorded 452 vascular plant species during a floral surveys in 1998 (Walston et al., 1999). A list of 67 indicator species was drawn up and six forest types were distinguished by a recent flora survey: semi-evergreen forest; mixed deciduous forest; degraded forest; bamboo forest; riverine forest; and karst forest. More recent inventory (see Part 2) has recorded 567 vascular plant species, of which 116 species are of conservation priority. The faunal surveys in Hin Nam No have recorded 377 vertebrate species including 55 mammal, 184 bird, 21 reptile, 21 amphibian and 96 fish species. Of these, 37 species are of conservation priority, with 11 of these being globally threatened. The latest inventories (see Part III) has recorded about 500 vertebrate species including 75 mammal, 262 bird, 43 reptile, 20 amphibian and 100 fish species. Of these, 95 species are of conservation priority including 48 mammal species, 18 reptile and amphibian species and 7 fish species.

Most notably, HNN NCA contains seven species of primate, five of which are globally threatened. The Red-shanked Douc *Pygathrix nemaeus* and the Southern White-cheeked Gibbon *Nomascus siki* are charismatic 'flagship' species of HNN NCA. More recently, new species of a flying squirrel *Biswamoyopterus laoensis* (Daosavanh et al., 2013), a bat *Hipposideros scutinares* (Robinson et al., 2003), a *gymnure Hylomys megalotis* (Jenkins and Robinson, 2002), a murid rodent *Saxatilomys paulinae* (Musser et al., 2005), a rat *Laonastes aenigmamus* belonging to a family of rodents thought to have been extinct 11 million years ago (Diatomyidae) were discovered in the Khammouane limestone region (Dawson et al., 2006; Jenkins et al., 2005)

Recent initial surveys of cave habitats in HNN NCA have recorded 70 faunal species, with seven of these being new species and five endemics, including a cave fish species *Bangana musaei* which is endemic and globally threatened. The caves of HNN NCA are also home to the Giant Huntsman Spider *Heteropoda maxima*, the world's largest spider by leg-span (DoFRM, 2015). Up to date, 261 taxa of cave animals belonging to 37 orders and 16 classes have been recorded. The cave fauna of the Hin Nam No NPA is the most diverse in Laos and probably in mainland Southeast Asia as well. As far as identified, it contains a high percentage of endemic species, many charismatic and scientific significant species, constituting an outstanding universal value for the area (Steiner 2016).

1.2.2 Socio-economic features

HNN NPA is located in Bualapha District, Khammouane Province. Bualapha District is on the border with Vietnam, and is one of the poorest districts in Laos. Ninety-three percent (93%) of the villages in the district are classified as poor according to Lao Government criteria. These include all of the 19 villages in the area immediately surrounding the protected area, whose approx. 8,000 inhabitants are almost exclusively members of ethnic minorities. The severe poverty of the population and their dependence on natural resources are causing heavy pressure on the area immediately in and around the protected area.

Nineteen (19) guardian villages with allocated management responsibilities in the HNN NCA which are part of five village clusters: Ban Dou and Langkhang (now counted together as Thongkham by the district), Khanyou, Nongping and Nongma. In total, 7,624 people lived in 1,493 households in these 19 villages in 2011, which increased to 8,099 persons in 1,570 households in 2014. The 19 guardian villages constitute 25.6% of the total population of Bualapha district (31,676 persons in 2014). Between 2011 and 2014 the population grew with an annual growth rate of 2.1% over the three year period. The ethnic groups in Bualapha district can be linguistically divided into three groups:

(a) *Tai-Lao group*: Phoutai, Yoi and Kaleung. Together, this group makes up 40% of the population of Bualapha district. These groups speak a similar dialect to the Lao language. Their livelihoods are based on paddy rice farming in valleys, which is the land with the best potential for agriculture. They are relatively well-off. They are mostly practicing the Buddhist religion. They are politically well connected and can represent their interests well with district government.

(b) *Mon-Khmer group*: Makong, Tri. Together, these groups make up 48% of the population of Bualapha. Their livelihoods were traditionally based on upland rice cultivation in a rotational slash-and-burn system. They are trying to adopt paddy field cultivation where possible in the hilly areas where they live. They are relatively very poor. They practice animism and are politically not well connected.

(c) Mixed Group: Nguan, Salang and others. Together, these groups make up 12% of the population of Bualapha. The mixed group is made up of people who have married between different ethnic groups. They usually speak Lao and are adhering lifestyles similar to that of the Tai-Lao group. They live just above the poverty line. The Nguan speak a dialect of Vietnamese. They are descendants from immigrants from Vietnam who arrived in Laos some 50 years ago. For their livelihoods, they depend on paddy rice farming and doing various types of business, e.g. boat and bus services. They are well connected politically and they are relatively very well-off. The Salang are a special group of people who used to live inside the forest of HNN NCA and were resettled outside the NCA boundaries. Their livelihoods used to be based on hunting and gathering. They are now trying to develop agriculture-based livelihoods. They are the most poor among all the ethnic groups.

PART 2

VEGETATION AND FLORA OF PHONG NHA -KE BANG AND HIN NAM NO

3.1 PHONG NHA - KE BANG NATIONAL PARK

3.1.1 Status of botanical study

During 1996-1997, under the support of WWF/RAS/93/102 Project, scientists from Institute of Ecology and Biological Resources, Forest Inventory and Planning Institute caried out biodiversity surveys in PNKB NP. Study of vegetation and flora in these surveys was conducted by Dr. Nguyen Ngoc Chinh, and the study results were reported in Le Xuan Canh et al. (1997). In 1999, Vietnam - Russian Tropical Centre (VRTC) conducted botanical and zoological studies in PNKB NP. Study of vegetation and flora was conducted by Dr. Kuznetsov and Dr. Phan Luong and the study resulds were reported in WWF-VRTC 1999. Meijboom and Ho Thi Ngoc Lan (2002) aggregated findings of these studies into a book "*Flora and fauna of Phong Nha-Ke Bang and Hin Nam No*" (published by WWF LINC Project). In this book, 13 forest types were described and a list of 1,436 vascular plant species were compiled for PNKB NP. However, many floral species in the list were not completely identified.

In 2005, Fauna & Flora International (FFI) supported surveys on inventory of orchid species and description of major species habitats and forest types found in PNKB NP (Averyanov et al., 2005). In 2011, with support of the "Conservation and Sustainable management of Natural resources in PNKB NP Region Project", the Centre for Plant Conservation carried out vegetation and floral studies in extension area of PNKB NP in Thuong Hoa and Hoa Son Commnes, Minh Hoa District, Quang Binh province. This study described 15 forest communities and recorded 598 species of vascular plants belonging to 386 genera and 127 families (Averyanov et al. 2012, Nguyen Tien Hiep et al. 2013). Results of botanical studies in PBKB NP are also can be found a number of publications such as Averyanov, Averyanova (2003); Averyanov et al., (2003a, b; 2004; 2005a, b, c; 2008),; Nguyen Tien Hiep et al., (2004); Averyanov (2008, 2011); Pham Van The, Averyanov (2011, 2012); Phan Ke Loc et al. (2005; 2011).

3.1.2 Vegetation

Tentative remote sensing data of 1995 showed that 96.2% of the PNKB NP territory was forest-covered, 92.2% in primary forest, much of it badly damaged by fire during the American war (Le Xuan Canh et al. 1997). After about 30 years under protection, the forests affected by war have been restored. About 75% of the park's forest cover is a dense wet tropical evergreen lowland forest on rock bellow 800 m; about 8.5% is evergreen tropical wet forests on limestone rocks at the elevation of above 800 m and 8.3% is evergreen tropical wet forest on soil mountains at the elevations of under 800 m (Averianov et al. 2012).

3.1.2.1 Major habitat types

Forest ecosystems in PNKB NP is little studied. Kuznetsov and Phan Luong first described 13 forest habitat types in specific topographic formations of PNKB NP (see details in Meijboom & Ho Thi Ngoc Lanh 2002):

a. Phong Nha area

1. Wide terraces on limestone slopes; Altitude (Alt.) 200-300 m (Coordinates 17°28'349; 106°12'698).

These terraces are 20 - 60 m wide and a few hundred meters long. The soil is formed by limestone mixed with sandstone and shale parent material. The soil is a clay soil mixed with road-metal material and is un-deep, roots can penetrate 30-50 cm deep. The surface of the soil is covered with leaf and twig litter layer. This litter layer contains also many thin tree roots. The vegetation is stratified in 3 to 4 different layers. The upper layer is well developed and has a closed canopy (height: 30-40 m; DBH: 60-110 cm). The forest has a polidominant and rich composition. Buttresses are common. The second layer and understorey layer are also well developed while the third layer is fragmented. There are numerous grasses/herbs, epiphytes, semi-epiphytes and lianas.

Upper (canopy) layer: Dominant species are *Hopea* (Dipterocarpaceae), *Litsea* (Lauraceae), *Elaeocarpus* spp (Elaeocarpaceae), *Canarium* (Burseraceae), *Xerospermum* (Sapindaceae) and cf. Chisocheton (Meliaceae). Other common species: *Cinnamomum* (Lauraceae); *Castanopsis, Quercus, Lithocarpus* (Fagaceae); *Tetrameles nudiflora* (Datiscaceae); *Diospyros* (Ebenaceae); *Dracontomelon* (Anacardiaceae); *Artocarpus, Ficus* (Moraceae); *Pterospermum* (Sterculiaceae); *Mangifera* (Anacardiaceae); *Garcinia* (Guttiferae); *Horsfieldia* (Myristicaceae); *Aglaia,* cf. *Dysoxylum* (Meliaceae).

Second layer: height: 15-20 m, DBH: 20-40 cm. Common species: *Streblus* (Moraceae), *Casearia* (Flacourtiaceae), *Knema* (Myristicaceae), *Hydnocarpus* (Kiggelariaceae), *Vitex* (Verbenaceae), *Baccaurea* (Euphorbiaceae), *Archidendron* (Fabaceae), *Syzygium* spp. (Myrtaceae) and *Elaeocarpus* (Elaeocarpaceae). Occasional: *Dillenia* (Dilleniaceae)

Third layer: height: 7-8 m; fragmented, trees grow some distance from each other or in small groups. Dominant species: *Helicia* (Proteaceae), *Ostodes* (Euporbiaceae), *Syzygium* (Myrtaceae), *Streblus* (Moraceae), *Eurya* (Theaceae). Other species: *Kydia* (Malvaceae), *Pavetta* (Rubiaceae), *Caryota* (Arecaceae).

Understorey layer: height:1-1.5m; well-developed. Common species: *Ardisia* (Myrsinaceae), cf. *Polyalthia*, cf. *Mitrephora* (Annonaceae); *Sterculia* (Sterculiaceae); *Lasianthus, Psychotria*(Rubiaceae), *Antidesma, Breynia* (Euphorbiaceae), *Licuala* (Arecaceae). Occasional: *Pinanga* (Arecaceae).

2. Slope with grades of 20 to 50º; Alt. 600m (Coordinates: 17°29'696; 106°13,354).

This area is characterized by sites covered with soil alternated with cliff exposure (karst or sandstone). The relief of the slopes is complex, consisting of small terraces and concavities of different sizes. The forest on steep slopes is stratified into two clear layers: the upper and understorey layers, the middle layer is absent or fragmented. The upper layer is characterized by a closed canopy at a height of 20-30 m (DBH: 40-80 cm). The understorey layer is formed by trees of 3-5 m height. The composition of grasses/herbs and lianas is very poor.

Upper (canopy) layer*:* Dominant specie: *Hopea* sp. (Dipterocarpaceae). Other tree species: *Vitex* (Verbenaceae); *Castanopsis* (Fagaceae), *Aglaia* (Meliaceae); *Mangifera* (Anacardiaceae); *Polyalthia* (Annonaceae); cf. *Canarium* (Burseraceae); *Pterospermum* (Sterculiaceae); *Cinnamomum*, *Litsea* (Lauraceae); *Elaeocarpus* spp. (Elaeocarpaceae); *Ficus*, *Artocarpus* (Moraceae); *Nephelium*, cf. *Xerospermum* and *Pometia* (Sapindaceae).

Middle layer (fragmented): Tree species: *Knema* (Myrsinaceae), *Syzygium* (Myrtaceae), *Casearia* (Flacourtiaceae), *Caryota* (Arecaceae), *Garcinia, Calophyllum* (Guttiferae) and *Diospyros* (Ebenaceae).

Understorey layer: height: 3 to 5 m. Dominant families: Moraceae (Streblus) and Euphorbiaceae (Breynia, Gen. sp.). Occasional: *Arenga pinnata, Pinanga* (Arecaceae).

3. Large permanent river valley on the lower terrace; Alt.100 m

This area is a part of abroad valley that once was inhabited by people. The area is characterized by a secondary formation composed of pioneer trees. The liana cf. *Argirea* (Convolvulaceae) covers the tree canopy like a blanket and restricts, together with the dense canopy of pioneer trees, the growth of juvenile forest trees. In some valleys, fragments of primary forest remain.

The soil is represented by road-metal material. A humus horizon of 5-7 cm is formed in some strips. There is a layer of leaf and twig litter on top of the soil. The tree root systems are superficial and penetrate 30-50 cm deep. The forest is stratified into four well developed layers.

Upper (canopy) layer: common species: cf. Sapindaceae (except *Pometia pinnata* which is occasional); cf. Combretaceae, *Litsea* (Lauraceae). Others tree species: *Endospermum* (Euphorbiaceae); *Hydnocarpus* (Kiggelariaceae), cf. *Peltophorum* (Fabaceae), *Tetrameles nudiflora* (Datiscaceae), *Dracontomelon dao* (Anacardiaceae), *Mangifera* (Anacardiaceae), *Castanopsis*, *Quercus* (Fagaceae).

Second layer: height: 15 to 20 m, DBH: 30 to 40 cm. Common species: *Diospyros* (Ebenaceae), *Casearia* (Flacourtiaceae), *Pterospermum* (Sterculiaceae), *Cinnamomum* (Lauraeae), cf. *Polyalthia* (Annonaceae), *Knema* (Myristicaceae), *Archidendron* (Fabaceae). Others: Gen. sp. (Rutaceae), *Elaeocarpus*, *Sloanea* (Elaeocarpaceae).

Third layer: height: 10-12 m. Dominant: *Croton* (Euphorbiaceae); co-dominant: *Helicia* (Proteaceae). Other species: *Syzygium* (Myrtaceae), *Garcinia* (Guttiferae), *Vitex* (Verbenaceae) and cf. *Grewia* (Tiliaceae).

Understorey layer: height: 4-5 m. Dominant palm species: *Caryota* cf. *mitis*. Others: *Calamus*, *Licuala*, *Arenga pinnata*, *Livistona* (Arecaceae), *Ardisia* (Myrsinaceae).

4. The river or permanent stream, Alt. 100-200 m (*Coordinates: 17°27'505; 106°10'972)*

Some tree species are able to grow directly along or in rivers or permanent streams on rocks: *Homonoia riparia* (Euphorbiaceae), and on the banks (alluvial soil): *Crateva* (Capparaceae) height 7-10 m, and *Elaeocarpus* (Elaeocarpaceae) height 2 to 5 m. About 10-15 m from the riverbank species such as *Duabanga* (Duabangaceae) and *Ficus* (Moraceae) are found, height 15 m. Typical forest trees grow further up-country if the soil is well-drained. Tree species in river on stones: *Homonoia riparia* (Euphorbiaceae), in riverbank: *Crateva* (Capparaceae), *Elaeocarpus* (Elaeocarpaceae). About 10-15 m from the riverbank: *Duabanga* (Duabangaceae) and *Ficus* (Moracea).

5. The karst massif, alt. 200-400 m (Coordinates: 17°25'006; 106°18'303)

The relief of the karst massif is very complicated. The karst material is ancient and heavily weathered. There is an abundant mosaic of specific configurations: huge rocks, small, narrow caves, sharp hilltops, and slopes from straight up, steep to gentle. Consequently, there is also a mosaic of soils and substrates. The soil is clay or subclay, dark brown, and not deep. A layer of leaf and twig litter can be found on the rocks surfaces. The karst massif is forested, the tree crowns overlap or are very close and support numerous lianas. The forest trees have different sizes depending on the niche in the karst. Huge trees can be found in the wind sheltered depressions and may reach a height up to 35 m. Buttresses are common. It is impossible to distinguish the different forest layers because of the mosaic in relief. Common big trees (DBH 40 to 100 cm): *Litsea* (Lauraceae); *Mangifera, Dracontomelon* (Anacardiaceae); *Bicshofia* (Euphorbiaceae); *Sterculia*, *Pterospermum* (Sterculiaceae); *Hopea* (Dipterocarpaceae); *Pometia*, *Harpulia* (Sapindaceae); *Canarium* (Burseraceae); *Horsfieldia* (Myristicaceae); *Ficus* (Moraceae); *Garcinia* (Clusiaceae); *Dalbergia* (Fabaceae). Other trees: *Aglaia*, cf. *Dysoxylum* (Meliaceae), cf. *Neolitsea*, *Phoebe* (Lauraceae). Common tree species < 20 m:

Polyalthia (Anacardiaceae), *Vitex* (Verbenaceae), *Knema* (Myristicaceae), *Casearia* (Flacourtiaceae), *Streblus* (Moraceae), *Syzygium* (Myrtaceae), *Cinnamomum* (Lauraceae), *Diospyros* (Ebenaceae). Small trees: *Grewia* (Tiliaceae), *Pavetta* (Rubiaceae), Gen. sp. (Euphorbiaceae).

6. Top of karst hill, alt. 600 m (Coordinates 17°26'020; 106°20'088).

The hilltop consists of karst material with a thin layer of soil which consists of rough humus and is 5 to 10 cm deep. There is a sharp borderline between the humus layer and the rock parent material. In general, a soil is only formed on the surface of the more gentle parts of the top. Tree root systems are superficial, roots sometimes penetrate into the cracks between rocks.

The described karst hill top has a diameter of 100-120 m. A huge depression of 30 m in diameter and 15 to 20 m in depth is formed in the middle. The hilltop is forested. The height of trees is 5 to 7 m and occasionally 12 m. (Trees that grow at the bottom of the huge karst depression reach 15 m in height). The tree trunks (on the top) are short and crooked resembling trees out of fairy tales. The first living branches start at 0.7-1 m and start overlapping as low as 1.5 to 2 m. The vegetation is not stratified into layers. Common tree species: *Hopea* (Dipterocaarpaceae), *Syzygium* (Myrtaceae), *Vitex* (Verbenaceae), *Lindera*, *Cinnamomum* (Lauraceae), cf. *Ternstroemia* (Theaceae), Gen. sp. (Fabaceae), *Elaeocarpus* (Elaeocarpaceae), *Garcinia* (Guttiferae), *Pterospermum* (Sterculiaceae), *Engelchardia* (Juglandaceae), cf. *Brydelia* (Euphorbiaceae), *Ardisia* (Myrsinaceae), *Lasianthus* (Rubiaceae). Bamboo is well developed under the tree canopy. Stems are strong, thin (1 cm in diameter) and 1.5 to 2 m high. Other shrubs: *Dracaena* (Dracenaceae) and *Rhaphydophora* (Araceae).

7. Karst slope and hilltop Alt. 300-400 m (Coordinates: 17°26'543; 106°19'649).

The slopes of limestone hills have grades of 30-40°, and sometimes of 70-80° (nearly vertical walls). Some gradients of the described karst slope are vertical and are 4 m high. The hilltop is 50 by 10 m. No soil is formed at the hilltop. Rough humus accumulates between rock walls. The litter layer is abundant in twigs. The rocks are heavily weathered. Rainwater accumulates in depressions in stones or penetrates between stones. The vegetation consists of slope species while the typical hilltop species are absent. Trees are in general up to 10 m and can occasionally reach 20 m on the slopes. Buttresses are moderately developed. The canopy is dense and closed. The crowns are slightly flattened by the wind. Trees differ in height. Lianas increase the density of the canopy. The vegetation is stratified into two layers. Upper layer: height: 10-20 m, DBH: 20-40. Common species: *Vitex* (Verbenaceae), *Diospyros* (Ebenaceae), *Elaeocarpus* (Elaeocarpaceae), *Cinnamomum*, *Litsea* (Lauraceae), *Hopea* (Dipterocarpaceae), cf. *Aglaia* (Meliaceae), *Streblus* (Moraceae), *Garcinia* (Guttiferae), *Pometia* (Sapindaceae), *Gardenia* (Rubiaceae) Occasionally on karst hill top: *Polyalthia* (Annonaceae), cf. *Dalbergia* (Fabaceae) and *Quercus* (Fagaceae). Understorey: Fragmented, dominated by *Breynia* (Euphorbiaceae)

8. Slope and wide ridge with clay soil. Alt. 300-400 m (coordinates: 17°26'560; 106°19'877; 17°26'751; 106°19'915)

This clay slope starts directly next to a karst hill and gradually transforms into a wide ridge of 20 to 60 (80) m. The borderline between the karst and clay slope is clear and narrow. The forest structure and the tree composition on the slopes and on the ridge are similar. Therefore, they are both included in one description. The slope has a grade of 30-35° and is completely covered with soil. The soil consists of well-structured clay (without quartz particles) and has a yellow-brown color. The humus horizon is 5-7 cm thick and is grey-brown colored. Shale material appears below 7 cm. Roots penetrate to 50 cm deep. The whole surface of the soil is

covered by a litter layer of 5-7 cm. The clay slopes here support a polidominant complex vegetation structure consisting of three layers: a top layer with a height up to 30-35 m, a second storey with a height up to 12-16 m and a third storey with a height up to 3-4 m.

Upper (canopy) layer: height: up to 30-35 m, DBH: 40-90 cm. Dominant species: *Hopea mollissima* (Dipterocarpaceae), co-dominant: *Litsea* (Lauraceae). Other tree species: *Quercus*, *Lithocarpus*, *Castanopsis* (Fagaceae), *Cinnamomum* (Lauraceae), *Elaeocarpus* (Elaeocarpaceae), *Endospermum* (Euphorbiaceae), *Podocarpus imbricatus* (Podocarpaceae), *Diospyros* (Ebenaceae), *Madhuca* (Sapotaceae), *Ficus* (Moraceae), *Canarium* (Burseraceae) and *Syzygium* (Myrtaceae).

Second layer: height: 12 to 16 m, DBH: 20 to 30 cm (occasionally 40 cm). Dominant species: *Polyalthia* (Annonaceae), Gen sp. (Tiliaceae), Gen. sp. (Rubiaceae), *Gironniera* (Ulmaceae), *Livistona* (Arecaceae). Others trees: *Lindera* (Lauraceae); *Sterculia*, *Scaphium*, *Pterospermum* (Sterculiaceae); *Wrightia* (Apocynaceae), *Garcinia* (Guttiferae), *Zanthoxylum* (Rutaceae), *Aporusa* (Euphorbiaceae), *Syzygium* (Myrtaceae), *Diospyros* (Ebenaceae), *Eurya* (Theaceae), *Dillenia* (Dilleniaceae)

Third layer: height: 2 m. Dominant species: *Licuala* (Arecaceae). Occasional species: *Lasianthus*, *Psychotria* (Rubiaceae), *Ardisia* (Myrsinaceae) and *Oxyspora* (Melastomataceae).

9. Valley's forest Alt. 100-150 m (Coordinates: 17°25'418; 106°19'476).

Numerous temporary streams end in the valleys (the valley described here is about of 200-300 m wide) running down from the surrounding ridges. Possibly, the valleys are flooded from time to time. The soils are alite and dark and are well developed. Quartz particles and granite insertions are absent. The zone of weathered parent material reaches 1.5 to 2 m. Roots penetrate to a depth of up to 1 m. The humus horizon is dark-brown and 10 cm thick. Stones of varying sizes are present on the surface of the soil. The topsoil is covered with a litter layer of 3 cm thick containing thin roots. The soil under the litter is moist. The forest is stratified into tree layers. The upper canopy is closed. The second layer is also well-developed however the crowns do not form a closed canopy.

Upper canopy: height: 30 to 35 m (occasionally 40 m), DBH: 60 to 150 cm. Dominant species: *Lagerstroemia* (Lythraceae). Co-dominant: *Pometia pinnata* (Sapindaceae), *Castanopsis* (Fagaceae) and *Litsea* (Lauraceae). Other tree species: *Bischofia* (Euphorbiaceae), *Elaeocarpus* (Elaeocarpaceae), *Lithocarpus* (Fagaceae), Gen. sp. (cf. Combretaceae), *Hopea mollissima* (Dipterocarpaceae), cf. *Canarium* (Burseraceae); *Mangifera* (Anacacrdiaceae); *Ficus* (Moraceae) and cf. *Dysoxylum* (Meliaceae). On adjacent elevated areas with a better drainage, other tree species appear such as: *Dipterocarpus* sp. (Dipterocarpaceae) and *Dracontomelon* cf. *dao* (Anacardiaceae). *Mangifera* (Anacardiaceae) is also common. *Lagerstroemia* is absent on the slopes because this species prefers moist and wet soils.

Second layer: height: up to 20 m, DBH: 30 to 50 cm. Dominant species: *Streblus* (Moraceae) and *Casearia* (Flacourtiaceae). Other trees: *Polyalthia* (Annonaceae), *Cinnamomum*, cf. *Neolitsea* (Lauraceae), cf. *Celtis*, *Gironniera* (Ulmaceae), *Knema* (Myristicaceae), *Vitex* (Verbenaceae), and *Syzygium* spp. (Myrtaceae).

Third layer: height: 4-6 m (trees) and 2-8 m (palms). Dominant palm specie: *Caryota* cf. *mitis* (Arecaceae). Other palm and tree species: *Licuala*, *Calamus*, *Livistona*, *Arenga pinnata* (Arecaceae), Gen. sp. (Annonaceae), *Ardisia* (Myrsinaceae), *Syzygium* (Myrtaceae), *Eurya* (Theaceae) and *Lasianthus* (Rubiaceae).

10. Alluvial valleys

Alluvial valleys exists between the hill ridges. The soil consist of sediment sands and is well developed. The hydrological network consists of numerous permanent and temporary streams. The riverflow is fast with an average slope of the riverbeds of 5-10°. Granite predominates the riverbeds, while sand deposits dominate the riverbanks. The valley is flooded during the wet season for the largest part with water levels rising up to 1.5 m.

Many streams dry up in the dry season while the water levels in the permanent rivers stabilize at 0.2-0.5 m. Specific formations of trees grow on the stony and sandy substrate directly along the riverbanks and river valleys. Here the trees reach a height of 4m with a DBH of 5 to 12 cm. The tree crowns overlap. Tree trunks often are curved. Some trees that grow in areas that are flooded during the wet season have asymmetric flag-like crowns formed due to the current of the river. Dominant species in these areas are: *Homonoia riparia* (Euphorbiaceae), *Elaeocarpus* (Elaeocarpaceae), *Ficus* (Moraceae) and *Syzygium* (Myrtaceae). *Trewia* (Euphorbiaceae), *Crateva* (Capparaceae) and *Elaeocarpus* grow on higher banks and reach heights of 6-7 m. The DBH is 14 to 20 cm. Occasionally large *Ficus* (Moracaceae) up to 20 m high can be observed. *Wormia* (Dilleniaceae) is common on the banks of the streams and reaches a height to 20 m and a DBH up to 80 cm. Its crown is massive and it has stilt roots at the basal part of its trunk. Wet polidominant forests are formed on the terraces 3-4 m above the riverbed. The vegetation is stratified in three well-developed layers.

Upper layer: height: 25 to 30 m, DBH: 40 to 80 cm. Dominant species: *Sterculia* (Sterculiaceae), *Elaeocarpus* (Elaeocarpaceae) and a huge semi-epiphyte *Ficus* (Moraceae). Other trees: *Lithocarpus* (Fagaceae); *Bischofia* (Euphorbiaceae); *Lagerstroemia* (Lythraceae); *Horsfieldia* (Myristicaceae); cf. *Litsea* (Lauraceae); *Celtis* (Ulmaceae); *Dipterocarpus* (Dipterocarpaceae) and *Wormia* (Dilleniaceae).

Second layer: height: 12-14 m, DBH: 20 to 40 cm. Tree species: cf. *Grewia* (Tiliaceae), *Streblus* (Moraceae), *Casearia* (Flacourtiaceae), *Garcinia* (Guttiferae), *Endospermum* (Euphorbiaceae), *Syzygium* (Myrtaceae), *Hydnocarpus* (Kiggelariaceae) and *Vitex* (Verbenaceae).

Understorey layer: height: 4 to 6 m. Species: *Polyalthia* (Annonaceae), *Syzygium* (Myrtaceae), *Ardisia, Maesa* (Myrsinaceae), *Mallotus* (Euphorbiaceae).

b. Ke Bang area

11. Forest on flat areas or on low slope not exposed to wind

The loam soil is thick and well structured with some limestone and schists. The humus horizon of 0-20 cm is weak and is dark-gray-gray-yellow colored. The forest can be distinguished in 3 to 4 different layers. The top layer reaches a height of 25-30 m with some individual trees reaching up to 40 m, while the diameter ranges from 60 to 220 cm. In the second layer, trees reach a height of 20-25 m, while the third layer has height of 8-12 m. The vegetation is very rich in lianas. According to VRTC (1999) this forest type, which is very rich in liana species with huge trunks (30-36 cm in diameter) is in original status and exists over several thousands years.

Upper layer: dominant species: *Pommetia pinnata* (Sapindaceae). Co-dominant species: *Magnolia sp.* (cf. *Manglietia sp*.) (Magnoliaceae), *Dipterocarpus kerrii* (Dipterocarpaceae), *Burretiodendron sp.* (Tiliaceae), cf. *Canarium* (Burseraceae), *Dacryodes sp.* (Podocarpaceae), *Endospermum sinensis* (Euphorbiaceae), *Artocarpus sp., Ficus sp.* (Moraceae), *Litsea sp.* (Lauraceae), cf. *Chisocheton* cf., *Dysoxylum*, cf. *Aglaia, Amoora sp.* (Meliaceae), *Madhuca sp.* (Sapotaceae), *Elaeocarpus spp*. (Elaeocarpaceae). Other species rarely found: *Mangifera sp.* (Anacardiaceae), *Lithocarpus sp.* (Fagaceae), *Tetrameles nudiflora* (Datiscaceae).

Second layer: height: 20 to 25 m. Dominant species: *Elaeocarpus spp.* (Elaeocarpaceae), *Quercus sp.* (Fagaceae), *Sterculia spp.* (Sterculiaceae). Co-dominant species: *Knema* cf. *linifolia* (Myristicaceae), *Garcinia sp*. (Clusiaceae), *Diospyros spp.* (Ebenaceae), *Cinnamomum sp.* (Lauraceae), *Lithocarpus sp.* (Fagaceae), *Barringtonia* (Lecythidaceae), *Lagerstroemia sp.* (Lythraceae), *Machilus sp., Phoebe sp.* (Lauraceae), *Dalbergia sp.* (Papilionoideae), *Sloanea sp.* (Elaeocarpaceae), *Grewia sp*. (Tiliaceae), *Gironniera sp.* (Ulmaceae), *Manglietia sp*. (Magnoliaceae).

Third layer: height: 8-12 m. Dominant species: *Helicia* sp. (Proteaceae), *Capparis* sp. (Capparaceae), *Elaeocarpus* spp. (Elaeocarpaceae), *Taxotrophis sp*. (Moraceae). Other species include: *Baccaurea spp*. (Euphorbiaceae), *Polyalthia spp.* (Annonaceae), *Wrightia sp.* (Apocynaceae), cf. *Tilia* (Tiliaceae), *Caryota urens* (Palmae), *Pterospermum sp.* (Sterculiaceae), *Kydia sp.* (Malvaceae), *Syzygium spp.* (Myrtaceae).

Understorey layer: height: up to 2 m. Dominant small trees and shrubs: *Sterculia sp*. (Sterculiaceae), *Ardisia spp., Maesa spp.* (Myrsinaceae), *Lasianthus spp., Psychotria sp*. (Rubiaceae). Other families presented include: Apocynaceae, Euphorbiaceae (*Antidesma spp, Breynia sp., Croton sp., Phyllanthus sp.*), Araliaceae (*Trevesia sp*.), Palmae (*Caryota sp., Pinanga sp., Licuala sp*.), Rutaceae (*Euodia lepta, Clausena sp*.), Violaceae (*Rinorea sp*.) and Apocynaceae.

12. Forest on steep limestone slopes

Soil is only formed on small, smooth and flat sites along the limestone slope. The surface of the limestone rocks is covered with cavities with sharp edges. Plants that grow on the slopes are exposed to increasing influence of winds. The height of the trees decreases with the altitude while also the species composition changes. Tree stems are often curved. The trees that grow on windy slopes have in general no buttresses. Surface roots spread around the stones and it often looks like the trees embrace their stony substratum. The forest structure on steep limestone slopes is not very complex. The canopy is closed with a height of 12-15 m and there is a fragmented sublayer. Herbal species encountered of the genera *Amorphophallus, Thyphonium* and probably *Pseudodracontium* are of special interest as there might be new species to science among these tuberous herbs. Upper layer: height: 12-15 m. Species: *Diospyros spp.* (Ebenaceae), *Hopea sp*. (Dipterocarpaceae), *Syzygium sp.* (Myrtaceae), *Quercus sp.* (Fagaceae), *Elaeocarpus spp.* (Elaeocarpaceae), *Acer spp.* (Aceraceae), *Garcinia sp.* (Clusiaceae), *Pterospermum sp.* (Sterculiaceae), *Knema sp*. (Myristicaceae), *Gironniera sp*. (Ulmaceae), *Wrightia sp.* (Apocynaceae), *Podocarpus imbricatus* (Podocarpaceae), *Trevesia sp.* (Araliaceae), *Polyalthia sp.* (Annonaceae), *Lithocarpus sp., Castanopsis sp.* (Fagaceae), *Goniotalamus sp.* (Annonaceae), *Baccaurea sp., Ostodes paniculata* (Euphorbiaceae), *Engelhardtia sp.* (Juglandaceae), *Cinnamomum sp.* (and other sp. from Lauraceae),and *Arenga pinnata* (Palmae).

13. Vegetation on limestone crest, altitude 500 m

The vegetation on the limestone crests is very characteristic as it is formed under very specific conditions. There is no formed soil layer and the vegetation is exposed to strong winds and solar radiation. Trees only reach a height of 2-3 m and have a diameter of 8-14 cm. The trunks are curved and the trees form a closed canopy. The tree-crowns are compact and dense and are sphere-like formed. Leaves are small, dense, skinny (xerophitous) and have a wax layer. Tree layer: Height: 2-3 m, DBH: 8-14 cm. Dominant species: *Phyllantus sp.* (Euphorbiaceae), *Wrightia sp.* (Apocynaceae), *Calophyllum sp., Garcinia sp*. (Clusiaceae)., *Illicium sp.* (Illiciaceae), *Elaeocarpus sp*. (Elaeocarpaceae), *Ternstroemia sp.* (Theaceae). Other species: *Dacrydium pierri, Podocarpus nervifolium, P. pilgeri, Decusocarpus fleuryi* (Podocarpaceae), *Breynia sp*. (Euphorbiaceae), *Quercus sp*. (Fagaceae), cf. *Lindera, Cinnamomum sp.*

(Lauraceae), *Syzygium sp.* (Myrtaceae), *Lasianthus sp.* (Rubiaceae), *Eurya sp.* (Theaceae), *Maesa sp., Ardisia sp.* (Myrsinaceae), *Rubus spp.* (Rosaceae), *Pterospermum sp.* (Sterculiaceae), *Callicarpa sp.* (Verbenaceae), *Lyonia sp.* (Ericaceae), *Diospyros sp.* (Ebenaceae), and species from Bignoniaceae and Fabaceae

3.1.2.2 Major forest communities

Applying UNESCO International Classification and Mapping of Vegetation (UNESCO, 1973) while considering high regional specificity of aboriginal vegetation observed in PNKB NP, Nguyen Tien Hiep et al. (2013) described 15 specific forest communities in extension area of PNKB NP (Hoa Son and Thuong Hoa Communes, Minh Hoa Districts, Quang Binh Province) as following:

1. Zonal primary plant communities

1.1. Lowland

1.1.1. Closed primary evergreen seasonal tropical lowland broad-leaved forests on leveled slopes and low ridges composed by stratified shale at elevation (350)500-600 m asl.

1.1.2. Closed primary evergreen seasonal tropical lowland broad-leaved forests on wet flat seasonally flooded river/stream valleys and on low flat river/stream terraces on crystalline eroded limestone and shaly limestone at elevation (250)300-400(450) m asl.

1.1.3. Closed primary evergreen seasonal tropical lowland broad-leaved forests on steep rocky mountain slopes on crystalline highly eroded limestone at elevation 400-700 m asl.

1.1.3a.Wind-formed modification. Closed primary evergreen seasonal tropical lowland broad-leaved short forests on vertical and subvertical cliffs on crystalline highly eroded limestone at elevation 400-700 m asl.

1.1.3b.Wind-formed modification. Closed primary evergreen seasonal tropical lowland broad-leaved short forests on rocky mountain tops on crystalline highly eroded limestone at elevation 400-700 m asl.

1.2. Submontane

1.2.1. Closed primary evergreen seasonal tropical submontane broad-leaved, mixed or coniferous forests (with *Dacrydium elatum* and *Dacrycarpus imbricatus*) on steep rocky slopes and on mountain tops on crystalline highly eroded limestone at elevation 700-800(900) m asl.

1.2.1a.Wind-formed modification. Closed primary evergreen seasonal tropical submontane broad-leaved, mixed or coniferous short forests on vertical and subvertical cliffs on crystalline highly eroded limestone at elevations 700-800(900) m asl.

1.2.1b. Wind-formed modification. Closed primary evergreen seasonal tropical submontane broad-leaved, mixed or coniferous short forest on rocky mountain tops on crystalline highly eroded limestone at elevations 700-800(900) m asl.

2. Azonal primary plant communities

2.1. Riparian riverine shrub and herbaceous communities on swampy and rocky steam/river valleys

2.2. Aquatic riverine aquatic herbs communities on steams and rivers

3. Secondary plant communities

3.1. Open medium and highly disturbed primary forests

3.2. Rich secondary forests and woodlands

3.3. Poor secondary forests and woodlands

3.4. Closed and open secondary scrub

3.5. Secondary herbaceous communities and grasslands

Below are simplified description of these plant communities based on field observation and representative plot examination:

1. Zonal primary kinds of plant communities

1.1 Lowland

1.1.1. Closed primary evergreen seasonal tropical lowland broad-leaved forests on leveled slopes and low ridges composed by stratified shale at elevation (350)500-600 m asl.

Non-limestone areas consist of relatively small portion of study area, studied in south-western part of Hoa Son commune, Minh Hoa district and associated with rolling hills and low ridges, as well as with narrow beds and low terraces of stream and rivers valleys at elevations 450-550 m asl. Dark to light brown stratified and clay shale were commonly observed as parental soil material here. Well developed weathered material covers commonly all forest floor without mother rock outcrops. Leaf litter form usually 100% cover to 5-10 cm in depth. Soils include yellow-brown, yellow to light yellow horizon 5-15 cm thick, based on light brown alluvial clay to 1 m in depth and deeper. Following structure of the forest was observed in studied area:

Upper layer includes numerous species of trees that reach 25-40(50) m tall, to 1 m DBH with coverage from 20 to 70%. Most typical species are *Allospondias lakonensis, Altingia siamensis, Canarium bengalense, Dracontomelum duperreanum, Elaeocarpus grandiflorus, Endospermum chinense, Engelhardia roxburghiana, Ficus glaberrima,* and species of such genera as *Aglaia, Diospyro*s and *Pterospermum*. Usual associates here are *Chukrasia tabularis, Dacrycarpus imbricatus, Diplopanax vietnamensis, Lithocarpus pseudoreinwardtii, Magnolia dandyi, Michelia masticata* and species of genera *Artocarpus, Actinodaphne* and *Magnolia.* Some trees, like *Engelhardia roxburghiana* may reach 45-50 m tall appearing as emerging above canopy of layer 1.

Second layer includes many species of trees with (7)10-20(25) m tall and DBH of (12)15-40 cm, layer coverage is from 60 to 70%. Most typical species are *Alangium ridleyi, Amesiodendron chinense, Cinnamomum ovatum, Diospyros latisepala, Lithocarpus pseudoreinwardtii, Polyalthia juncunda, Schima wallichii, Xerospermum microcarpum,* as well as species of such genera as *Actinodaphne, Beilschmiedia, Schefflera* and *Syzygium*.

Third layer (shrub) is rich in species and reaches 3-7(10) m tall with coverage varying from 10 to 80%. Typical species observed here are *Archidendron clypearia, Diospyros choboensis, Ficus langkokensis, Ficus variolosa, Flacourtia rukam, Gironniera subequalis, Grewia bulot, Michelia masticata, Miliusa sinensis, Psychotria sarmentosa, Styrax litseoides, Symplocos adenophylla* and species of *Aglaia, Elaeocarpus, Garcinia, Michelia* and *Tabernaemontana*. Palms (*Livistona* sp.) are common in this layer. Numerous saplings of large trees of first layer observed here (*Alangium ridleyi, Elaeocarpus grandiflorus, Michelia masticata, Pometia pinnata* and species of *Actinodaphne* and *Pterospermum*) exhibits potentially normal regeneration of the forest.

Fourth layer (herbaceous): reaches 3 m high with coverage up to 80%. This layer includes species from various families such as Araceae, Euphorbiaceae, Begoniaceae, Myrsinaceae, Melastomaceae, Anonaceae, Rubiaceae, Polypodiaceae, Maranthaceae, Rutaceae, Leeaceae, Orchidaceae, Taccaceae. Numerous seedlings of trees of higher forest layers have remarkable proportion in species composition of herbaceous layer.

Mosses and lichen stratum is very poor (less than 1% of coverage). Genuine epiphytes are not common and presented by such species as *Asplenium nidus, Oberonia* sp., *Thrixpermum centipeda, Aglaomorpha coronans, Asplenium nidus, Dendrobium* sp. and *Nephrolepis cordifolia.* A number of creeping epiphytic vines allies to this group of species of non-strata vegetation. They are *Dischidia* sp., *Epipremnum pinnatum, Piper albispicum, Pothos repens*, and *Scindapsus poilanei.*

Numerous herbaceous and woody lianas are fairly common in forests of described type, particularly in their disturbed modifications. Most common species here are *Ancistrocladus tectorius, Artabotrys hexapelalus, Bauhinia* sp., *Bowringia callicarpa, Byttneria tortilis, Calamus poilanei, Capparis cantoniensis, Cocculus* sp., *Combretum* sp., *Combretum sundaicum, Connarus paniculatus, Derris* sp., *Dioscorea* sp., *Entada phaseoloides, Erythropalum scandens, Fibraurea tinctoria, Ficus sagittata, Ficus subulata, Galeola nudiflora, Gnetum montanum, Gynostemma pentaphylla, Gynostemma pubescens, Kadsura grandiflora, Millettia* sp., *Morinda officinalis, Mussaenda cambodiana, Smilax glabra, Stauntonia cavaleriana, Tetrastigma* sp., *Thladiantha cordifolia.*

Among them are remarkable achlorophyllous orchid: *Galeola nudiflora* and significant medicinal plant *Morinda officinalis* widely used in traditional oriental medicine. Noteworthy, observed forests include a numbers of such primitive archaic elements of tertiary floras as *Altingia siamensis, Diplopanax vietnamensis*, numerous magnolias (*Magnolia, Michelia*) and gymnosperms. Some of them, like *Diplopanax vietnamensis*, are genuine "living fossils", which is regarded as congeneric with *Mastixicarpum*, representatives of which were an integral component of subtropical broad-leaved evergreen vegetation that covered much of the Northern Hemisphere from the uppermost Cretaceous to the late Miocene, about 65 to 7 million years ago (Averyanov, Nguyen Tien Hiep, 2002).

1.1.2. Closed primary evergreen seasonal tropical lowland broad-leaved forests on wet flat seasonally flooded river/stream valleys and on low flat river/stream terraces on crystalline eroded limestone and shaly limestone at elevations (250)300-400(450) m asl.

Forest of this type spreads in along stream and river valleys at elevation 250-450(450) m asl. and occupies seasonally flooded alluvial valley beds and low valley terraces. Commonly, stream or river valleys in study area are fairly narrow and often appears as narrow canyons with very steep rocky slopes and bluffs composed with highly eroded solid karstic white to gray limestone. Meanwhile, very often waterproof gray to dark gray, or almost black stratified lime shale, or clayey shale form bottom of valley beds. During rainy season in September - October, stream water covers here forest floor in period from 2 to 3 months. Flooded water brings a lot of alluvial clay material awashed from steep valley slopes, which identified specific soil character in such localities. Leaf litter covers 70-90% of surface during rainless time. At this time it's depth varies from 2 to 5 cm. Fallen leaves, however, are easily awashed by heavy rains at the beginning of rainy season into depressions, karstic dolines or riverbeds. It denudates forest floor, when open soil surface may reach 100%. Observed soils consist of brown to light brown horizon of 5-15 cm in depth, deeper light brown to light yellow-brown alluvial clay to 1 m thick based on more or less weathered gravel of limestone, lime shale or clay shale, placed eventually on mother rocks. Following structure of the forest was specified in studied area

First layer: includes a number of tree species 20-30(35) m tall, to 0.8(1) m DBH with canopy coverage 15-50%. Most common species of this stratum observed here are *Allospondias lakonensis, Artocarpus borneensis, Canarium unigram, Cryptocarya concinna, Dipterocarpus hasseltii, Elaeocarpus grandiflorus, Manglietia chevalieri, Michelia masticata, Pometia pinnata, Sloanea sinensis* and species of such genera as *Actinodaphne, Aglaia, Ailanthus, Nephelium* and *Sygyzium*. Largest trees found in all studied area were

observed in this forest type. Such trees often appear as giant emergents, which may reach 40-50 m tall and 1.5-2 m DBH forming impressive buttresses 3-4 m long and 2-3 m tall with total side projection of trunk 7-8(10) m wide. *Dracontomelum duperreanum, Dysoxylum mollissimum* and *Lagerstroemia ovalifolia* and some other species, appear as most common emergent in studied area, very often growing also on lower part of rocky limestone mountain slopes. Canopy diameter of such trees can reach 40 m in diameter with canopy coverage of 30-40 %.

Second layer: is formed by trees 10-20(25) m tall, (10)15-40 cm DBH. Coverage varies from 50 to 90%. Most common species are *Dipterocarpus retusus, Elaeocarpus grandiflorus, Hydnocarpus annamensis, Knema pierrei, Pometia pinnata, Sarcosperma kachinensis,* as well as representatives of such genera as *Actinodaphne, Adenanthera, Aglaia, Castanopsis, Cinnamomum, Michelia* and *Polyalthia*.

Third layer (bushes): is rather poor. It is formed by scarce trees and shrubs 3-7(10) m tall with coverage 25-35%. Usually this stratum is not too much rich in species and includes *Arenga westerhautii, Caryota sympetala, Ficus nervosa, Leea indica, Saurauia tristyla, Streblus macrophyllus, Wrightia macrocarpa*, species of *Antidesma, Calamus, Camellia, Microdesmis, Pinanga*, as well as immature saplings of *Cryptocarya, Knema pierrei, Litsea, Syzygium* and a number of tree species of higher strata. *Streblus macrophyllus* is most common species here.

Fourth layer (herbaceous): includes herbs and shrubs 0.05-3 m tall forming coverage 25-85%. Species composition may be rich, but most herbs, shrubs and seedlings here are presented by small, depressed, very weak samples with miserable portion in higher layers. Very often they are seedlings or juvenile saplings originated from seeds of plants from higher canopy incapable survive in flooded season. Among such species were specified: *Aglaia* sp., *Alpinia* sp., *Amischotolype mollisssima, Amomum* sp., *Amorphophalus* sp., *Angiopteris evecta, Ardisia* sp., *Asarum wulingense, Asplenium obscurum, Begonia tetraptera, Blastus* sp., *Calamus* sp., *Calanthe odora, Capparis* sp., *Caryota sympetala, Clausena* sp., *Clinacanthus* sp., *Colysis* sp., *Corymborkis veratrifolia, Costus tonkinensis, Croton* sp., *Curculigo latifolia, Dendrocnide* sp., *Diplazium donianum, Diplazium* sp., *Elatostema* sp., *Gomphandra* sp., *Hydnocarpus* sp., *Impatiens* sp., *Lasianthus* sp., *Leea indica, Musa* sp., *Ophiorrhiza* sp., *Phrynium* sp., *Pilea* sp., *Pollia thyrsiflora, Polystichum* sp., *Pseudodracontium* sp., *Psychotria* sp., *Pteris grevilleana, Rhynchotechum ellipticum, Sambucus hookeri, Sterculia* sp., *Strychnos* sp., *Tectaria decurrens, Trevesia palmata.*

Few flood-tolerant species very often appear here as absolute co- or mono-dominants of plant community representing to 99% portion in own cover. Usual species of this group are *Aglaonema ovatum, Aglaonema siamense, Alocasia* sp., *Goodyera fumata, Homalonema occulta, Hydrocotyle javanica, Schismatoglottis calyptrata, Tacca chantrieri, Thelypteris* sp., and *Zippelia begonifolia,* but most common in flooded forests are some species of *Aspidistra, Ophiopogon* and *Peliosanthes*. In rather open wet places may be commonly found dense cover of creeping herbaceous vine *Gynostemma pubescens.*

Moss and lichens cover is miserable. It presented by few juvenile, unidentified, xylophytes and epiphytes not higher than 1 cm, not exceeding 3-5% of soil surface. Lithophytic, epiphytic herbs and different vines present non-layer vegetation. Richness of lithophytes may be high. It straightly depends of amount of rock outcrops not covered flooded water in rainy season. Even temporary shortly flooded rocks remain very poor in lithophytic species.

Large herbaceous and woody lianas are rather common, particularly in opened disturbed forest modifications or in open places of fallen trees of rocky outcrops. Some vines can reach 30-40 m long and 15-20 cm in of stem diameter. Among vine species most common here are *Anamirta cocculus, Bauhinia ornata, Bauhinia oxysepala, Callerya reticulata, Fissistigma*

sp., *Hiptage* sp., *Millettia pachyloba, Paederia* sp., *Stephania sinica, Strychnos* sp., *Tetrastigma* sp. and *Trichosanthes* sp.

Temporary flooding is serious factor limiting species diversity of valley forest in studied area, particularly in lowest strata. Other kinds of primary forests exhibit much more high species diversity.

1.1.3. Closed primary evergreen seasonal tropical lowland broad-leaved forests on steep rocky mountain slopes on crystalline highly eroded limestone at elevation. 400-700 m asl.

This is the kind of forest that covers the largest area of study area. Forest of this type is most widespread, diverse and rich-species kind of vegetation with most complicated vertical structure that characterized by existence of 2-3 tree strata. These forests cover more or less steep, usually rocky slopes of remnant karstic limestone mountains that represent most usual kind of landform. Forests of this kind spread at elevations 400-700 m asl. Characteristic specifity of forest habitats on remnant karstic limestone mountains consists of very steep inclination of their slopes and their rocky character with rock outcrops to 90% of surface, and usual slope inclination 35-80°, often in combination with more or less high vertical cliffs. Mountain rocks here are composed by solid, crystalline, marble-like, highly eroded white, light to dark gray limestone, often forming mosaic picture with intermixture of all types in alone cliff of mountain top.

Forests on lower part of mountain slopes faced to narrow stream valleys may be shady and very humid with abundance of epiphytic mosses and wet-loving species. At the same time, on steep cliffy slopes of southern exposition environmental conditions may be rather dry with domination of dry-tolerant and even succulent species. Specific conditions are sometime observed on high terraces and in anticline depressions between tops of limestone ridges were soils commonly richer than on slopes due to accumulation here more amounts of leaf and other organic litter. Leaf litter horizon commonly have thickness (3)5-10 cm with coverage 70-100% (except rock outcrops). However, accumulations of leaf litter in small depressions, caverns and karstic pockets my reach thickness 0.5 m and even more. Such pockets form specific substrate conditions necessary for normal existence and regeneration of largest part of woody species in forest on rocky limestone.

Surface humus soil horizon may be almost black to dark brown, but very often it brown, gray-brown or yellow-brown. Often this horizon, particularly on steep slopes only (3)5-15 cm deep. Meantime, on terraces, depressions, on leveled parts of lower slopes, or on mountain foothills it reaches 40-60 cm in depth. Light brown, gray or yellow clay mixed with more or less weathered limestone lies deeper. This horizon varies from 0.5 to 1.5 m thick and is placed directly on mother rocks. Fertility of soils reaches maximum on leveled parts of middle and lowers mountain slopes, where also the largest forest trees demonstratively are always observed. On highest part of mountain slopes soils thinner and first (canopy) forest layer much shorter. Following structure of the forest was specified in study area.

Giant trees-emergents are most impressive elements of described forests. They represent integral regular element of intact primary wood on middle and lower parts of mountain slopes. Such trees reach 40-45(50) m tall with trunks to 2.5 m DBH, spreading buttresses to 3-4 m long and to 2-3 m tall. As more common trees-emergents in study area were observed *Bischofia javanica, Dracontomelum duperreanum, Dysoxylum mollissimum, Elaeocarpus grandiflorus,* and some others, including few un-identified species of Rubiaceae. Giant canopies of these trees may reach 40 m in diameter. Their density varies from 10 to 30%.

First (canopy) layer is formed by trees (15)25-30(40) m tall, with (0.2)0.4-1.5(2) m DBH. The height of canopy forest stratum may be very variable. It directly depends of slope elevation, its inclination, soil richness and forest proximity to mountain tops. Coverage of this stratum

varies from (15)20 to 50(80)%. Forest of this type has the richest species composition in first and other tree and shrub layers. Species observed here as dominants and co-dominants of first (canopy) layer are *Ailanthus integrifolia, Alangium ridleyi, Allospondias lakonensis, Amoora oligosperma, Artocarpus borneensis, Artocarpus* sp., *Beilschmiedia pergamentacea, Bischofia javanica, Burettiodendron brilletii, Canarium nigrum, Chukrasia tabularis, Cinnamomum ovatum, Cryptocarya annamensis, Dipterocarpus hasseltii, Dipterocarpus retusus, Dracontomelum duppereanum, Dysoxylum loureirii, Elaeocarpus grandiflorus, Endospermum chinense, Ficus altissima, Ficus glaberrima, Gironniera subaequalis, Hopea siamensis, Lithocarpus pseudoreinwardtii, Lithocarpus* sp., *Manglietia fordiana, Michelia doltsopa, Michelia gioi, Michelia macclurei, Michelia* sp., *Polyalthia juncunda, Polyalthia* sp., *Pometia pinnata, Pterospermum truncatolobatum, Pterospermum* sp., *Sapindus* sp., *Schima wallichii, Sloanea sigun, Sloanea sinensis, Sterculia* sp., *Vatica cinerea, Zenia insignis.*

Second forest layer is well presented in low and middle part of mountain slopes where it often reaches 20-30(35) tall with trees (10)15-50 cm DBH forming coverage of (40)50-70%. Among most common trees here were observed following species: *Alangium ridleyi, Castanopsis* sp., *Celtis philippinensis, Cinnamomum* sp., *Deutzianthus tonkinensis, Diospyros* sp., *Dipterocarpus* sp., *Dracontomelum duperreanum, Engelhardtia roxburghiana, Ficus* spp., *Hopea siamensis, Hopea* sp., *Hydnocarpus annamensis, Knema pierrei, Lagerstroemia* sp., *Machilus* sp., *Michelia doltsopa, Magnolia* spp., *Nephelium* sp., *Polyalthia jucunda, Pterospermum* sp., *Sapindus* sp., *Streblus macrophyllus, Syzygium* sp., *Vatica cinerea*.

On more or less flattened slopes on rich soils also third forest layer may be usually observed. Trees of this stratum have commonly height (7)10-20 m with 10-20(40) cm DBH and canopy coverage (10)40-60%. Species usually observed here are *Ardisia* sp., *Diospyros hasseltii, Diospyros* sp., *Garcinia oblongifolia, Hydnocarpus annamensis, Knema pierrei, Polyalthia jucunda, Polyalthia* sp., *Sapindus* sp., *Streblus macrophyllus, Sumbaviopsis albicans, Syzygium* sp., *Vatica cinerea, Wrightia macrocarpa.*

The most common co-dominants here are *Streblus macrophyllus* and *Sumbaviopsis albicans.* At the same time, this layer less pronounced in high part of slopes by trees only 10-15 m tall with coverage only 10-30%. Sometimes, particularly on extra steep slopes, it actually absents, when shrubs and small trees present second forest stratum.

Shrub layer of the forest in most cases is well presented and consists of small trees and shrubs (2)3-10 m tall. Coverage varies in wide limits being specified as (10)40-60(80)%. More than half representatives here are saplings of trees of highest forest layer. Genuine shrubby species form specific fraction of this layer are *Antidesma* sp., *Arenga westerhoutii, Baccaurea* sp., *Breynia* sp., *Calamus* sp., *Callicarpa* sp., *Calophyllum balansae, Caryota* sp., *Clausena austroindica, Dalbergia* sp, *Dendrocnide* sp., *Deutzianthus tonkinensis, Diospyros rufogemmata, Diospyros* sp., *Ficus* sp., *Flacourtia rukam, Illicium cambodianum, Lasianthus* sp., *Memecylon edule, Miliusa sinensis, Phyllanthus insulensis, Pittosporum pauciflorum, Psychotria* sp., *Radermachera* sp., *Schefflera* sp.

Herbaceous layer includes herbs, sedges, ferns, undershrubs and small shrubs to 3(4) m tall forming coverage (10)20-80%. Species composition in this stratum is very rich and diverse. In humid lower parts of slopes wet- and shade-loving species dominate. At the same time, in high rocky slopes, dry-lowing and lithophytic species become abundant. Species composition in middle and particularly on high parts of mountain slopes is different. Seedlings and saplings of trees of highest forest strata are very common on any part of slopes. Often their portion may reach 20-30% of stratum density. These young plants form important basis of potential forest regeneration.

Sometimes in forest floor may be found very rare endemic species of Indochina like *Anoectochilus calcareus, Aphyllorchis montana, Mischobulbum longiscapum* and *Rhomboda petelottii.* Lichen and mosses cover (layer) commonly is less than 3 cm tall. It may reach 50(60)% of coverage, but almost in all cases is presented by juvenile and immature, unidentifiable lithophytes and xylophytes. Woody vines (climbers) are usual and diverse in slope forests. Some of them, like *Alyxia hainanensis, Jasminum* sp., *Melodinus* sp., *Smilax corbularia*, *Smilax* sp., *Stixis suaveolens* and *Uncaria* sp. are rather short and approximate to living form of climbing shrub. Some another species represent giant lianas to 40-45 m long with stems sometimes to 20 cm in diameter; stem of some species flat undulate to 30 cm wide. Largest vines observed in studied area are *Anamirta cocculus, Afgekia filipes, Byttneria tortilis, Entada phaseoloides, Epipremnum pinnatum, Erythropalum scandens, Fissistigma* sp., *Gnetum montanum* and *Strychnos* sp. Genuine herbaceous climbers are not common and may be found only in more or less open places, usually on rocky outcrops and on cliffs. Herbaceous vines observed here are *Aristolochia contorta, Clematis uncinata, Stephania sinica, Stephania* sp. and *Trichosanthes* spp.

1.1.3a. Wind-formed modification. Closed primary evergreen seasonal tropical lowland broad-leaved short forests on vertical and sub-vertical cliffs on crystalline highly eroded limestone at elevation 400-700 m asl.

Forests of this type are observed on extra steep rocky slopes and on sub-vertical cliffs commonly with inclination to 80-90°. Such plant communities cover inaccessible cliffy portions of remnant karstic limestone mountain slopes, often bordered mountain tops or ridges edges. Their vertical structure, species composition and natural conditions are very similar to those found in short forests on mountain tops, described in detail in following paragraph. Coverage of all layers of cliff forests in primary conditions may reach 100%, but commonly much less. Exploration of these forests by description of model plots is difficult due to physical inaccessibility of habitats, particularly in rainy season. Noticeably, that forests on extra steep slopes and on cliffs is alone plant community, which can retain their intact structure and composition of primary aboriginal species under deep anthropogenic degradation of limestone vegetation all over Vietnam. Very often, such forests represent last miserable fragments of primary vegetation covered vast areas in prehistoric ages.

1.1.3b. Wind-formed modification. Closed primary evergreen seasonal tropical lowland broad-leaved short forests on rocky mountain tops on crystalline highly eroded limestone at elevation 400-700 m asl.

Forests of mountain summits occupies not more than 2-3% of study territory being inserted into matrix of primary forest that covers extensive area of mountain slopes. Like large archipelago composed with numerous small islands, they occupy very small-square rocky habitats on tops of mountains and narrow edges of ridges. Beside miserable portion in total plant cover, these forests have high specifity including many endemic species in all strata. Some species found here are strictly endemic of very limited distribution. This is particularly true for epiphytic and lithophytic herbs abundant in top mountain forests.

Short broad-leaved forests were studied on mountain peaks with elevation 550-700 m asl. In all cases, studied forest habitats were bordered by more or less high cliffs along their square perimeter. Meantime, mountain summits itself were rocky, but more or less flat with open rock outcrops (60)70-90(95)%. White to light gray solid, crystalline, marble like, highly eroded limestone is main kind of mother rocks in all observed area. The leaf litter cover is actually absent on rocky forest floor. All fallen leaves here are accumulated in deep limestone pockets, caverns and crevices, where they form layer to 20-30 cm thick. This layer in some cases may reach even 1 m in depth. Fertile dark brown to nearly black humus rich-soils 20-50 cm thick are placed here below leaf litter layer. Such soil and drainage features form specific

natural conditions necessary for growth of most woody and herbaceous species, characteristic for mountain top forest.

Vertical structure of short mountain top communities (or woodlands or scrubs- not closed forest) is much simpler than structure observed in forests on slopes. Usually communities here are composed by only 2 woody layers of trees and shrubs. Herbaceous and mosses/lichen strata commonly also well presented, but their coverage often not too high. In some cases, bamboo thickets also observed in form of short additional well pronounced layer.

First (canopy) forest layer is composed by trees (4)6-10(12) m tall with DBH 10-25 cm. Nevertheless small dimensions, some trees here may be very old, as their growth on rocky limestone is commonly very slow. Coverage of this layer varies from 10 to 40% and some cases may reach 70-80%. Most common species observed here as forest layer co-dominants are *Abelia chinensis, Adinandra* sp., *Antidesma bunius, Ardisia* sp., *Beilschmiedia pergamentacea, Calophyllum balansae, Calophyllum dryobalanoides, Campylotropis henryi, Caryota maxima, Cinnamomum* sp., *Diospyros* sp., *Garcinia oblongifolia, Garcinia* sp., *Homalium phanerophlebium, Hopea siamensis, Illicium cambodianum, Ixora cuneifolia, Magnolia liliifera, Memecylon edule, Miliusa fusca, Phoebe tavoyana, Phyllanthus insularis, Pistacia cucphuongensis, Pittosporum pauciflorum, Podocarpus neriifolius, Psychotria* sp., *Radermachera* sp., *Sinosideroxylon wightianum, Styrax litseoides, Tirpitzia sinensis, Xerospermum microcarpum.*

As most common trees in top mountain forest were specified such species as *Abelia chinensis, Campylotropis henryi, Hopea siamensis* and *Pistacia cucphuongensis*. Specifity of canopy forest is fairly high. Some trees occur only in this kind of habitat. Among them are such rare endemic and sub-endemic species as *Abelia chinensis, Calophyllum balansae, Calophyllum dryobalanoides, Campylotropis henryi, Illicium cambodianum, Memecylon edule, Phyllanthus insularis, Pistacia cucphuongensis, Pittosporum pauciflorum, Sinosideroxylon wightianum* and *Tirpitzia sinensis.*

Second (shrub) layer, 2-4(5) m tall includes not very many species, but its coverage may reach 30-40 and even 60%. Saplings of trees of first stratum form essential portion of density. Mainly these are young trees of such species as *Calophyllum balansae, Campylotropis henryi, Garcinia oblongifolia, Hopea siamensis, Illicium cambodianum, Litsea* sp., *Memecylon edule, Pittosporum pauciflorum, Sinosideroxylon wightianum* and *Tirpitzia sinensis*. Very often, particularly in habitats damaged in the past by fire, more or less dense layer of bamboo thicket 1-2 m tall present. In intact habitats, bamboo regularly absent, but in mountain tops where vegetation was disturbed by fire, bamboo (unidentified in sterile state) forms, as a rule, very dense impassible thickets with coverage to 90%.

Third (herbaceous) layer is presented by exclusively lithophytic herbs 5-100 cm tall. They survive here only in limestone pockets and rock crevices and form coverage only 5-10%. Nevertheless, their species composition is enough rich and include a number of local endemic species. Among herbs in mountain-top forests were observed are *Aeschynanthus* sp., *Anoectochilus calcareus, Antrophyum callifolium, Ardisia* spp., *Aspidistra* sp., *Asplenium antrophioides, Asplenium cardiophyllum, Asplenium tenuifolium, Asplenium thunbergii, Begonia crassula, Begonia* sp., *Campylotropis henryi, Carex* sp., *Cheirostylis chinensis, Colysis dissimilialata, Cyclopeltis crenata, Habenaria calcicola, Hedyotis acutangula, Impatiens verrucifer, Nephelaphyllum tenuiflorum, Ophiopogon reptans, Ophiopogon* sp., *Ophiorrhiza sanguinea, Ophiorrhiza* sp., *Piper albispicum, Pseudodracontium* sp., *Pteris plumbea, Rhomboda petelotii, Selaginella* sp., *Tropidia curculigoides, Tupistra theana.*

Rocky habitats on mountain tops are rather dry and some herbaceous species here belong to true stem, or leaf succulents. Plant with juicy succulent leaves like *Begonia crassula*, or herbs

with bottle-like stems like *Impatiens verrucifer* gives to rocky outcrops characteristic desert appearance.

Lichen and mosses cover is weak and is presented by juvenile, unidentifiable lithophytes growing mainly on north faced rocks. Their total cover is commonly much less than 10%. Epiphytes in intact primary mountain-top short forests reach their maximal abundance in study area. Some epiphytic species grow here in great abundance, forming continue unbroken cover of rock outcrops and stems of old gnarled trees. Most usual species in this group are *Appendicula hexandra, Ceratostylis subulata, Dendrobium spatella, Dendrobium terminale, Dendrobium truncatum, Eria spirodela, Eria thao, Flickingeria angustifolia, Flickingeria fimbriata, Pholidota levelleana, Pholidota yunnanensis, Pyrrosia lanceolata, Pyrrosia lingua, Thelasis pygmaea* and *Vaccinium dunalianum*. Small creeping epiphytic vines like *Dischidia acuminata* and *Dischidia tonkinensis* also allied to this group.

Small herbaceous and woody vines are not rare, but their participation in forest cover here is not significant. Among vines and climbers are most common such species as *Alyxia hainanensis, Bauhinia ornata, Clematis uncinata, Clematis* sp., *Morinda officinalis, Morinda umbellata, Pottsia grandiflora, Secamone* sp. and *Ventilago* sp. Among plants of unusual living forms are not rare parasitic canopy shrubs, mainly species of *Loranthus* sp. Species composition of short mountain-top forests are very characteristic and rich in aboriginal strictly endemic rare species. Three species found here during field assessment are found and described as new for science. They are *Begonia crassula, Bulbophyllum salmoneum* and *Tupistra theana.*

It is noticeable that short mountain-top communities were damaged in the past by anthropogenic or natural forest fires in largest part of mountain tops and ridges edges. Plant communities are presented by different stages of regeneration successions in such localities. They often appear in form of open shrubs or woodlands. Regeneration of primary forest and full spectrum of aboriginal species composition after forest fire and soil degradation grows extremely slow and needs many hundreds years. It is usual picture in any rocky limestone areas all over Vietnam (Averyanov et al., 2000). Lithophytic component is most sensitive, regeneration of which sometimes very problematic.

1.2 Submontane

1.2.1. Closed primary evergreen seasonal tropical submontane broad-leaved, mixed or coniferous forests (with Dacrydium elatum and Dacrycarpus imbricatus) on steep rocky slopes and on mountain tops on crystalline highly eroded limestone at elevation 700-800(900) m asl.

It is provisionally accepted that submontane tropical forests spread in Indochina, above nominal elevational belt at about 700-800 m asl. (Averyanov et al., 2003a,b,c, 2004). In studied area forest of this type covers only few tops of mountains elevated higher than 700 m. Submontane forests have structure similar to lowland forests, but species compositions here are fairly different. Climate conditions of submontane forests are more humid and essentially cooler. Numerous cool-loving and even temperate floristic elements are characteristic feature that brightly outline specifity of these woods.

Mixed and monotonuosly coniferous forests are most characteristic and peculiar kind of vegetation in studied area with very rich and specific species composition. Noticeably that primary coniferous forests all over the world and in Indochina represent one of the most endangered kind, extinction of which has presently catastrophic character (Averyanov et al., 2000, 2005a, c, 2008; Nguyen Tien Hiep et al., 2004; Orlova, Averyanov, 2004). Coniferous forest on rocky limestone with domination of *Dacrydium elatum* and *Dacrycarpus imbricatus* have unique strictly endemic nature. These plant communities on rocky limestone firstly

discovered in 1997 by Averyanov L., Phan Ke Loc and Nguyen Tien Hiep and shortly described later (Averyanov et al., 2005b) are typical for PNKB NP area and probably do not occur anywhere outside Quang Binh province.

Mixed and coniferous submontane forests were observed on high part of steep mountain slopes and on summits of limestone mountains at elevation 750-800 m asl. Mountain rocks here composed by solid, marble-like gray limestone with outcrops 3-5%. Leaf litter with considerable portion of conifer needle-like leaves has 100% coverage and 5 to 10 cm depth, up to 30-40 cm thick in depressions. Upper soil horizon well structured, dark brown, to 10 cm in depth placed on fine limestone gravel 15-25 cm thick, deeper lies rough gravel bedded directly on solid limestone.

First (canopy) layer in mixed and coniferous forests is formed by broad-leaved and coniferous trees 25-30 m tall, 60-80 cm DBH. Main dominants here are *Dacrydium elatum, Dacrycarpus imbricatus* and *Hopea siamensis*. Their coverage reaches 50%.

Second layer includes trees 10-20 m tall with DBH 10-20 cm. Coverage of this stratum varies from 60 to 70%. Following species were observed as most common co-dominants in this stratum: *Archidendron clypearia, Camellia* sp., *Cinnamomum* sp., *Diospyros* sp., *Garcinia* sp., *Hopea siamensis, Magnolia* sp., *Podocarpus neriifolius, Symplocos* sp., as well as representatives of such families as Euphorbiaceae, Fagaceae, Magnoliaceae, Rubiaceae and Theaceae.

Third (shrub) layer, 4-10 m tall, coverage 60-70%. It is rich and includes following commonly observed species: *Calophyllum balansae, Calophyllum* sp., *Camellia lutescens, Cinnamomum* sp., *Diospyros* sp., *Enkianthus quinqueflorus, Ficus variolosa, Garcinia* sp., *Glycosmis ovoidea, Illicium cambodianum, Ixora* sp., *Lasianthus cyanocarpus, Lithocarpus* sp., *Magnolia* spp., *Medinilla* sp., *Phoebe tavoyana, Podocarpus neriifolius.* Saplings of *Dacrycarpus imbricatus* and *Dacrydium elatum* commonly found in this stratum give evidence of natural regeneration of first forest storey.

Fourth (herbaceous) layer includes herbs, undershrubs and juvenile plantlets 0.01-4 m tall with total coverage estimated as 20-40%. Terrestrial herbs, undershrubs and ferns are main dominants in this stratum. Seedlings of woody species of highest strata are also common in this layer, among which were regularly observed *Archidendron* sp., *Arenga westerhoutii, Calamus* sp., *Dacrycarpus imbricatus* and *Korthalsia* sp.

Stratum of mosses and lichens is relatively well developed and covers about 5% of forest floor. Some moss species form on particularly steep slopes characteristic *Sphagnum*-like pillows 1-3 cm tall. Lianas are rather uncommon. Regularly they are small short vines or juvenile samples of large woody climbers. Among species of this group were specified following species *Entada phaseoloides, Piper* sp., *Psychotria serpens, Luvunga* sp., *Smilax* sp. and *Tetrastigma* sp.

It should be mentioned that main dominant of studied coniferous forests *Dacrycarpus imbricatus* and *Dacrydium elatum* are reasonably regarded as vulnerable (A1cd and A2cd respectively) according to IUCN criteria (Nguyen Tien Hiep et al., 2004). Forests dominated with these species are globally endangered kind of primary vegetation desired priority in conservation actions.

1.2.1a. Wind-formed modification. Closed primary evergreen seasonal tropical submontane broad-leaved, mixed and coniferous short forests on vertical and subvertical cliffs on crystalline highly eroded limestone at elevation 700-800(900) m asl.

Wind-formed modifications on subvertical cliffs were observed on extra steep slopes and cliffs of highest mountains. Domination or co-domination of conifer species are main

specifity of these plant community. Coverage may be relatively low, but species composition is similar with conifer plant communities on rocky mountain tops, which are shortly mentioned below.

1.2.1b. Wind-formed modification. Closed primary evergreen seasonal tropical submontane broad-leaved, mixed and coniferous short forests on rocky mountain tops on crystalline highly eroded limestone at elevation 700-800(900) m asl.

Wind-formed coniferous forest modifications on rocky mountain tops are rare. Coniferous wind form short forests cover highest rocky inaccessible tops of remnant limestone mountains bordered commonly by high vertical cliffs. As main coniferous dominants observed in the area were *Dacrydium elatum*, *Dacrycarpus imbricatus* and strictly endemic *Calocedrus rupestris*. Great abundance of epiphytic and lithophytic aboriginal endemic species, particularly ferns and orchids are very characteristic feature of these plant communities. Coniferous short mountain top forests are most rich in species critically globally endangered kind of plant community.

2 Azonal primary kinds of plant communities

2.1. Riparian riverine shrub and herbaceous communities on swampy and rocky steam/river valleys

This kind of vegetation is poor presented in study area due to torrential character of water regime in streams and small rivers that straightly follow to amount of rainy precipitation. In period from September to December, water level dramatically increase. All sparse plants inhabited river beds appear at this time flooded. Regular inundation is very strong limited factor decreasing plant diversity of such habitats.

2.2. Aquatic riverine aquatic herbs communities on steams and rivers

Due to torrential character of water regime in streams and small rivers aquatic plants are very rare and includes few poorly developed plantlets not desirable for special study.

3. Secondary plant communities

Intact primary forests in proximity to inhabited regions, agricultural field, roads, farms and any explored areas are replaced by more or less disturbed and secondary plant communities that represent different stages of successive degradation of aboriginal forests described above. All following plant communities are common in studied area. However, they were not subject of detailed study in present survey.

3.1. Open medium and highly disturbed primary forests

Very usual modification commonly observed on perimeter of any inhabited territory. Cutting of large trees with high quality timber is main disturbing structure of initial stage of forest degradation. Usually this process eliminates first (canopy) forest stratum, but species composition on this stage remain very rich, not actually differing from species spectrum of intact primary forest. This kind of the forest is common in studied area.

3.2. Rich secondary forests and woodlands

Also very common modification observed everywhere near inhabited areas. It characterized by replacing of aboriginal native trees of highest forest strata by fast growing plants which often not typical for intact primary wood. Species composition remains rich.

3.3. Poor secondary forests and woodlands

Further degradation of aboriginal forest is observed everywhere in conditions of increasing of anthropogenic pressure. The elimination of almost all timber trees by cutting, leads to more or less fast growth of both aboriginal and allochtonous elements. Forest structure and species

composition become poorer and more and more different from aboriginal species spectrum. The increasing of anthropogenic pressure commonly stops forest regeneration and leads to succeeded it degradation into scrub communities.

3.4. Closed and open secondary scrubs

Pasturing is usual widespread additional factor of forest degrading into closed and open scrub. Scrub plant communities are very common along roads and in vicinities of villages in study area. They commonly appear as vast pasturelands with numerous shrubby species. Under permanent pasturing, this is climax plant community. Forest usually does not regenerate under these conditions. Species composition may be enough rich, but taxonomic spectrum dramatically differs from species composition of primary forest. Large portion here have introduced, exotic and adventives species alien to aboriginal flora.

3.5. Secondary herbaceous communities and grasslands

Secondary herbaceous communities and grasslands are final climax stage of vegetation degradation. Such communities are also common in inhabited area. Aboriginal plants have miserable portion in such communities. Exotic weed species have absolute domination here.

3.1.3 Flora

Up to date, a total of 2,804 species of vascular plants belonging to 201 families and 6 fila has been recorded in PNKB NP. Annex 1 shows the full list of the recorded species and Table 2.1 below shows the species diversity by families. Species diversity widely varies between families. Orchidaceae has the highest species diversity with 247 species. Then follow Rubiaceae (162 species), Euphorbiaceae (146 species), Lauraceae (92 species), Fabaceae (69 species), Apocynaceae (65 species) and Moraceae (62 species). Seven families have more than 50 species each; 18 families have 31-50 species each; 43 families have 11-31 species each; 28 families have 6-10 species each; and 105 families have only 1-5 species each.

Table 2.1 List of recorded families and their species diversity in PNKB NP

No. of species in fam.	No. of families (ratio)	Families and number of species in each family
1- 5	105 (74,6%)	PSILOTACEAE (1 loài), OPHIOGLOSSACEAE (1), DICKSONIACEAE (1), GRAMMITIDACEAE (1), PLAGIOGYRIACEAE (1), CEPHALOTAXACEAE (1), CUPRESSACEAE (1), TAXACEAE (1), BASELLACEAE (1), BOMBACACEAE (1), BUDDLEIACEAE (1), CARICACEAE (1), CARDIOPTERIDACEAE (1), CHENOPODIACEAE (1), DATISCACEAE (1), DAPHNIPHYLLACEAE (1), ELAEAGNACEAE (1), HYDRANGEACEAE (1), ITEACEAE (1), IXONANTHACEAE (1), LINACEAE (1), NYCTAGINACEAE (1), PANDACEAE (1), PENTAPHRAGMATACEAE (1), PENTAPHYLACACEAE (1), ICACINACEAE (1), PLATANACEAE (1), PORTULACEAE (1), RHIZOPHORACEAE (1), SALICACEAE (1), SAURURACEAE (1), SCHISANDRACAEA (1), SONNERATIACEAE (1), SPHENOCLEACEAE (1), STACHYURACEAE (1), AMARYLLIDACEAE (1), ASPARAGACEAE (1), BROMELIACEAE (1), CANNACEAE (1), CENTROLEPIDACEAE (1), FLAGELLARIACEAE (1), HYDROCHARITACEAE (1), STEMONACEAE (1), EQUISETACEAE (2), DIPTERIDACEAE (2), GLEICHENIACEAE (2), CECROPIACEAE (2), MARSILEACEAE (2), CYCADACEAE (2), BALANOPHORACEAE (2), CAMPANULACEAE (2), OLACACEAE (2), LECYTHIDACEAE (2), MOLLUGINACEAE (2), NYSSACEAE (2), ONAGRACEAE (2), OPILIACEAE (2), PITTOSPORACEAE (2), PLANTAGINACEAE (2), PRIMULACEAE (2), ACORACEAE (2), CONVALLARIACEAE (2), IRIDACEAE (2), POTAMOGETONACEAE (2), TRILLIACEAE (2), VITTARIACEAE (3), ANCISTROCLADACEAE (3), AQUIFOLIACEAE (3), CONNARACEAE (3),

		CONVOLVULACEAE (3), CORNACEAE (3), HAMAMELIDACEAE (3), HYPERICACEAE (3), MALPIGHIACEAE (3), MELIOSMACEAE (3), STYRACACEAE (3), DANVALLIACEAE (4), LOMARIOPSIDACEAE (4), PODOCARPACEAE (4), BALSAMINACEAE (4), BOMBACACEAE (4), CHLORANTHACEAE (4), LARDIZABALACEAE (4), LEEACEAE (4), PASSIFLORACEAE (4), SIMAROUBACEAE (4), STAPHYLEACEAE (4), HYPOXYDACEAE (4), MUSACEAE (4), ORCHIDACEAE (4), PHORMIACEAE (4), ADIANTACEAE (5), BLECHNACEAE (5), HYMENOPHYLLACEAE (5), OLEANDRACEAE (5), ACTINIDIACEAE (5), ALANGIACEAE (5), APIACEAE (5), DILLENIACEAE (5), HERNANDIACEAE (5), LORANTHACEAE (5), OXALIDACEAE (5), VIOLACEAE (5), DRACAENACEAE (5), TACCACEAE (5)
6- 10	28 (13,9%)	ANGIOPTEERIDACEAE (6), CYATHEACEAE (6), ACERACEAE (6), COMBRETACEAE (6), JUGLANDACEAE (6), LYTHRACEAE (6), POLYGALACEAE (6), THYMELAEACEAE (6), XANTHOPHYLLACEAE (6), MARANTACEAE (6), SCHIZEACEAE (7), GNETACEAE (7), CAPRIFOLIACEAE (7), ILLICIACEAE (7), MARATTIACEAE (8), ICACINACEAE (8), RANUNCULACEAE (8), SELAGINELLACEAE (9), WOODSIACEAE (9), AMARANTHACEAE (9), ARISTOLOCHIACEAE (9), BIGNONIACEAE (9), POLYGONACEAE (9), LYCOPODIACEAE (10), ASCLEPIADACEAE (10), BURSERACEAE (10), SYMPLOCACEAE (10), ULMACEAE (10)
11 - 30	43 (21,4%)	LAMIACEAE (11), PROTEACEAE (11), RHAMNACEAE (11), DIOSCOREACEAE (11), SMILACACEAE (11), CAPPARACEAE (12), SCROPHULARIACEAE (12), LOBELIACEAE (13), PTERIDACEAE (14), DIPTEROCARPACEAE (14), MALVACEAE (15), MENISPERMACEAE (15), ROSACEAE (15), TILIACEAE (15), TECTARIACEAE (16), THELYPTERIDACEAE (16), COMMELINACEAE (16), DENNSTAEDTIACEAE (17), ERICACEAE (17), MYRISTICACEAE (17), SOLANACEAE (17), ANACARDIACEAE (18), CLUSIACEAE (18), SAPOTACEAE (18), OLEACEAE (19), ARALIACEAE (20), SAPINDACEAE (20), ELAEOCARPACEAE (21), CONVALLARIACEAE (21), ASPLENIACEAE (22), BEGONIACEAE (22), CELASTRACEAE (22), DRYOPTERIDACEAE (23), FLACOURTIACEAE (23), CUCURBITACEAE (24), PIPERACEAE (24), MAGNOLIACEAE (25), MYRTACEAE (25), ZINGIBERACEAE (25), GESNERIACEAE (26), MIMOSACEAE (27), CYPERACEAE (27), EBENACEAE (28)
31 - 50	18 (9,0%)	ACANTHACEAE (32), MELASTOMATACEAE (32), THEACEAE (32), ARECACEAE (32), MELIACEAE (33), STERCULIACEAE (35), VITACEAE (35), URTICACEAE (36), ARACEAE (37), POLYPODIACEAE (39), ASTERACEAE (41), CAESALPINIACEAE (41), ANNONACEAE (43), MYRSINACEAE (45), VERBENACEAE (45), FAGACEAE (47), RUTACEAE (48), GRAMINEAE (49)
> 50	7 (4,8%)	MORACEAE (62), APOCYNACEAE (65), FABACEAE (69), LAURACEAE (92), EUPHORBIACEAE (146), RUBIACEAE (162), ORCHIDACEAE (247)

Out of 2,804 plant species recorded in PNKB NP, 456 species are of conservation priority, including 84 species enlisted in 2015 IUCN Red List, 116 species in Red Data Book of Viet Nam in 2007, 254 species in CITES Appendix I and Appendix II, 25 species under Decree 32/2006/ND-CP of Vietnam Government and 88 locally endemic species. The list of all conservation priority species is presented in Annex 2. Table 2.2 shows the list of 58 globally threatened species that includes 9 species under critically endangered (CR), 16 species under endangered (EN) and 33 species under vulnerable (VU) category.

Table 2.2 The most globally threatened plant species recorded in PNKB NP

No.	Scientific name	IUCN, 2015
1.	*Dipterocarpus gracilis* Blume	CR
2.	*Dipterocarpus hasseltii* Blume	CR
3.	*Dipterocarpus turbinatus* C.F.Gaertn. f.	CR
4.	*Hopea chinensis* (Merr.) Hand.-Mazz. (*Hopea mollissima* C. Y. Wu)	CR
5.	*Hopea hainanensis* Merr. et Chun	CR
6.	*Hopea reticulata* Tardieu	CR
7.	*Vatica diospyroides* Symington	CR
8.	*Diospyros mun* A.Chev. ex Lecomte	CR
9.	*Aquilaria crassna* Pierre ex Lecomte	CR
10.	*Calocedrus rupestris* Aver.	EN
11.	*Mangifera dongnaiensis* Pierre	EN
12.	*Afzelia xylocarpa* (Kurz) Craib	EN
13.	*Erythrophloeum fordii* Oliv.	EN
14.	*Dipterocarpus alatus* Roxb. ex G.Don	EN
15.	*Dipterocarpus costatus* Gaertn.	EN
16.	*Hopea ferrea* Laness.	EN
17.	*Hopea pierrei* Hance	EN
18.	*Vatica cinerea* King	EN
19.	*Annamocarya sinensis* (Dode) J.-F. Leroy	EN
20.	*Cinnamomum mairei* H.Lév.	EN
21.	*Magnolia nana* Dandy	EN
22.	*Paphiopedilum concolor* (Lindl. ex Bateman) Pfitzer	EN
23.	*Paphiopedilum dianthum* Tang et F.T. Wang	EN
24.	*Paphiopedilum godefroyae* (God.-Leb.) Stein	EN
25.	*Paphiopedilum malipoense* S.C. Chen et Z. H.Tsi	EN
26.	*Cephalotaxus mannii* Hook.f.	VU
27.	*Cycas pectinata* Buch.-Ham.	VU
28.	*Cycas siamensis* Miq.	VU
29.	*Amentotaxus yunnanensis* H. L. Li	VU
30.	*Mangifera flava* Evrard.	VU
31.	*Mangifera pentandra* Hook.f.	VU
32.	*Pistacia cucphuongensis* Dai & Yakovlev	VU
33.	*Xylopia pierrei* Hance	VU
34.	*Bursera tonkinensis* Guillaumin	VU
35.	*Dipterocarpus retusus* Blume	VU
36.	*Hopea odorata* Roxb.	VU
37.	*Diospyros candolleana* Wight	VU
38.	*Dalbergia tonkinensis* Prain	VU
39.	*Fagus longipetiolata* Seemen	VU
40.	*Bennettiodendron cordatum* Merr.	VU
41.	*Hydnocarpus annamensis* (Gagnep.) Lescot & Sleumer	VU
42.	*Hydnocarpus hainanensis* (Merr.) Sleumer	VU
43.	*Illicium ternstroemioides* A. C. Sm.	VU
44.	*Alseodaphne hainanensis* Merr.	VU
45.	*Aglaia perviridis* Hiern	VU

46.	*Horsfieldia longiflora* W.J. de Wilde	VU
47.	*Knema mixta* W.J.de Wilde	VU
48.	*Knema pierrei* Warb.	VU
49.	*Knema poilanei* W.J. de Wilde	VU
50.	*Knema squamulosa* W.J. de Wilde	VU
51.	*Knema tonkinensis* (Warb.) W.J.de Wilde	VU
52.	*Diplopanax stachyanthus* Hand.-Mazz.	VU
53.	*Platanus kerrii* Gagnep.	VU
54.	*Boniodendron minus* (Hemsl.) T.C.Chen *(Sinoradlkofera minor* (Hemsl.) F.G. Mey.)	VU
55.	*Madhuca hainanensis* Chun et F.C. How	VU
56.	*Madhuca pasquieri* (Dubard) H. J. Lam	VU
57.	*Styrax litseoides* J.E.Vidal	VU
58.	*Camellia fleuryi* (A. Chev.) Sealy	VU

3.2 HIN NAM NO NATIONAL CONSERVATION AREA

3.2.1 Status of botanical study

Vegetation and flora in HNN NCA is very poorly studied. There are only two key studies in the area. A study conducted by Tran Ngoc Ninh and Pheng Phaengsintham under Wildlife and habitat survey programme organized by WWF-Laos and WCS - Laos in 1998-1999. This study identified 6 major forest types and recorded 521 species of vascular plants in HNN area (Walston & Vinton 1999). Second study was conducted by Vichith Lamxay during 2014-2015, under the Hin Nam No Region Project. This study described 6 major forest types, recorded 182 species of vascular plants (166 species with herbarium vouchers) and identified 67 indicator species (Lamxay 2014). Furthermore, this study provided baseline data on species diversity, distribution, abundance, indicator species and ecological features of key forest types in HNN NCA (Lamxay 2015).

3.2.2 Vegetation

As mentioned above, 6 major forest types were identified in HNN NCA (Walston & Vinton 1999, Lamxay 2014). These forest types are described in more details in Lamyxay (2014) as cited below. They are: (1) Degraded Forest, (2) Semi-Evergreen Forest, (3) Mixed Deciduous Forest, (4) Bamboo Forest, (5) Riverine Forest and (6) Karst Forest. All forest types were described and classified based on their flora composition and different elevation from 200-500 m. Out of 6 forest types, Mixed deciduous, Semi-evergreen and Karst forest are the dominant forest types in HNN NCA.

1) Degraded Forest

Forest at the foot hill of Phou Louang mountains near the villages was very seriously disturbed by development of agriculture land. Two subtypes of disturbed habitats were found in the area:

1.1The Pure stand of tall grass is composed of tall grass *Thysanolaena latifolia* c.4-5 m tall as a pure stand of dominant broom grass species with small trees c. 3-4 m tall as *Peltophorum dasyrrhachis* (Caesalpiniaceae), *Cratoxylum formosum* (Hypericaceae), *Triadica cochinchinensis*, *Mallatus barbatus, Macaranga denticulata* (Euphorbiaceae), *Trema orientalis* (Ulmaceae) and *Phoebe lanceolata* (Lauraceae).

1.2 The Old disturbed area (more than 5 years) is composed of deciduous and evergreen trees c. 8-10 m tall. The dominant trees in upper (canopy) layer are *Peltophorum dasyrrhachis* (Caesalpiniaceae), *Cratoxylum formosum* (Hypericaceae), *Triadica cochinchinensis*,

Mallatus barbatus, Macaranga denticulata (Euphorbiaceae). The middle layer is dominated by evergreen small trees c. 5 m tall such as *Antidesma* spp., *Aporosa villosa, Baccaurea ramiflora, Breynia glauca, Glochidion sphaerogynum* (Euphorbiaceae), *Phoebe lanceolata* (Lauraceae), *Trema orientalis* (Ulmaceae), *Maesa ramentacea, Ardisia* spp. (Myrsinaceae). The liana *Acacia* spp. (Fabaceae), *Smilax* spp. (Smilacaceae), *Dioscorea* spp. (Dioscoreaceae) and *Combretum* spp. (Combretaceae). Lower layer is dominated by herbs that are *Alpinia* sp., *Amomum* sp. and *Etlingera* sp. *Zingiber* sp. (Zingiberaceae), *Tacca integrifolia* (Taccaceae), palm are *Rhapis laosensis, Caryota mitis* and *Daemonorop* sp.

2) Semi-evergreen forest

Semi-evergreen forest occurs on the slopes of Phou Chang King mountains in the HNN NCA, at elevations 250-500 m. The floristic composition of the Semi-evergreen forest is composed of the mixture of large evergreen and some deciduous trees c. 40-45 m in height and c. 80-100 cm in diameter. This forest consist of three layers:

The upper layer is dominated by evergreen trees of Dipterocarp species c. 25-40 m tall as *Anisoptera costrata, Dipterocarpus retusus*; *D. costatus*, *Hopea ferrea*, *Shorea thorelii* (Dipterocarpaceae), *Bischoffia javanica* (Euphorbiaceae), *Alstonia costratas* (Apocynaceae), *Mangifera caloneura* and *M. sylvatica* (Anacardiaceae) and the large Fabaceous tree *Erythrophleum fordii* mixed with large deciduous trees as *Tetrameles nudiflora* (Datiscaceae), *Largestroemia* spp. (Lythraceae) and *Peltophorum dasyrrhachis* (Leguminosae).

The middle layer is composed of evergreen trees c. 10-20 m in height as *Barringtonia longipes* (Lecythidaceae), *Saraca indica* (Caesalpiniaceae), *Baccaurea ramiflora* (Euphorbiaceae), *Castranopsis* sp. and *Lithocarpus* sp. (Fagaceae), *Cinnamonum* spp., *Phoebe lanceolata* (Lauraceae), *Diospiros* spp. (Ebenaceae), *Canthium umbellatum* (Rubiaceae), Sysygium sp. (Myrtaceae).

The lower layer is composed of small trees c. 5 m tall *Aralia chinensis, Trevesia palmata* (Araliaceae), *Memecylon* sp. (Melastomaceae), *Antidesma* spp., *Bacaurrea ramiflora, Breynia glauca* (Euphorbiaceae), *Dillenia ovata* (Dilleniaceae), *Knema* sp. (Myristicaceae), *Chassalia curviflora* var. *ophioxyloides, Chassalia curviflora* var. *longifolia*, *Gardenia sootepensis, Hedyotis capitellata*, *Hedyotis elegans*, *Ixora javanica, Ixora fusca, Lasianthus hirsutus, Oxyceros horridus*, *Pavetta petiolaris*, *Prismatomeris* sp. , *Psychotria* sarmentosa, *Schizomussaenda dehiscens, Uncaria macrophylla* (Rubiaceae), *Goniothalamus* spp., *Artabotrys* spp., *Polyalthia* spp. (Annonaceae), *Pandanus fibrisus* (Pandanaceae).

The liana that were found are *Acacia* spp., *Bauhinia scandens*., *Derris* sp., *Entada glandulosa* (Fabaceae), *Cnestis* sp., *Connarus* spp. (Connaraceae), *Ampelocissus martinitii, Tetrastigma leucostaphyllum* (Vitaceae), *Smilax* spp. (Smilaceae) but epiphytic fern, orchids, Araceae (e.g *Photos*), *Dischidia, Hoya* (Asclepiadaceae) and some parasitic Loranthaceae were found. Palm *Calamus , Areca triandra, Caryota mitis* and *Rhapis* are abundant species in the lower layer. Epiphytic fern were also found such as: *Adiantum caudatum*, (Pteridaceae), *Pteridium aquilium* (Dennstaedtiaceae), *Hymenophyllum barbatum* (Hymenophyllaceae), *Diplazium esculentum* (Woodsiaceae) .

The Bamboo species *Dendrocalamus lonoifimbriatus, Kinabaluchloa wrayi, Schizostachum virgatum, Pseudostachyum polymorphum* and *Neohouzeana mekongensis* (Gramineae) were found as dominant bamboo species in under shade of this forest.

At range of Phou Chang king mountain, the forest structure and floristic composition undergo changes from lowland (200 m elevation) near the Xe Bang Fai river side to the top of mountains (c. 500 m elevation). The hill semi-evergreen forest can be classified into two subtypes such as the (a) Semi-evergreen hill limestone forest with bamboo population under shade of large trees and (b) Semi-evergreen hill limestone forest without bamboo. In addition,

differences could be observed in the dominant composition of key species and indicator species. At lower elevations, there is the greatest significant population of the hard wood trees "Mai Kacha" *Erythrophleum fordii Oliv.* (between 200 m to 350 m). Higher up (300-450 m) is dominant key species to be large trees belonging to the Dipterocarp family such as "Mai Ngang deng" *Dipterocarpus costatus*. On the highest level, where bare rocks are mixed with sandy soil (elevation 350-500 m) there are a concentration of "Mai Ken hin" *Hopea ferrea* (Dipterocarpaceae) presented. At the same altitude, where there were only rocks and very little soil, the forest type becomes more like Karst forest and the dominant indicator tree species *Diospiros* spp., ebony, were found. At the core zone of Kouan Ka Ane (the large flat area along the Houay Ka Ane river and along the foot of limestone mountains), mostly Semi-evergreen forest was presented. The floristic composition of the Semi-evergreen forest here is composed of the mixture of large evergreen and deciduous trees c. 40-45 m in height and c. 80-150 cm in diameter. This forest also has three layers:

The upper layer is dominated by evergreen trees of Dipterocarp species c. 25-40 m tall as *Dipterocarpus retusus*; *D. costatus* (Dipterocapaceae), *Bischoffia javanica* (Euphorbiaceae), *Alstonia costratas* (Apocynaceae), *Mangifera caloneura and M. sylvatica* (Anacardiaceae), *Pterocarpus macrocarpus* (Fabaceae) and the large trees of *Callerya atropurpurea* mixed with large deciduous trees as *Tetrameles nudiflora* (Datiscaceae), *Largestroemia* spp. (Lythraceae) and *Neonauclea purpurea* (Rubiaceae). In addition, there was also large trees of *Ficus* spp. (Moraceae).

The middle layer is composed of evergreen trees c. 10-20 m in height as *Barrintonia longipes* (Lecythidaceae), *Saraca indica* (Caesalpiniaceae), *Baccaurea ramiflora* (Euphorbiaceae), *Cinnamonum* spp., *Phoebe lanceolata* (Lauraceae), *Sysygium* sp. (Myrtaceae), *Streblus taxoides* (Moraceae).

The lower layer is composed of small trees c. 5 m tall *Aralia chinensis, Trevesia palmata* (Araliaceae), *Memecylon* sp. (Melastomaceae), *Antidesma* spp., *Bacaurrea ramiflora* (Euphorbiaceae), *Dillenia ovata* (Dilleniaceae), *Knema* sp. (Myristicaceae), *Psychotria sarmentosa* (Rubiaceae), *Goniothalamus* spp., *Artabotrys* spp., *Polyalthia* spp. (Annonaceae), *Pandanus fibrisus* (Pandanaceae). The liana that were found are *Acacia* spp., *Bauhinia scandens, Entada glandulosa* (Fabaceae), *Ampelocissus martinitii, Tetrastigma leucostaphyllum* (Vitaceae), *Smilax* spp. (Smilaceae) but epiphytic fern, orchids, Araceae (e.g. *Photos*), *Dischidia, Hoya* (Asclepiadaceae) and some parasitic Loranthaceae were found. Palm species of rattan *Calamus* spp., *Areca triandra, Caryota mitis* and two species of *Rhapis* as *Rhapis laosensis* and *Rhapis gracilis* are abundant species in the lowest layer. Epiphytic fern and orchid were found. No Bamboo species were found here.

3) Mixed deciduous forest

Mixed deciduous forest that occurs in the flat land along Xe Bang Fai river and also in the lower Kouan Ka Ane area in the HNN NCA, at elevation 250-350 m. The floristic composition of the mixed deciduous forest is composed of the mixture of large deciduous trees c. 40-45 m in height and c. 50-100 cm in diameter on the top of canopy and some evergreen trees in the top and middle of canopy. This forest has three layers:

The upper layer is dominated by deciduous tree species c. 25-40 m tall as the large deciduous trees as "Mai Phoung" *Tetrameles nudiflora* (Datiscaceae), "Mai Peuay" *Largestroemia caliculata* and *L. floribunda* (Lythraceae), "Mai Houa Lone" *Parkia sumatrana* Miq. "Mai A Rang" *Peltophorum dasyrrhachis* (Caesalpiniaceae), "Mai Ngen" *Terminalia bellirica* (Combrataceae).

The middle layer is composed of evergreen trees c. 10-20 m in height as "Som hor" *Allospondias lakonensis* (Anacardaceae), "Ka Chian" *Polyalthia cerasoides* (Annonaceae),

“Mai ngen” *Terminalia bellirica* (Combretaceae), “Mak San” *Dillenia ovata* (Dilleniaceae) “Ngang Khao” *Dipterocarpus alatus* (Dipterocarpaceae) “Nom Ngan” *Barrintonia longipes* (Lecythidaceae), “Mak Fai” *Baccaurea ramiflora* (Euphorbiaceae), “Khe hom” *Cinnamonum* spp., “Phai Ven” *Phoebe lanceolata* (Lauraceae). “Dang dam” *Diospiros* spp. (Ebenaceae), “Mak Mong” *Garcinia speciosa* (Clusiaceae), “Ka bok” *Irvingia malayana* (Ixonanthaceae) “Mak Had” *Artocarpus lakoocha and Ficus* spp. (Moraceae), “Tom” *Mitragyna rotundifolia* (Rubiaceae).

The lower layer is composed of small trees c. 5 m tall *Memecylon* sp. (Melastomaceae), *Antidesma* spp., *Bacaurrea ramiflora, Breynia glauca* (Euphorbiaceae), *Chassalia curviflora* var. *ophioxyloides, Chassalia curviflora* var. *longifolia, Gardenia sootepensis, Hedyotis capitellata, Hedyotis elegans, Ixora javanica, Ixora fusca, Lasianthus hirsutus, Oxyceros horridus, Pavetta petiolaris, Prismatomeris* sp. , *Psychotria* sarmentosa, *Schizomussaenda dehiscens* (Rubiaceae), *Goniothalamus* spp., *Artabotrys* spp., *Polyalthia* spp. (Annonaceae), *Pandanus fibrisus* (Pandanaceae), *Alpinia* spp. *Amomum* spp. *Zingiber* spp. (Zingiberaceae).

The liana that were found are *Acacia* spp., *Bauhinia scandens., Entada glandulosa* (Fabaceae), *Connarus* spp. (Connaraceae), *Ampelocissus martinitii, Tetrastigma leucostaphyllum* (Vitaceae), *Smilax* spp. (Smilaceae) but epiphytic fern, orchids, Araceae (e.g. *Photos scanden*), *Dischidia* sp., *Hoya* spp. (Asclepiadaceae) and some parasitic plants

Loranthaceae were found. Palm *Calamus* spp., *Areca triandra, Caryota mitis* and *Rhapis gracilis* are abundant species in the lower layer. Epiphytic fern *Adiantum caudatum,* (Pteridaceae), *Pteridium aquilium* (Dennstaedtiaceae), *Hymenophyllum barbatum* (Hymenophyllaceae), *Diplazium esculentum* (Woodsiaceae) were found. Bamboo species were not found in this forest.

4) Bamboo forest

Almost pure stands of Bamboo were found in scattered area at Kouan Ka Ane and range of Phou Chang King. They consisted of dominant bamboo species such as “Mai Sod” *Pseudostachyum polymorphum* and/or “Mai Hia” *Schizostachum virgatum* and/or “Mai Phang” *Dendrocalamus longifimbriatus* (Graminae) c. 10 tall as a pure stand of dominant bamboo species with an upper layer of some scattered large evergreen trees (20-25 m high) “Mai Ngang Deng” *Dipterocarpus costratus* (Dipterocarpaceae) and deciduous trees such as “Mai Phoung” *Tetrameles nudiflora* (Datiscaceae), “Mai Peuay” *Largestroemia caliculata* and *L. floribunda* (Lythraceae), “Mai Houa Lone” *Parkia sumatrana*

The middle layer is dominated by one or two bamboo species mixed with some smaller evergreen trees (5-10 m tall) such as “Mai A Rang” *Peltophorum dasyrrhachis* , “Mai Khi Mou”*Callerya atropurpurea* (Leguminoseae), “Ka bok” *Irvingia malayana* (Ixonanthaceae), “Mak mong” *Garcinia speciosa* (Clusiaceae), “Mak Lam ngai pa” *Dimocarpus longan* (Sapindaceae), *Triadica cochinchinensis, Mallatus barbatus, Macaranga denticulata* (Euphorbiaceae), *Trema orientalis* (Ulmaceae) and *Phoebe lanceolata* (Lauraceae). There are some NTFPs in the undergrowth in Bamboo forest, however, “San” *Rhapis gracilis* (Arecaceae), *Goniothalamus* spp. and *Polyanthia* spp. (Annonacea), “Nam Koi” *Streblus taxoides* (Moraceae) and “Mak Neng” *Amomum* spp. (Zingiberaceae).

5) Riverine/Riverside forest

Along the Xe Bang Fai river, Houy Kai river and Houay Ka An, the dominant species are typical of riverine forest such as “Mai Ka Ma” *Saraca indica* (Caesalpiniaceae). The large trees of Mai Ka Ma are useful as they protect the riverside from erosion by their large spread and fibrous roots and large trunk at base. In doing so this tree is like a 'keystone' species, providing a habitat for other species such as “Mak Deua” *Ficus* spp. (Moraceae), “Mai Phoung” *Tetrameles nudiflora* (Datiscaceae) and “Mai Khom Phad” *Bischofia javanica*

(Euphorbiaceae). The other riverine plant species are *Homonoia riparia*, *Trewia nudiflora* (Euphorbiaceae), *Crateva magna* (Capparidaceae), *Elaeocarpus stipularis* (Elaeocarpaceae) also the lage and long spread of climber *Acacia* spp.,"Keua siou" *Bauhinia scandens*., " Keua Mak Ba" *Entada glandulosa* (Fabaceae), "Keua to tep" *Connarus* spp. (Connaraceae), *Ampelocissus martinitii, Tetrastigma leucostaphyllum* (Vitaceae). At Xe Bang Fai riverside the dominant tree species are "Mai Ka Ma" *Saraca indica* (Caesalpiniaceae), *Acer oblongum* (Aceraceae), *Syzygium mekongensis* (Myrtaceae), *Homonoia riparia* (Euphorbiaceae) and large trees of *Ficus* spp. (Moraceae).

6) Karst forest

Karst forest features are well developed in areas of limestone. Essentially no quantitative data exists on the community structure and species richness of limestone forests. Brief descriptions for such forests in the HNN NCA of Khammouane Province lists *Dracaena fragrans* (Dracaenaceae), *Arenga pinnata* (Arecaceae), and *Dendrocalamus* (Gramineae) as dominant species (Rundel, 1999). However, in this survey, the floristic composition of karst forest was examined at Pha Koun Ka An. The special dominant species in the karst forest are the ebony wood tree species from the *Diospyros* group or "Mai Moun" group e.g. *Diospyros curranii, D. variegate* and *Diospyros wallichii* (Ebenaceae). Another typical karst species is the single stem dragon blood tree species *Dracaena loureiri* (Dracaenaceae). Other species also occur but remain small (3-7m) due to the stressed conditions of high temperature and lack of water. They often have swollen trunks and large spread root systems, e.g. " Mai Nhom" *Toona ciliata* (Meliaceae), "Mai Po deng" *Sterculia pexa* and *Sterculia urena* (Sterculiaceae), " Mak Hai" *Ficus* spp. and "Mai Nam Koi" *Streblus taxoides* (Moraceae), "Peuay dok khao" *Lagestroemia* sp. (Lythraceae), *Hymenodictyon orixense* (Rubiaceae), *Vitex* sp. (Verbanaceae). Some herbaceous species also seem to be able to survive on the rock surface, e.g. *Euphorbia antiquorum* (Euphorbiaceae) and *Raphidophora* spp. (Araceae), *Elatostema, Aganostemma, Begonia, Impatien, Peliosanthes, Amorphophallus, Steudnera,* and *Gesneriaceae* species. Last but not least, several species of Orchids e.g. *Dendrobium* spp. and ferns are presented in Karst forest.

3.2.3 Flora

Very little is known about flora in HHN NCA. A total of 567 species of vascular plants belonging to 121 families and 5 fila were recorded from the area (Annex 1). The list of recorded families and their species diversity is presented in Table 2.3. The species diversity widely varies between families. Ninety four families (77.7% of total family number) have only 1-5 species each; 14 families have 6-10 species each; 11 families have 11-30 species each. There are only 2 families which have more than 30 species each: Rubiaceae (31 species) and Orchidaceae (48 species). Further inventory is necessary to get better understanding of species diversity of flora in HNN NCA.

Table 2.3 List of recorded families and their species diversity in HNN NCA

No.of species in fam.	No.of families (Ratio)	Families and their species richess
1- 5	94 (77,7%)	LYCOPODIACEAE (1 loài), EQUISETACEAE (1), OPHIOGLOSSACEAE (1), ADIANTACEAE (1), ANGIOPTEERIDACEAE (1), ASPLENIACEAE (1), CYATHEACEAE (1), DICKSONIACEAE (1), GLEICHENIACEAE (1), PTERIDACEAE (1), GNETACEAE (1), ACERACEAE (1), ALANGIACEAE (1), ANCISTROCLADACEAE (1), BORAGINACEAE (1), CUSCUTACEAE (1), DATISCACEAE (1), FLACOURTIACEAE (1), BIXACEAE (1), HAMAMELIDACEAE (1), HERNANDIACEAE (1), HYPERICACEAE (1), ILLICIACEAE (1), IXONANTHACEAE (1), JUGLANDACEAE (1), CRYPTERONIACEAE (1), OLEACEAE (1), OXALIDACEAE (1),

		PASSIFLORACEAE (1), PITTOSPORACEAE (1), PLANTAGINACEAE (1), CRASSULACEAE (1), PORTULACEAE (1), RHAMNACEAE (1), SAURAUIACEAE (1), SCROPHULARIACEAE (1), SONNERATIACEAE (1), THYMELAEACEAE (1), URTICACEAE (1), VIOLACEAE (1), ACORACEAE (1), COSTACEAE (1), DRACAENACEAE (1), HYPOXYDACEAE (1), IRIDACEAE (1), TACCACEAE (1), SELAGINELLACEAE (2), WOODSIACEAE (2), ASCLEPIADACEAE (2), BOMBACACEAE (2), ICACINACEAE (2), MALVACEAE (2), MYRISTICACEAE (2), OPILIACEAE (2), POLYGONACEAE (2), SAPOTACEAE (2), OCHNACEAE (2), SIMAROUBACEAE (2), THEACEAE (2), TILIACEAE (2), ULMACEAE (2), CONVALLARIACEAE (2), DIOSCOREACEAE (2), PANDANACEAE (2), SMILACACEAE (2), MARANTACEAE (3), AMARYLLIDACEAE (3), SCHIZEACEAE (3), PODOCARPACEAE (3), CYCADACEAE (3), AMARANTHACEAE (3), BIGNONIACEAE (3), CAPPARACEAE (3), ELAEOCARPACEAE (3), JUGLANDACEAE (3), LECYTHIDACEAE (3), MENISPERMACEAE (3), PIPERACEAE (3), ROSACEAE (3), COMMELINACEAE (3), ANNONACEAE (4), APIACEAE (4), ARALIACEAE (4), DILLENIACEAE (4), LOBELIACEAE (4), LYTHRACEAE (4), VITACEAE (4), POLYPODIACEAE (5), ACANTHACEAE (5), CLUSIACEAE (5), CUCURBITACEAE (5), RUTACEAE (5), SAPINDACEAE (5), ZINGIBERACEAE (5),
6- 10	14 (11,6%)	COMBRETACEAE (6), CONVOLVULACEAE (6), FAGACEAE (6), MYRTACEAE (6), CYPERACEAE (6), EBENACEAE (7), LAURACEAE (7), MELASTOMATACEAE (7), MYRSINACEAE (7), ASTERACEAE (9), DIPTEROCARPACEAE (9), MELIACEAE (9), ANACARDIACEAE (10), SOLANACEAE (10),
11 - 30	11 (9,1%)	STERCULIACEAE (11), VERBENACEAE (11), APOCYNACEAE (12), MIMOSACEAE (12), ARECACEAE (16), ARACEAE (17), CAESALPINIACEAE (19), GRAMINEAE (19), FABACEAE (22), EUPHORBIACEAE (26), MORACEAE (26)
31 - 50	2 (1,7%)	RUBIACEAE (31), ORCHIDACEAE (48)

Out of 567 recorded plant species, 106 species are of conservation priority, including 32 species listed in 2015 IUCN Red List, 35 species in Vietnam Red Data Book in 2007, 56 species in CITES Appendix I and Appendix II , 17 species under Decree 32/2006/ND-CP of Vietnam Government and 11 locally endemic species (Annex 2). Table 2.4 shows the list of globally threatened species including 4 species at critically endangered (CR), 6 species at endangered (EN), and 10 species at Vulnerable (VU) category.

Table 2.4 List of the most globally threatened plant species recorded in HNN NCA

No	Scientific name	IUCN (2015)
1.	*Dipterocarpus turbinatus* C.F.Gaertn. f.	CR
2.	*Hopea chinensis* (Merr.) Hand.-Mazz. (*Hopea mollissima* C. Y. Wu)	CR
3.	*Diospyros mun* A.Chev. ex Lecomte	CR
4.	*Aquilaria crassna* Pierre ex Lecomte	CR
5.	*Afzelia xylocarpa* (Kurz) Craib	EN
6.	*Erythrophloeum fordii* Oliv.	EN
7.	*Dipterocarpus alatus* Roxb. ex G.Don	EN
8.	*Dipterocarpus costatus* Gaertn.	EN
9.	*Hopea ferrea* Laness.	EN
10.	*Vatica cinerea* King	EN
11.	*Cycas pectinata* Buch.-Ham.	VU
12.	*Cycas siamensis* Miq.	VU
13.	*Mangifera flava* Evrard.	VU

14.	*Mangifera pentandra* Hook.f.	VU
15.	*Dipterocarpus retusus* Blume	VU
16.	*Hopea odorata* Roxb.	VU
17.	*Dalbergia tonkinensis* Prain	VU
18.	*Knema pierrei* Warb.	VU
19.	*Knema poilanei* W.J. de Wilde	VU
20.	*Madhuca pasquieri* (Dubard) H. J. Lam	VU

PART 3
FAUNA OF PHONG NHA - KE BANG AND HIN NAM NO

3.1 MAMMAL FAUNA

3.1.1 Status of the mammal faunal study

Phong Nha - Ke Bang NP: Before 2000, there were some mammal surveys conducted by WWF - Indochina, FFI - Indochina, Birdlife International in Vietnam and Vietnam - Russian Tropical Centre (VRTC). Results of these studies were reported in Eames et al. (1994), Le Xuan Canh et al. (1997), Nguyen Xuan Dang et al. (1998), Do Tuoc & Truong Van La (1999), Timmins et al. (1999a) and WWF-VRTC (1999). Meijboom & Ho Thi Ngoc Lanh (2002) summarized results of these studies in a book "*Flora and fauna of Phong Nha-Ke Bang and Hin Namno*". This document provides a list of 134 mammal species recorded in PNKB-HNN region (PNKB NP: 132 species, HNN NCA: 58 species) and some discussion of conservation importance of the mammal fauna in the region.

During 2000-2010, short mammal surveys were conducted by scientists from Institute of Ecology and Biological Resources, Hanoi National University, Kyoto University (Japan), and Vietnam-Russian Tropical Centre. Most results of these studies were un-published. During 2011-2012, the "Nature Conservation and Sustainable Natural Resource Management in PNKB NP Region Project" supported a series of intensive biodiversity surveys in and outside PNKB NP including mammal surveys with focus on Rodents (Rodentia), Insectivorous (Soricomorpha), Bats (Chiroptera) and Primates (Primates). Results of the mammal studies are presented in un-published reports of Nguyen Manh Ha & Do Tuoc (2011), Nguyen Xuan Dang & Nguyen Xuan Nghia (2011), Bleisch et al. (2012) and Vu Dinh Thong et al. (2012).

Hin Nam No National Conservation Area: Mammal fauna in HNN NCA is very little studied. Before 2000, there were some short surveys conducted by WWF- Laos and WCS - Laos in collaboration with Laos research agencies. The most notable studies in this period are wildlife and habitat surveys conducted by WWF- Laos and WCS - Laos during 1998-1999. Results of these surveys were published in Walston & Vinton (1999), Duckworth et al. (1999) and Meijboom and Ho Thi Ngoc Lanh (2002). Later publication compiled a list of 58 mammal species recorded in HNN NCA. After 2000, there are very few mammal studies in HNN NCA, however, some data on mammal fauna of HNN NCA can be found in Timmins et al. (2003), Jenkins et al. (2005), Musser et al. (2005), Timmins & Duckworth (2008), Timmins & Boonratana (2008), Phiapalath (2009), Vongsa (2010), Coudrat et al. (2012), Timmins & Duckworth (2013), Vongkhamheng (2014),...

3.1.2 Taxonomic composition of the mammal fauna

Up to date, 150 mammal species from 32 families and 11 orders have been recorded in PNKN - HNN region (PNKB NP: 143 species of 32 families and 11 orders; HNN NCA: 75 species of 32 families and 11 orders). Full list of recorded species is presented in Annex 3 and Table 3.1 shows the taxonomic structure of the mammal fauna.

Table 3.1 Taxonomic structure of mammal fauna in PNKB-HNN region

English name (order, family)	Scientific name (order, family)	Number of recorded species		
		PNKB-HNN	PNKB	HNN
I. Ord. SCANDENTS	**Scandentia**	**2**	**1**	**2**
1. Fam. Treeshrews	Tupaiidae	2	1	2
II. Ord. FLYING LEMURS	**Dermoptera**	**1**	**1**	**0**

2. Fam. Colugos	Cynocephalidae	1	1	0
III. Ord. PRIMATES	**Primates**	**11**	**9**	**11**
3. Fam. Slow Loris	Lorisidae	2	2	2
4. Fam. Monkeys	Cercopithecidae	8	6	8
5. Fam. Gibbons	Hylobatidae	1	1	1
IV. Ord. LAGOMORPH	**Lagomorpha**	**2**	**2**	**1**
6. Fam. Hares and Rabbits	Leporidae	2	2	1
V. Ord. ERINACEOMORPH	**Erinaceomorpha**	**1**	**1**	**0**
7. Fam. Gymnures	Erinaceidae	1	1	0
VI. Ord. SORICOMORPH	**Soricomorpha**	**4**	**4**	**1**
8. Fam. Shrews	Soricidae	3	3	1
9. Fam. Moles	Talpidae	1	1	0
VII. Ord. BATS	**Chiroptera**	**54**	**50**	**22**
10. Fam. Old World Fruit Bats	Pteropodidae	9	8	3
11. Fam. Horseshoe Bats	Rhinolophidae	11	10	6
12. Fam. Old World Leaf-nosed Bats	Hipposideridae	7	7	3
13. Fam. Old World False Vampires	Megadermatidae	2	2	2
14. Fam. Sheath-tailed Bats	Emballonuridae	1	1	0
15. Fam. Plain-nosed Bats	Vespertilionidae	22	20	7
16. Fam. Bent-winged Bats	Miniopteridae	2	2	1
VIII. Ord. PANGOLINS	**Pholidota**	**2**	**2**	**1**
17. Fam. Pangolins	Manidae	2	2	1
IX. Ord. CARNIVORES	**Carnivora**	**30**	**30**	**16**
18. Fam. Cats	Felidae	7	7	5
19. Fam. Civets	Viverridae	9	9	4
20. Fam. Mongooses	Herpestidae	2	2	1
21. Fam. Dogs	Canidae	1	1	1
22. Fam. Bears	Ursidae	2	2	2
23. Fam. Mustelids	Mustelidae	9	9	3
X. Ord. EVEN-TOED UNGULATES	**Artiodactyla**	**8**	**8**	**8**
24. Fam. Pigs	Suidae	1	1	1
25. Fam. Mousedeers	Tragulidae	1	1	1
26. Fam. Deers	Cervidae	3	3	3
27. Fam. Cattle, Buffalo, Goats,...	Bovidae	3	3	3
XI. Ord. RODENTS	**Rodentia**	**35**	**35**	**12**
28. Fam. Squirrels	Sciuridae	10	10	7
29. Fam. Bamboo Rats	Spalacidae	2	2	1
30. Fam. Rats and Mouses	Muridae	20	20	1
31. Fam. Porcupines	Hystricidae	2	2	2
32. Fam. Rock Rats	Diatomyidae	1	1	1
Total (species):		**150**	**143**	**75**

Note: PNKB: Phong Nha - Ke Bang NP, HNN: Hin Nam No NCA

Order Bats (Chiroptera) has the highest species diversity with 54 species recorded (PNKB NP: 50 species, HNN NCA: 20 species), accounting for 36.0% of total number of species recorded in the region. The second highest species diversity is order Rodents (Rodentia) with 35 species recorded (PNKB NP: 35 species, HNN NP: 12 species). Then follow orders Carnivores (Carnivora) with 30 species, Primates (Primates) with 11 species, Even-toed Ungulates (Artiodactyla) with 8 species and Soricomorpha with 4 species. Other orders

(Pholidota, Erinaceomorpha, Lagomorpha, Scandentia and Dermoptera), have only 1-2 species each.

3.1.3 Conservation significance of the mammal fauna

PNKB-HNN region is a site of global significance for the conservation of mammal biodiversity, especially in term of Primates, Carnivores and Bats. In PNKB NP alone, 143 mammal species were recorded, accounting for 45.3% of total number of known mammal species in Vietnam (Nguyen Xuan Dang et al. 2016). Ten (10) of 24 primate species occurred in Vietnam are found in PNKB NP. In addition, PNKB NP harbors a world largest population of Hatinh langur *Trachypithecus hatinhensis* and Vietnam largest population of Red-shanked Douc *Pygathryx nemaeus* (Bleisch et al. 2012). PNKB NP is a home for 30 of 39 carnivore species known to occur in Vietnam including the most threatened species (see Tale 3.3). To date, at least 50 bat species are known to occur in PNKB NP, representing 41.3% of the total bat species in Vietnam and approximate 4.0% of total bat species in the World (Vu Dinh Thong, 2011). PNKB NP contains a great number of cave systems, including the world largest caves. The cave systems together with various forest habitats are ideal homes for bats, but very few of which were surveyed on bats. Number of bat species recorded from PNKB NP is rapidly increased over the surveys, strongly indicating that bats of PNKB NP would be much more diverse than the currently known. In addition, PNKB NP is the only locality of Vietnam with confirmed record of *Macroglobosus sobrinus*.

In HNN NCA, 75 mammal species was recorded. The fauna contains seven species of Primate, five of which are globally threatened. The Red-shanked Douc *Pygathrix nemaeus* and the Southern White-cheeked Gibbon *Nomascus siki* are charismatic ‘flagship' species of the NCA, and along with the Black Langur *Trachypithecus laotum* are globally endangered. HNN NCA harbours the largest and one of the last viable populations of these two endangered langurs in the world (DoFRM, 2015). Like PNKB NP, HNN NCA contains the great number of cave systems, including the world largest caves which should support very rich bat fauna in the area.

PHNK - HNN region is the home of 73 mammal species of conservation priority (PNKB NP: 70 species, HNN NCA: 48 species) including 38 globally threatened species, 46 species locally threatened in Vietnam, 48 species locally threatened in Laos, 41 species under Decree 32/2006/ND-CP and 25 species under Decree 160/2013/ND-CP of Vietnamese Government and 8 species endemic to Vietnam and Laos (Table 3.2, Annex 4).

Table 3.2 Number of conservation priority species recorded in PNKB-HNN Region

Area	Total (species)	IUCN (2015)	VNRB (2007)	LSR (1999)	ND 32 (2006)	ND 160 (2013)	Ende-mic
PNKB	**70**	37	45	41	40	24	6
HNN	**48**	31	34	35	28	19	8
PNKB & HNN	**73**	38	46	48	41	25	8

Notes: IUCN: 2015 IUCN Red List, VNRB: Vietnam Red Data Book in 2007, ND32: Decree 32/2006/ND-CP, ND160: Decree 160/2013/ND-CP of Vietnam Government, LSR: Lao's Wildlife Status Report (Duckworth et al. 1999)

3.1.4 Mammal species of conservation priority

Out of 73 mammal species of conservation priority recorded in PNKB-HNN region, 48 species are globally threatened (Table 3.3) including 3 species at critically endangered (CR), 9 species at endangered (EN), 16 species at vulnerable (VU) and 9 species at near threatened (NT) category.

Table 3.3 Globally threatened mammal species recorded in PNKB-HNN Region

No.	Scientific name	English name	Distribution		IUCN (2015)
			PNKB	HNN	
1.	*Manis javanica*	Sunda Pangolin	c		CR
2.	*Manis pentadactyla*	Chinese Pangolin	c	c	CR
3.	*Pseudorys nghetinhensis*	Sao la	u	u	CR
4.	*Pygathrix nemaeus*	Red-shanked Douc	c	c	EN
5.	*Trachypithecus hatinhensis*	Hatinh Langur	c	c	EN
6.	*Trachypithecus francoisi*	Francois's Langur		c	EN
7.	*Nomascus siki*	White-cheeked Gibbon	c	c	EN
8.	*Prionailurus viverrinus*	Fishing Cat	u		EN
9.	*Panthera tigris*	Tiger	c	c	EN
10.	*Cuon alpinus*	Dhole	c	u	EN
11.	*Muntiacus vuquangensis*	Large-antlered Muntjak	c	c	EN
12.	*Laonastes aenigmamus*	Laotian Rock Rat	c	c	EN
13.	*Nycticebus bengalensis*	Slow loris	c	u	VU
14.	*Nycticebus pygmaeus*	Pygmy loris	c	u	VU
15.	*Macaca arctoides*	Stump-tailed Macaque	c	c	VU
16.	*Macaca leonina*	Pig-tailed Macaque	c	c	VU
17.	*Trachypithecus laotum*	Laotian Langur		c	VU
18.	*Hipposideros cineraceus*	Lesser Leaf-nosed Bat	c		VU
19.	*Neofelis nebulosa*	Clouded Leopard	u	u	VU
20.	*Arctictis binturong*	Binturong	c	c	VU
21.	*Chrotogale owstoni*	Owston's Civet	c	u	VU
22.	*Viverra megaspila*	Large-spotted civet	c		VU
23.	*Helarctos malayanus*	Sun Bear	c	c	VU
24.	*Ursus thibetanus*	Asiatic Black Bear	c	c	VU
25.	*Aonyx cinerea*	Oriental Small-clawed Otter	c	u	VU
26.	*Lutrogale perspicillata*	Smooth-coated Otter	u	u	VU
27.	*Rusa unicolor*	Sambar	c	c	VU
28.	*Bos frontalis*	Gaur	c	c	VU
29.	*Macaca assamensis*	Assamese Macaque	c	c	NT
30.	*Viverra zibetha*	Large Indian Civet	c		NT
31.	*Lutra lutra*	Eurasian Otter	c		NT
32.	*Arctonyx collaris*	Hog Badger	c	c	NT
33.	*Panthera pardus*	Leopard	c		NT
34.	*Catopuma temminckii*	Asian Golden Cat	c	u	NT
35.	*Pardofelis marmorata*	Mabled Cat	c	u	NT
36.	*Myotis pilosus*	Peters's Big-footed Bat	c	c	NT
37.	*Capricornis milneedwardsii*	Chinese Serow	c	c	NT
38.	*Ratufa bicolor*	Black Giant Squirrel	c	c	NT
		Total (species):	**36**	**31**	**38**

Note: IUCN - IUCN Red List (IUCN, 2016); c - confirmed record, u-un-confirmed record. CR - Critically endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened

PNKB-HNN Region is especially important for conservation of Hatinh langur *Trachypithecus hatinhensis,* Red-shanked Douc *Pygathrix nemaeus,* Laotian Black lagur *Trachypithecus laotum,* Southern White-cheeked Gibbon *Nomascus siki,* Malaysian Bear *Helarctos*

malayanus, Sun bear *Ursus thibetanus*, Chinese Serow *Capricornis milneedwardsii*, Annamite Striped Rabit *Nesolagus timminsii* and Laotian Rock Rat *Laonastes aenigmamus*.

- **Hatinh langur *Trachypithecus hatinhensis***

Hatinh langur is an endemic species of Northern Annamite Range in Vietnam and Laos. Current distribution range of Hatinh langur is limited to karst forests in western Quang Binh and Quang Tri Provinces of Vietnam and small area in eastern Khammouane province of Laos (Duckworth et al. 1999; Nadler et al. 2003; trong Nadler et al. 2004). The population of Hatinh langur in PNKB NP is the world largest population (Nadler et al. 2010). Pham Nhat (2002) estimated the population constisted of some 800 individuals at maximum. However, using line-transect census method, Haus et al. (2009) estimated the population size of 1,670 - 2,610 individuals. In Laos, Hatinh langur is reported to have very limited distribution area with confirmed record only in HNN NCA (Duckworth et al. 1999, Nadler et al. 2003).

- **Red-shanked Douc *Pygathrix nemaeus***

Red-shanked Douc is an endemic species of Great Annamite Range with distribution range covering eastern central Laos and Northern Annamite in Vietnam (Nadler et al. 2007). Recently, the species is reported to occur in Campuchia, however, the population status is unkown (Ngoc Thanh Vu et al. 2008). In Vietnam, Red-shanked Douc occurs from Nghe An to Kon Tum Provinces and PHNKB NP harbours the largest population of 445 – 2.137 individuals (Haus et al. 2007). In Laos, Red-shanked Douc occurs from Nam Kading NCA in Bolikhamxay Province to Se Kong river in Attapeu Province. The largest population is found in basin of Nam Theun river where Nakai-Nam Theun NCA and HNN NCA are situated. This is also the wold largest population of Red-shanked Douc.

- **Laotian Black Langur *Trachypithecus laotum***

Laotian Black Langur occurs only in 2 provinces of Laos: Khammouane and Bolikhamxay provinces. Global population size of this species is currently unknown, however, surveys showed that they were common in an area of 500 - 2.000 km^2 (Timmins & Boonratana 2008). HNN NCA may habour the world largest population of Laotian Black Langur (Dang et al. 1999)

- **White-cheeked Gibbon *Nomascus siki***

White-cheeked Gibbon is endemic to central Annamite Range both in Vietnam and Laos. In Vietnam, the species is found from South Ha Tinh to North Quang Tri provinces. No data of its population size in Vietnam is available, however, recent studies indicate that PNKB NP may harbour the largest population of this species. Le Trong Dat et al. (2009) found 37 groups of about 100 individuals in an area of 5,400 ha in U Bo area of PNKB NP. In Laos, White-cheeked Gibbon is found from Nam Kadinh NCA to Phou Xang He NCA and Dong Phou Vieng NCA (Van Ngoc Thinh et al, 2010). Data on its country population size is not available, however, large populations of this species were reported to occur in Nam Kadinh NCA, Nakai - Nam Theun NCA, Phou Hin Poun NCA and Hin Nam No NCA (Nguyen et al. 2008)

- **Annamite Striped Rabbit *Nesolagus timminsi***

Annamite Striped Rabit is an endemic species of Norrthern and Central Annamites. The species occurs both in Vietnam and Laos, however, major population is in Vietnam (Pham Trong Anh et al. 2007, Abramov et al. 2008). In Vietnam, Annamite Striped Rabbit occurs from Nghe An Province to Thua Thien Hue Province. The most frequent records of this species are from Quang Binh and Quang Tri Provinces. In PNKB NP, the first specimen of Annamite Striped Rabbit was collected near A Rem village, and camera-trapped pictures of

this species were obtained in 2011 and 2012 by Management Board of PNKB NP. The world largest population of Annamite Striped Rabbit supposed to occur in PNKB NP and nearby Bac Huong Hoa NR .

- **Laotian Rock Rat/Truong Son Rock Rat *Laonastes aenigmamus***

Laotian Rock Rat was first described for science in 2005 by Jenkins et al. (2005) based on specimens collected from Khammouane limestones. The species was later proved to belong ancient family Diatomyidae (Dawson et al. 2006). The discovery of Loatian Rock Rat has special scientific significance, because the species is the only living species of family Diatomyidae which was considered to be extinct 11 million years ago and represents a typical "lazarus effect" within mammals.

In 2011, during small mammal surveys in PBKN NP, a small population of Laotian Rock Rat was found in extension area of PNKB NP, in Thuong Hoa Commune, Minh Hoa District, Quang Binh Province. The species was given Vietnamese name as "Chuot da truong son - Truong Son Rock Rat" for its restrictive distribution in Truong Son (Annamite) Range (Nguyen Xuan Dang et al. 2012). Recent studies reveal significant morphological and genetic differences between Laotian and Vietnamese groups suggesting two groups may belong to different species of family Diatomyidae (Nguyen Xuan Dang et al. 2014). This makes the conservation of Laotian Rock Rat/Truong son Rock Rat even more important both in Khammouane and PNKB limestone habitats. Having restricted distribution range and undergoing high hunting pressure, Laotian Rock Rat/Truong son Rock rat has been enlisted in IUCN Red List at Endangered category (EN) since 2012 (IUCN, 2016).

3.2 BIRD FAUANA

3.2.1 Status of the bird fauna study

Phong Nha - Ke Bang NP: The first specific ornithological survey in PNKB NP was undertaken in June 1994 by BirdLife International in collaboration with the IUCN/SSC specialists. The aim of this survey was to identify areas supporting populations of endemic *Lophura* pheasants, which, if not already protected, would be suitable for protected area establishment. This survey recorded several species of conservation priority for Phong Nha area such as Sooty Babbler *Stachyris herbeti*, Red-collared Woodpecker *Picus rabieri* and Austen's Brown Hornbill *Anorrhinus austeni* (Eames *et al*. 1994, Lambert *et al*. 1994, Le Trong Trai et. 2013).

During 1996-1997, WWF-Indochina in collaboration with Institute of Ecology and Biological Resources and Forest Inventory and Planning Institute organized series of biodiversity surveys in PNKB NP. Ornithological study in these surveys was conducted by Truong Van La and 254 bird species were recorded in PNKB NP in these surveys (Le Xuan Canh et al. 1997).

From March to May 1997, the Vietnam-Russian Tropical Centre (VRTC) in collaboration with WWF - Indochina conducted a complex biodiversity expedition to Ke Bang area of PNKB NP in Thuong Hoa commune, Minh Hoa district. This expedition recorded four threatened species of birds, including Crested Argus *Rheinardia ocellata*, Sooty Babbler *Stachyris herbeti*, Red-collared Woodpecker *Picus rabieri* and Austen's Brown Hornbill *Jabouilleia danjoui* (Kalyakin 1999). Another comprehensive biodiversity survey, including birds, was conducted by Robert Timmins (Timmins *et al.* 1999). This survey recorded several globally threatened species, including Crested Argus, Chestnut-necklaced Partridge *Arborophila charltonii*, Red-collared Woodpecker and Short-tailed Scimitar Babbler *Jabouilleia danjoui*.

Meijboom and Ho Thi Ngoc Lanh (2002) aggregated results of above mentioned studies to coompile a checklist of 358 bird species recorded in PNKB NP, of which 50 species are of conservation priority.

The latest ornithological survey in PNKB NP is conducted by BirdLife International in 2011, under support of the "Nature Conservation and Sustainable Natural Resource Management in Phong Nha-Ke Bang National Park Region Project" (Le Trong Trai et al. 2011). This survey recorded 159 species of birds including 5 globally threatened species. In 2013, Le Trong Trai and his collaborators reviewed the list of bird species reported to occur in PNKB NP by various authors to exclude mistakenly recorded species. As the results they published an updated list of 303 bird species for PNKB NP (Le Trong Trai et al. 2013).

Hin Nam No NCA: The first ornithological study in HNN NCA was conducted during 1995-1996 by Timmins and Khounboline. The second ornithological study in this area was conducted in 1998 by Davidson and Showler. Results of these studies was aggreated in Walston & Vintont (1999) and Meijboom and Ho Thi Ngoc Lanh (2002). Totally, 223 bird species were recorded, of which 50 species are of conservation priority. After 2000, there are very few ornithological studies in HNN NCA. Alstrom et al. (2010) described a new bird species from PNKB - HNN region - Limestone Leaf-warbler *Phylloscopus calciatilis.* During recent years, J. Foppes - Team leader of "Intergrated nature conservation and Sustainable Resource management in Hin Nam No Region" carried his bird watching in HNN NCA and recorded many species that are not previously recorded in HNN NCA (Foppes 2016, personal communication).

3.2.2 Taxonomic composition of the bird fauna

To date, in PNKB-HNN region, ornithological studies has recorded 361 bird species belonging to 58 families and 17 orders (PNKB NP: 302 species of 55 families and 15 orders; HNN NCA: 262 species of 54 families and 17 orders). Full list of the recorded bird species is presented in Annex 5. Table 3.4 summarizes a taxonomic composition of the bird fauna.

Table 3.4 Taxonomic composition of the bird fauna in PNKB-HNN region

English name (order, family)	Scientific name (order, family)	Number of species		
		PNKB-HNN	PNKB	HNN
I. Ord. GALIFORM	GALIFORMES	**9**	**9**	**8**
1. Fam. Pheasants, Junglefowl	Phasianidae	9	9	8
II. Ord. PICIFORM	PICIFORMES	**23**	**18**	**18**
2. Fam. Woodpeckers	Picidae	15	12	12
3. Fam. Barbets	Ramphastidae	8	6	6
III. Ord. CORACIIFORM	CORACIIFORMES	**22**	**19**	**19**
4. Fam. Hornbills	Bucerotidae	5	4	5
5. Fam. Hoopoes	Upupidae	1	1	
6. Fam. Rollers	Coraciidae	2	2	2
7. Fam. Kingfishers	Alcedinidae	9	9	5
8. Fam. Bee-eaters	Meropidae	5	3	3
IV. Ord. TROGONIFORM	TROGONIFORMES	**2**	**2**	**2**
9. Fam. Trogons	Trogonidae	2	2	2
V. Ord. CUCULIFORM	CUCULIFORMES	**16**	**14**	**12**
10. Fam. Cuckoos	Cuculidae	16	14	12
VI. Ord. PSITACIFORM	PSITACIFORMES	**5**	**5**	**2**
11. Fam. Parrots	Psittacidae	5	5	2
VII. Ord. APODIFORM	APODIFORMES	**7**	**5**	**5**
12. Fam. Swifts	Apodidae	6	4	5

13. Fam. Treeswifts	Hemiprocnidae	1	1	
VIII. Ord. STRIGIFORM	STRIGIFORMES	**9**	**7**	**6**
14. Fam. Barn Owls	Tytonidae	2	1	1
15. Fam. Owls	Strigidae	7	6	5
IX. Ord. CAPRIMULGIFORM	CAPRIMULGIFORMES	**3**	**1**	**3**
16. Fam. Nightjars	Caprimulgidae	3	1	3
X. CULUMBIFORM	CULUMBIFORMES	**12**	**11**	**8**
17. Fam. Pigeons, Doves	Columbidae	12	11	8
XI. Ord. GRUIFORM	GRUIFORMES	**5**	**3**	**3**
18. Fam. Buttonquail	Turnicidae	2	1	1
19. Fam. Rails, Crakes, Coot	Rallidae	3	2	2
XII. Ord. CHARADRIIFORM	CHARADRIIFORMES	**4**	**2**	**3**
20. Fam. Snipes	Scolopacidae	2	1	2
21. Fam. Plovers	Charadriidae	2	1	1
XIII. Ord. FALCONIFORM	FALCONIFORMES	**19**	**15**	**16**
22. Fam. Hawks, Eagles	Accipitridae	14	11	11
23. Fam. Falcons	Falconidae	4	4	4
24. Fam. Osprey	Pandionidae	1		1
XIV. Ord. COCONIIFORM	COCONIIFORMES	**8**	**5**	**5**
25. Fam. Herons, Egrets, Bitterns	Ardeidae	8	5	5
XV. Ord. ANSERIFORM	ANSERIFORMES	**1**		**1**
26. Fam. Whistling Ducks	Anatidae	1		1
XVI. Ord. PELECANIFORM	PELECANIFORMES	**1**		**1**
27. Fam. Pelicans	Pelecanidae	1		1
XVII. Ord. PASSERIFORM	PASSERIFORMES	**215**	**186**	**154**
28. Fam. Pittas	Pittidae	5	5	4
29. Fam. Broadbills	Eurylaimidae	4	2	4
30. Fam. Leafbirds	Irenidae	1	1	1
31. Fam. Leafbirds	Chloropseidae	3	3	3
32. Fam. Ioras	Aegithinidae	2	2	2
33. Fam. Shrikes	Laniidae	4	4	3
34. Fam. Magpies	Corvidae	8	7	8
35. Fam. Wood-swallows	Artamidae	1	1	1
36. Fam. Orioles, Minivets	Oriolidae	3	2	3
37. Fam. Cuckoo-shrikes, Minivets	Campephagidae	7	5	6
38. Fam. Fantails	Rhipiduridae	1	1	1
39.Fam. Monarchs, Paradise-flycatchers	Monarchidae	3	3	1
40. Fam. Drongos	Dicruridae	7	7	6
41. Fam. Thrushes, Cochoas, Allies	Turdidae	11	8	8
42. Fam. Flychatchers	Muscicapidae	25	21	21
43. Fam. Starlings, Mynas	Sturnidae	9	9	6
44. Fam. Nuthatches	Sittidae	1	1	1
45. Fam. Typical Tits	Paridae	3	2	2
46.Fam. Swallows	Hirundinidae	6	4	3
47. Fam. Bulbuls	Pycnonotidae	13	11	8
48. Fam. White-eyes	Zosteropidae	2	1	2
49. Fam. Warblers	Sylviidae	22	20	13

50. Fam. Cisticolsa, Prinias	Cisticolidae	6	6	3
51. Fam. Lauginhthrushes	Timaliidae	39	36	25
52. Fam. Larks	Alaudidae	2	2	
53. Fam. Flowerpeckers	Dicaeidae	4	4	2
54. Fam. Sunbirds, Spiderhunters	Nectariniidae	9	8	7
55. Fam. Sparrows	Passeridae	4	2	3
56. Fam. Wagtails, Pipits	Motacillidae	7	5	5
57. Fam. Munias	Estrildidae	2	2	2
58. Fam. Finches	Fringillidae	1	1	
Total: 17 orders, 58 families		**361**	**302**	**262**

As usually, order Passeriformes has highest species diversity with 215 species (PNKB NP: 186 species, HNN NCA: 154 species), accounting for 59.6% of total species number recorded in the region. Orders having relatively high species diversity are Piciformes (23 species), Coraciiformes (22 species), Cuculiformes (16 species), Culumbiformes (12 species). Other orders have a species number less than 10 species each. The largest family is Timaliidae (39 species). Then follow families Muscicapidae (25 species), Sylviidae (22 species), Cuculidae (16 species), Picidae (15 species), Accipitridae (14 species), Pycnonotidae (13 species), Columbidae (12 species) and Turdidae (11 species). Other families have less than 10 species each.

3.2.3 Conservation significance of the bird fauna

PNKB-HNN region has global importance for conservation of bird biodiversity for its vast forest area, diversity of habitat types, especially the primary karst forests with restrictive access that supports a very rich, diverse and unique bird fauna. The bird fauna contains many locally endemic species which are not found anywhere in the world. PNKB NP alone harbors 302 bird species, accounting for 34% total number of bird species currently known to Vietnam. It is worth to note that bird fauna in PNKB-HNN region has not yet completely inventoried. Further studies will add many more species for the bird list and new species for science may also be discovered in the region.

PNKB NP was recognized by Birdlife International as one of 63 Important Bird Area (IBA) in Vietnam - Ke Bang IBA (Tordoff 2002). The Ke Bang IBA supports four of the seven restricted-range species that define the Annamese Lowlands Endemic Bird Area, including Sooty Babbler *Stachyris herberti*, Crested Argus *Rheinardia ocellata*, Short-tailed Scimitar Babbler *Jabouilleia danjoui* and Grey-faced Tit Babbler *Macronous kelleyi* (Le Trong Trai et al. 2013). Sooty Babbler, a species restricted to limestone forest habitats in central Vietnam and adjacent area of Laos, is quite common in Ke Bang IBA (Tordoff ed. 2002). Other three restricted-range species were also receive confirmed record in PNKB NP by recent surveys (Le Trong Trai et al. 2013).

Out of 361 species of birds recorded in PNKB-HNN region, 41 species (PNKB NP: 35 species, HNN NCA: 26 species) are of conservation priority. They comprise 10 species listed in 2015 IUCN Red List, 13 species in Vietnam Red Data Book in 2007, 25 species under Laos threatened categories, 17 species under Decree 32/2006/ND-CP and 4 species under Decree 160/2013/NĐ-CP of Vietnam Government, and 7 species endemic to PNKB-HNN region or restricted-range species (Annex 6, Table 3.5)

Table 3.5 Number of conservation priority bird species recorded in PNKB-HNN region

Area	Total (spec.)	IUCN (2015)	VNRD (2007)	LSR (1999)	ND 32 (2006)	ND 160 (2013)	Endemic, Res-range
PNKB	**35**	9	12	21	16	4	6
HNN	**26**	6	12	9	12	4	4

PNKB & HNN	**41**	10	13	25	17	4	7

Notes: IUCN: 2015 IUCN Red List, VNRD: Vietnam Red Data Book in 2007, ND32: Vietnam Government Decree 32/2006/ND-CP, ND160: Vietnam Government Decree 160/2013/NĐ-CP, LSR: Lao's Wildlife Status Report (Duckworth et al. 1999), Res-range: Restricted range species

PNKB-HNN region is a home of 10 globally threatened species (Table 3.6) including 2 species at Endangered (EN) and Vulnerable (VU), 8 species at Near-threatened (NT) category and 4 restricted-range species.

Table 3.6 Globally threatened bird species recorded in PNKB and HNN areas

No.	Scientific name	English name	Distribution		IUCN (2015)
			PNKB	HNN	
1.	*Pavo muticus*	Green Peafowl	u		EN
2.	*Aceros nipalensis*	Rufous-necked hornbill		u	VU
3.	*Picus rabieri*	Red-collared Woodpecker	c	c	NT
4.	*Buceros bicornis*	Great Hornbill	c	c	NT
5.	*Anorrhinus austeni*	Brown Hornbill	c	c	NT
6.	*Alcedo hercules*	Blyth's Kingfisher	c		NT
7.	*Ichthyophaga humilis*	Lesser Fish Eagle	c	c	NT
8.	*Terpsiphone atrocaudata*	Japanese Paradise-flycatcher	c		NT
9.	*Rheinardia ocellata*	Crested Argus	c	c	NT, RRS*
10.	*Jabouilleia danjoui*	Short-tailed Scimitar Babbler	c		NT, RRS*
11.	*Stachyris herberti*	Sooty Babbler	c	c	RRS*
12.	*Macronous kelleyi*	Grey-faced Tit Babbler	c	c	RRS*

Note: IUCN - 2015 IUCN Red List; c - confirmed record, u - unconfirmed record. CR - critically endangered, EN - endangered, VU - vulnerable, NT - Near-threatened. (*) RRS = Restricted range / Endemic (BirdLife International 2011)

Green Peafowl *Pavo muticus* is not found in HNN NCA and un-confirmly recorded in PNKB NP, while Rufous-necked hornbill *Aceros nipalensis* is un-confirmly recorded in HNN NCA and not found in PNKB NP. Further studies need to clarify status of these species in the region. Sooty Babbler *Stachyris herberti* occurs in PNKB-HNN region and DaKrong Nature Reserve in Quang Tri Province (Vietnam). Its major population is found in PNKB NP, while in DaKrong Nature Reserve the population is very small (Le Trong Trai et al. 2013). Short-tailed Scimitar Babbler *Jabouilleia danjoui* has restricted range and is found only in Northern and Central Vietnam and Central Laos. The country largest population of this species is found in PNKB NP (Le Trong Trai et al. 2013).

Limestone Leaf-warbler *Phylloscopus calciatilis* was first described in 2010 (Astrom et al. 2010) and has not yet evaluated in 2015 IUCN Red List. This species lives only in limestone broadleaved evergreen forest and limestone broadleaved semi-evergreen forest. The species was also recorded in some other locations such as Quang Ba (Ha Giang Province), Cuc Phuong NP (Ninh Binh Province), Pa Ham (Lai Chau Province), Nadi mountain and Sayphou Loyang (Bolikhamxay province, Laos), however, the birds are most abundant in PNKB-HNN region (Astrom et al. 2010).

3.3 HERPETOFAUNA

3.3.1 Status of the herpetofauna study

Phong Nha - Ke Bang NP: Before 2000, there were some herpetological surveys in PNKB NP including surveys conducted by WWF-Indochina in collaboration with Institute of Ecology and Resources and Vietnam Russian Tropical Centre (VRTC), and surveys cunducted by Collaborative programme between PNKB NP and Cologne Zoo (Germany). Results of these studies were reported in: Do Tuoc and Truong Van La (1999), Le Xuan Canh et al. (1997), WWF Indochina -VRTC (1999) and Ziegler & Herrmann (2000). Meijboom and Ho Thi Ngoc Lanh (2002) summarized results of these studies in a book " *Flora and fauna of Phong Nha-Ke Bang and Hin Namno*" published by WWF LINC Project. The book provides a list of 72 reptile and 32 amphibian species recorded in PNKB NP.

During 2000-2010, herpetofauna in PNKB NP is intensively investigated by Collaborative programme between PNKB NP and Cologne Zoo (Germany), and number of recorded species is rapidly increased including description of new species for science. Ziegler & Herrmann (2000) published a list of 111 species including 34 amphibian and 77 reptile species. Four years later, Ziegler et al. (2004) published a list of 132 species (40 amphibian and 92 reptile species). Ziegler et al. (2006) updated the list of 140 species (42 amphibian and 98 reptile species) and Ziegler et al. (2007) added 9 new species of snakes increasing the list of snake species recorded in PNKB NP to 59 species. Hendrix et al. (2008) published a list of 47 amphibian species recorded in PNKB NP. In 2009, Ziegler & Vu (2009) provided an updated list of reptiles and amphibians from PNKB NP and adjacent areas with a total of 138 species (45 species of amphibians and 93 species of reptiles). This list excluded some historical records which were not rediscovered during recent surveys in the National park such as *Bombina maxima Eutropis chapaensis, Scincella rupicola, Sphenomorphus buenloicus, Dendrelaphis pictus, Malayemys subtrijuga.*

During 2010-2011, Nguyen Quang Truong et al. (2011) carried out additional herpetological surveys in PNKB NP. This study added 8 new species records to the herpetological list of PNKB NP and one new species for science - Chalo caecilian *Ichthyophis chaloensis*, thus increasing the herpetofaunal species list of PNKB NP to 161 species (107 reptile and 54 amphibian species). In 2013, Luu Quang Vinh et al. reviewed the herpetofaunal list of PNKB NP to exclude mistakenly recorded species and updating recent taxonomic/nomenclatural changes since the last review by Ziegler & Vu (2009). As the result, they published an updated list comprising 151 species (50 amphibian and 101 reptile species) confirmedly recorded in PBKB NP.

Hin Nam No NCA: Herpetofauna in HNN NCA is poorly studied. Before 2000, there were some herpetological surveys conducted by WWF-Laos and WCS-Laos, of which the most notable are surveys in 1998-1999. Results of these surveys were published in Walston & Vinton (1999) and Duckworth et al. (1999). Meijboom and Ho Thi Ngoc Lanh (2002) summarized results of these studies to compile a list of 22 reptile and 22 amphibian species recorded in HNN area. After 2000, only few herpetological studies were conducted in HNN NCA such as Luu et al. (2013, 2015, 2015) and Ziegler et al. (2015).

3.3.2 Taxonomic composition of the herpetofauna

To date, 120 reptile species from 17 families and 58 amphibian species from 8 families have been recorded in PNKB-HNN region. In PNKB NP, 107 reptile species of 16 families and 56 amphibian species of 8 families were recorded, while in HNN NCA, 43 reptile species of 17 families and 20 amphibian species of 7 families were recorded. Full list of recorded species is presented in Annex 7 and taxonomic composition of herpetofauna is shown in Table 3.7.

Table 3.7 Taxonomic composition of herpetofauna in PNKB-HNN region

English name (class,family)	Scientific name (class,family)	Number of recorded species		
		PNKB - HNN	PNKB	HNN

Class REPTILES	REPTILIA	120	107	43
1. Fam. Agamid Lizards	Agamidae	5	5	5
2. Fam. Gekkos	Gekkonidae	16	10	11
3. Fam. True Lizards	Lacertidae	3	3	
4. Fam. Skinks	Scincidae	14	13	6
5. Fam. Glass lizards	Anguidae	1	1	
6. Fam. Monitor lizards	Varanidae	1	1	
7. Fam. Blind snakes	Typhlopidae	1	1	
8. Fam. Sunbeam snakes	Xenopeltidae	2	2	
9. Fam. Pythons	Pythonidae	2	2	
10. Fam. Colubrids	Colubridae	48	45	9
11. Fam. Kraits, coral snakes and cobras	Elapidae	5	5	1
12. Fam. Pitvipers	Viperidae	6	6	2
13. Fam. Big-headed turtle	Platysternidae	1	1	
14. Fam. Old world pond turtle	Geoemydidae	9	8	3
15. Fam. Tortoises	Testudinidae	2	2	2
16. Fam. Softshell turtles	Trionychidae	3	2	3
17. Fam. Crocodiles	Crocodylidae	1		1
AMPHIBIANS	AMPHIBIA	58	56	20
1. Fam. Toads	Bufonidae	3	3	2
2. Fam. Treefrogs	Hylidae	1	1	
3. Fam. Spadefoot frogs	Megophryidae	7	7	1
4. Fam. Narrow-mouthed frogs	Microhylidae	9	9	6
5. Fam. True frogs	Dicroglossidae	8	8	3
6. Fam. Ranids	Ranidae	13	12	5
7. Fam. Afro-Asian Treefrogs	Rhacophoridae	16	15	3
8. Fam. Asiatic tailed caecilians	Ichthyophiidae	1	1	
Total (species):		**178**	**163**	**63**

Within Reptilia, family Colubridae has the highest species diversity with 48 species reorded, accounting for 40% of total number of reptile species recorded in the region. Then follow families Gekkonidae (16 species) and Scincidae (14 species). Other families have only 1-9 species each. Within Amphibia, family Rhacophoridae has the highest species diversity with 16 species recorded, accounting for 27.6% of total number of amphibian species recorded in PNKB NP. Then follow families Ranidae (13 species), Microhylidae (9 species), Dicroglossidae (8 species), Megophryidae (7 species). Other species have only 1-3 species each.

3.3.3 Conservation significance of the herpetofauna

Results of herpetological studies in PNKB-HNN region indicate global importance of this region in herpetofaunal conservation. In HNN NCA, there are still few herpetological studies; up to date, only 63 species (43 reptile and 20 amphibian species) have been recorded. Further studies in future will add more species to the list and species new for science may be also discovered. In PNKB NP, herpetological studies have confirmed occurrence of 163 species (107 reptile and 56 amphibian species), of which 18 species are new for science (Table 3.8). Scientists are aware of further new discoveries to be described from the region in the near future (Luu et al. 2013). These facts underline the importance of PNKB NP in a regional scale and the Truong Son (Annamite) Mountain Range in a wider geographical scale as centres of biodiversity and endemism (Luu et al. 2013).

Table 3.8 List of species new for science discovered in PNKB NP

No.	English name	Scientific name
1.	Quyet's frog	*Gracixalus quyeti* (Nguyen, Hendrix, Boehme, Vu & Ziegler, 2008)
2.	Chalo caecilian	*Ichthyophis chaloensis* Geissler, Poyarkov, Grismer, Nguyen, Hang, Neang, Kupfer, Ziegler, Böhme, Müller 2014
3.	Hidden bow-fingered gecko	*Cyrtodactylus cryptus* Heidrich, Roesler, Vu, Boehme & Ziegler, 2007
4.	Phongnhakebang slender-toed gecko	*Cyrtodactylus phongnhakebangensis* Ziegler, Roesler, Hermann & Vu, 2002
5.	Roesler's bent-toed gecko	*Cyrtodactylus roesleri* Ziegler, Nazarov, Orlov, Nguyen, Vu, Dang, Dinh & Schmitz, 2010
6.	Phong Nha Ke Bang gecko	*Gekko scientiadventura* Roesler, Ziegler, Vu, Hermann & Boehme, 2005
7.	Boehme's supple skink	*Lygosoma boehmei* Ziegler, Schmitz, Heidrich, Vu & Nguyen, 2007
8.	Four-toed skink	*Sphenomorphus tetradactylus* (Darevsky & Orlov, 2005)
9.	Nogge's water skink	*Tropidophorus noggei* Ziegler, Vu & Bui, 2005
10.	Bourret's cat snake	*Boiga bourreti* Tillack, Ziegler & Le, 2004
11.	Thanh's reed snake	*Calamaria thanhi* Ziegler & Le, 2005
12.	Ruhstrat's wolf snake	*Lycodon ruhstrati abditus* Vogel, David, Pauwels, Sumonth, Norval, Hendrix, Vu & Ziegler, 2009
13.	Andrea's keelback	*Amphiesma andreae* Ziegler & Le, 2006
14.	White-lipped keelback	*Amphiesma leucomystax* David, Bain, Nguyen, Orlov, Vogel, Vu & Ziegler, 2007
15.	Smith's snake	*Fimbrios smithi* Ziegler, David, Miralles, Doan & Nguyen, 2008
16.	Siever's three horn-scaled pitviper	*Protobothrops sieversorum* (Ziegler, Herrman, David, Orlov and Pauwels, 2000)
17.	Truongson pitviper	*Viridovipera truongsonensis* (Orlov, Ryabov, Bui & Ho, 2004) (*Trimeresurus truongsonensis)*
18.	Cyclornated box turtle	*Cuora cyclornata* Blank, McCord & Le, 2006

Source: Nguyen et al. (2009), Ziegler & Vu (2009), Ziegler & Nguyen (2010), Ziegler et al. (2010) and Geissler et al. (2014.

Out of 178 species recorded in PNKB-HNN region, 41 species are of conservation priority (PNKB NP: 34 species, HNN NCA: 18 species) including 18 globally threatened species, 25 species nationally threatened in Vietnam, 17 species nationally threatened in Laos, 16 species enlisted in Decree 32/2006/ND-CP and 3 species enlisted in Decree 160/2013/ND-CP of Vietnam Government, and 8 species are endemic to Vietnam and Laos (Table 3.9).

Table 3.9 Number of conservation priority herpetofaunal species in PNKB-HNN

Area	Total (species)	IUCN (2015)	VNRD (2007)	LSR (1999)	ND 32 (2006)	ND 160 (2013	Endemic
PNKB	**34**	15	23	15	14	3	4
HNN	**18**	9	10	7	5	0	5
PNKB & HNN	**41**	18	25	17	16	3	8

Notes: IUCN: 2015 IUCN Red List, VNRD: Vietnam Red Data Book in 2007, ND32: Vietnam Government Decree 32/2006/ND-CP, ND160: Vietnam Government Decree 160/2013/NĐ-CP, LSR: Lao's Wildlife Status Report (Duckworth et al. 1999)

The list of 42 reptile and amphibian species of conservation priority is presented in Annex 8. Table 3.10 below presents the list of 19 globally threatened species recorded in PNKB-HNN region. They include 3 species at critically endangered (CR), 8 species at endangered (EN), 7 species at Vulnerable (VU) and 1 species at Low risk (LR) category.

Table 3.10 Globally threatened species recorded in PNKB-HNN region

No.	Scientific name	English name	Distribution		IUCN (2015)
			PNKB	HNN	
	I. REPTILIA	**REPTILES**			
1.	*Crocodylus siamensis*	Siamese crocodile		c	CR
2.	*Cuora bourreti*	Bourett's box turtle	c		CR
3.	*Cuora cyclornata*	Cyclornated box turtle	c		CR
4.	*Heosemys annamdalii*	Yellow headed temple turtle		u	EN
5.	*Mauremys mutica*	Asian yellow pond turtle	c		EN
6.	*Mauremys sinensis*	Chines stripe-necked turtle	c		EN
7.	*Sacalia quadriocellata*	Four-eyed turtle	c		EN
8.	*Platysternon megacephalum*	Big-headed turtle	c		EN
9.	*Cuora mouhotii*	Keeled box turtle	c	u	EN
10.	*Indotestudo elongata*	Elongated tortoise	c	u	EN
11.	*Palea steindachneri*	Wattle-necked softshell turtle	c	u	EN
12.	*Heosemys grandis*	Giant asian pond turtle	c		VU
13.	*Manouria impressa*	Impressed tortoise	c	u	VU
14.	*Amyda cartilaginea*	Southeast Asian softshell turtle		u	VU
15.	*Pelodiscus sinensis*	Chinese softshell turtle	c	u	VU
16.	*Ophiophagus hannah*	King cobra	c		VU
17.	*Python molurus*	Asiatic rock python	c		LR
	AMPHIBIA	**AMPHIBIANS**			
18.	*Rhacophorus annamensis*	Annamese flying frog	c		VU
19.	*Rhacophorus kio*	Kio whipping frog	c	c	VU

Note: IUCN - 2015 IUCN Red List; c - confirmed record, u - unconfirmed record. CR - critically endangered, EN - endangered, VU - vulnerable, NT - Near threatened.

PNKB-HNN region is especially important for conservation of turtles and tortoises. Thirteen (13) endangered species of turtles and tortoises were found in this region including 2 critically endangered species: Bourret Turtle *Cuora bourreti* and Cyclornated box turtle *Cuora cyclornata.* In addtion, a small population of Siamese crocodyle *Crocodylus siamensis*, a globaly critically endangered species exists in HNN area (Ziegler et al. 2015).

3.4 FISH FAUNA

3.4.1 Status of the fish fauna study

Phong Nha - Ke Bang NP: Fish fauna in PNKB NP was intensively studied by Nguyen Thai Tu and his collaborators. During 1996-1997, under project WWF/RAS/93/102, Nguyen Thai Tu and his collaborators conducted the first surveys on the fish fauna and recorded 64 fish

species belonging to 21 families (Le Xuan Canh et al. 1997). After this period, they continued their fish studies in PNKB NP and published results in various journals and scientific workshop proceedings such as Nguyen Thai Tu et al. (1998, 1999, 2000, 2003,...). In 2011, with support from the "Nature Conservation and Sustainable Natural Resource Management in PNKB NP Region Project", Nguyen Thai Tu and his collaborators conducted fish surveys in buffer zone and core zone of PNKB NP, collecting 111 specimens of fish. Based on taxonomic analysis of these specimens and results of their previous studies, they compiled a list of 121 fish species belonging to 38 families and 10 orders (Nguyen Thai Tu & Ho Anh Tuan 2011). In 2016, Ho Anh Tuan reviewed this list based on re-examining all collected fish specimens to exclude miss-identified taxa and update systematic changes. As the result, he published a new list of 120 fish species belonging to 35 families and 12 orders (Ho Anh Tuan, 2016).

Hin Nam No NCA: The first ichthyologic survey in HNN area was carried out by Nguyen Huu Duc & Luangoudom in 1998 under joint wildlife and habitat surveys of WWF-Laos and WCS - Laos (Huu Duc & & Luangoudom 1999). The survey covered upper and middle parts of Xe Bang Fai river, while only upper part of the river belongs to HNN NCA. Meijboom and Ho Ngoc Lanh (2002) refined the results of this study to compile a list of 92 fish species for HNN NCA. Further ichthyologic studies in Xe Bang Fai river basin (including HNN NCA) were conducted by Kottelat and his collaborators. Kottelat & Steiner (2010) published a new cave fish species from Tham Xe Bangfai cave - *Bangana musaei*. Kottelat (2015) aggregated results of all ichthyologic studies on the basins of Nam Theun and Xe Bang Fai rivers during 1996 to 2012 to compile an updated list of 178 fish species recorded in basin of Xe Bang Fai river, of which 22 species were found in its upstream where HNN NCA is situated.

3.4.2 Taxonomic composition of the fish fauna

Up to date, 210 fish species of 38 families and 12 orders have been recorded in PNKB-HNN region (Annex 9). Out of which, 117 species of 30 families and 12 orders were found in PNKB NP and 100 species of 20 families and 8 orders were found in HNN NCA. The taxonomic composition of the fish fauna is shown in Table 3.11.

Table 3.11 Taxonomic composition of fish fauna in PNKB-HNN region

English name (order, family)	Scientific name (order, family)	Number of recorded species		
		PNKB-HNN	**PNKB**	**HNN**
I. Ord. BONY TONGUES	OSTEOGLOSSIFORMES	**1**	**1**	**1**
1. Fam. Featherbacks	Notopteridae	1	1	1
II. Ord. EELS, MORAYS	ANGUILLIFORMES	**1**	**1**	**0**
2. Fam. Freshwater eels	Anguillidae	1	1	0
III. Ord. HERRINGS	CLUPEIFORMES	**2**	**1**	**1**
3. Fam. Herrings, shads, etc.	Clupeidae	2	1	1
IV. Ord. CARPS	CYPRINIFORMES	**150**	**50**	**72**
4. Fam. Minnows , Carps	Cyprinidae	93	40	54
5. Fam. Algae-eaters	Gyrinocheilidae	1	0	1
6. Fam. Hillstream loaches	Homalopteridae	5	0	5
7. Fam. True loaches	Cobitidae	9	3	6
8. Fam. River loaches	Balitoridae	5	2	4
9. Fam. Stone Loaches	Nemacheilidae	7	5	2
V. Ord. CATFISHES	SILURIFORMES	**22**	**10**	**12**
10. Fam. Catfishes	Bagridae	9	3	6
11. Fam. Wels and Glass catfishes	Siluridae	3	2	1

12. Fam. Asian Catfises	Sisoridae	5	4	1
13. Fam. Airbreathing catfishes	Clariidae	5	1	4
VI. Ord. LIZARDFISHES & RELATIVES	AULOPIFORMES	**1**	**1**	**0**
14. Fam. Lizardfishes	Synodontidae	1	1	0
VII. Ord. NEEDLEFISHES & RELATIVES	BELONIFORMES	**1**	**1**	**0**
15. Fam. Halfbeaks	Hemirhamphidae	1	1	0
VIII. Ord. SWAMP EELS	SYNBRANCHIFORMES	**5**	**3**	**4**
16. Fam. Swamp eels	Synbranchidae	1	1	1
17. Fam. Spiny eels	Mastacembelidae	4	2	3
IX. Ord. SCORPIONFISHES, FLATHEADS	SCORPAENIFORMES	**1**	**1**	**0**
18. Fam. Flatheads	Platycephalidae	1	1	0
X. Ord. PERCH-LIKE FISHES	PERCIFORMES	**49**	**43**	**8**
19. Fam. Glass fishes	Ambassidae	1	1	0
20. Fam. Temperate perches	Percichthyidae	1	1	0
21. Fam. Lates perches	Latidae	1	1	0
22. Fam. Grunters or tigerperches	Terapontidae	2	2	0
23. Fam. Slimys, slipmouths, or ponyfishes	Leiognathidae	1	1	0
24. Fam. Mojarras	Gerreidae	3	3	0
25. Fam. Moonyfishes or fingerfishes	Monodactylidae	1	1	0
26. Fam. Mullets	Mugilidae	1	1	0
27. Fam. Cichlids	Cichlidae	1	1	0
28. Fam. Freshwater sleepers	Odontobutidae	2	2	0
29. Fam. Sleeper gobies	Eleotridae	5	5	0
30. Fam. True gobies	Gobiidae	16	15	1
31. Fam. Scats	Scatophagidae	1	1	0
32.Fam. Climbing gouramis	Anabantidae	1	1	1
33. Fam. Gouramis	Osphronemidae	7	5	3
34. Fam. Snakeheads	Channidae	4	2	2
35. Fam. Pristolepidids	Pristolepididae	1	0	1
XI. Ord. FLATFISHES	PLEURONECTIFORMES	**4**	**4**	**0**
36. Fam. Large-tooth flounders	Paralichthyidae	1	1	0
37. Fam. True soles	Soleidae	3	3	0
XII. Ord. COWFISHES	TETRAODONTIFORMES	**3**	**1**	**2**
38. Fam. Puffer fishes	Tetraodontidae	3	1	2
Total (species):		**210**	**118**	**100**

Order Cypriniformes has the highest species diversity with 150 species recorded (PNKB NP: 50 species, HNN NCA: 72 species), accounting for 71.4 % of total number of recorded species. Then follow families Perciformes with 49 species (PNKB: 43 species, HNN: 8 species) and Siluriformes with 22 species (PNKB: 10 species, HNN: 12 species). Other orders have only 1-9 species each.

3.4.3 Conservation significance of the fish fauna

The fact that 210 fish species recorded in PNKB-HNN region indicates high diversity of fish fauna in the region and importance of the region for conservation of global fish biodiversity. The conservation significance of the fish fauna is further defined by following features:

- There is great difference in species composition between fish fauna in PNKB NP and fish fauna in HNN NCA. Out of 210 species recorded in PNKB-HNN region, only 8 species (3.8%) are found in both faunas. Thus, combination of PNKB and HNN areas in a conservation landscape significantly increases importance of the region in the global fish conservation.
- One of the most notable topographic feature of PNKB-HNN region is vast kart system with many underground streams, rivers and caves. The underground ecosystem usually supports an unique cave fish fauna which adapt to the cave environment significantly different from outside environment. Cave fish fauna in PNKB-HNN region is still poorly studied, however, results of preliminary survey already indicate richness and endemism of this fauna. Nguyen Thai Tu & Ho Anh Tuan (2011) recorded 12 fish species which live mainly in cave environment in PNKB NP, including endemic *Lobocheilos* sp. found only in Khe Lanh stream of PNKB NP. In HNN area, Kottelat & Steiner (2010) discovered a cave fish species new for science - *Bangana musaei* which live only in cave environment of HNN area.
- Fish fauna in PNKB-HNN region is characterized by high endemism. Kottelat (2015) reported 178 fish species found in basin of Xe Bang Fai river and 9% of them were endemic species. Nguyen Thai Tu & Ho Anh Tuan (2011) reported 212 fish species recorded in PNKB NP with 33 species (15.6%) being endemic to this area

Furthermore, PNKB-HNN region is a home of 25 fish species of conservation priority, including 6 species listed in 2015 IUCN Red List, 4 species in Vietnam Red Data Book in 2007, and 17 endemic species (Table 3.12, Annex 10).

Table 3.12 Number of conservation priority fish species recorded in PNKB-HNN region

Area	Total (species)	IUCN (2015)	VNRD (2007)	ND 32 (2006)	ND 160 (2013	Endemic
PNKB	**23**	6	3	0	0	16
HNN	**3**	1	1	0	0	1
PNKB & HNN	**25**	6	4	0	0	17

Notes: IUCN: 2015 IUCN Red List, VNRD: Vietnam Red Data Book in 2007, ND32: Government Decree 32/2006/ND-CP , ND160: Government Decree 160/2013/NĐ-CP

There are only 6 globally threatened species found in PNKB-HNN region, including 2 species at Vulnerable (VU) and 4 species at Near-threatened (NT) category (Table 3.13). However, there are 11 species ranked at Data deficient (DD) which are very rare in the wild and also need conservation actions.

Table 3.13 Globally threatened fish species recorded in PNKB-HNN region

No.	Scientific name	English name	Distribution		IUCN (2015)
			PNKB	HNN	
1.	*Cyprinus carpio*	Common carp	c		VU
2.	*Sewellia lineolata*	Tiger hillstream loache	c		VU
3.	*Onychostoma gerlachi*		c		NT
4.	*Hypophthalmichthys molitrix*		c		NT
5.	*Glyptothorax interspinalus*		c		NT

6.	*Cirrhinus molitorella*	Mud carp	c	c	NT
7.	*Cyprinus hieni*	Hien's carp	c		DD
8.	*Cyprinus melanes*				DD
9.	*Cyprinus quidatensis*	Qui dat carp	c		DD
10.	*Hypsibarbus annamensis*		c		DD
11.	*Hypsibarbus macrosquamatus*		c		DD
12.	*Schistura finis*		c		DD
13.	*Hemibagrus centralus*		c		DD
14.	*Sineleotris namxamensis*		c		DD
15.	*Macropodus spechti*	Black paradisefish	c		DD
16.	*Macropodus erythropterus*	Red-backed paradisefish	c		DD
17.	*Carassioides phongnhaensis*		c		DD

Note: IUCN - 2015 IUCN Red List; c -confirmed record, u - unconfirmed record. CR - critically endangered, EN - endangered, VU - vulnerable, NT - Near-threatened.

3.5 BUTTERFLY FAUNA

Having vast area with complicated topography and variety of vegetation types, PNKB-HNN region must harbor very rich insect fauna. However, up to now, insect fauna in PNKB-HNN region is very poorly investigated. Actually, there are no insect study in HNN NCA and only two preliminary insect studies in PNKB NP - a study conducted by Institute of Ecology and Biological Resources under support of WWF-Indochina in 1997 (Le Xuan Canh et al. 1997), and study conducted by VRTC in 1999 (WWF Indochina -VRTC 1999). The most notable results of these studies are findings related to butterfly fauna (order Lepidoptera). A total of 270 butterfly species were recorded in PNKB NP (Annex 11). The fauna includes one species listed in CITES Appendix II (*Troides aeacus*) and 2 species new for science: *Celaenorrhinus incestus* and *Celaenorrhinus kuznetsovi* (Devyatkin 2000).

3.6 CAVE FAUNA

3.6.1 Cave fauna in Phong Nha -Ke Bang National Park

Cave fauna in PNKB NP area was first investigated by S. T. Moulds, Pham Dinh Sac and R. Mouritz in 2010 (Moulds et al. 2010). The investigation of cave fauna was continued in 2011 by Pham Dinh Sac and his collaborators from Institute of Ecology and Biological Resources (Hanoi) under support of the "Nature Conservation and Sustainable Natural Resource Management in PNKB NP Region Project". This investigation collected 730 adult individuals of 83 invertebrate species belonging to 55 families, 24 orders and 7 classes (Pham Dinh Sac et al. 2011). Out of 83 recorded species, 48 species (57.83%) are cave specialist dwellers (Pham Dinh Sac et al. 2011, Pham Dinh Sac 2013). The list of recorded species and their recording localities is shown in Annex 12.

Based on analysis of the collected specimens, Lourenco & Pham (2010, 2012) discovered one new genus together with two new species of scorpions. The new genus *Vietbocap* belongs to family Pseudochactidae. To date, only 4 species from 3 genera are known to family Pseudochactidae, namely genus *Troglokhammouanus* found in Laos, genus *Pseudochatas* found in Uzbekistan and Tajikistan, and genus *Vietbocap* found in Vietnam. Two new scorpion species are *Vietbocap canhi* found in Dong Thien Son cave and *Vietbocap thienduongensis* found in Dong Thien Duong cave in PNKB NP. They are typical cave scorpions that adapt to live in very specific cave environment. They are endemics of PNKB area. In addition, the collected specimens contains 25 forms which are possibly new species for science and endemic to PNKB area. However, more time needs to analyze and more specimens need collect to confirm their taxonomic status. Having more than 300 caves of

various size, PNKB NP represents as a natural museum of many endemic invertebrate species which have not been investigated (Pham Dinh Sac 2013).

3.6.2 Cave fauna in Hin Nam No National Conservation Area

Cave fauna in HNN NCA has been investigated since 2006, however, only a part of the survey results were published. Lourenço (2007) published a new genus and a new species of scorpion *Troglokhammouanus steineri* collected in Tham Xe Bang Fai cave. In 2006, Steiner investigated cave fauna in 9 caves in Xe Bang Fai and Ban Dou area of HNN NCA. The study is supported by Integrated Nature Conservation and Sustainable Resources Management in the Hin Nam No Region Project. In this study, a total of 1459 specimens have been collected, which contain approximately 218 different taxa from 16 classes and 34 orders. Nineteen (19) taxa are identified to genus level, for most taxa the identification is still pending. Combining these data with data from previous studies by various authors, the complete cave fauna of Hin Nam No and adjacent caves known so far amounts to 261 taxa from 37 orders and 16 classes (Annex 13).

The most important discovery in this study was an eyeless cave fish, which is most probably new to science. It is the second cave fish known in the area, and the fourth cave fish of all Laos. The occurrence of *Bangana musaei*, the first cave fish, could be acertained, including in one new location. One of the character species of the caves in the HNN NCA is the Cave Huntsman Spider *Heteropoda steineri*. It is the only *Heteropoda* known to show cave adaptions, and is endemic to the HNN NCA. It co-occurs here with the more widely distributed *Heteropoda maxima*, the largest spider in the world. Other flagship species of the area are the Giant Harvestman of the genus *Gagrella*, the scorpion *Troglokhammouanus steineri*, a living fossil and only known from the Tham Xe Bang Fai cave, cave crickets of the genus *Diestrammena*, which form the main prey of most predators, the large noctuid moth *Erebus macrops*. Further interesting findings are a pseudoscorpion, a trechine beetle and a *schizomida*.

Generally, the cave fauna of the HNN NCA is the most diverse in Laos and probably in mainland Southeast Asia as well. As far as identified, it contains a high percentage of endemic species, many charismatic and scientific significant species, constituting an outstanding universal value for the area. Within the HNN NCA, the Tham Xe Bang Fai system clearly sticks out as a biological hotspot, due to its size, its range of different cave habitats and also the coexistance and interrelation of its cave fauna and stream fauna elements. Similarities to the cave fauna of PNKB area in Vietnam are obvious, since they belong to the same karst block, but the same niches seem to be occupied by different species, and some important endemites, like the cave fishes are lacking in Vietnam. Overall, the biodiversity of HNN seems to be considerably higher (Steiner 2016).

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PART 4

CONSERVATION OF BIODIVERSITY IN PHONG NHA - KE BANG AND HIN NAM NO

4.1 OVERVIEW OF BIODIVERSITY CONSERVATION VALUES IN PHONG NHA - KE BANG AND HIN NAM NO

Conservation values of each floral and faunal groups are discussed in respective paragraphs of this document. Here we highlight the most important conservation values of PNKB-HNN region.

4.1.1 Forest ecosystem diversity

Most PNKB NP (96.2%) is covered by forest and 92.2% of which are in primary status. The forest belongs to formations of closed tropical evergreen seasonal forests and include 4 main climax types - Broad-leaved lowland forests (at elevations less than 700 m a.s.l.) on limestone and on silicate mother rocks; and Broad-leaved and coniferous submontane forest on remnant limestone mountains at elevations higher than 700 m a.s.l. In some specific habitats and on unusual landscape forms, like rocky mountain tops and vertical cliffs, these forests form specific modifications with peculiar physiognomy and species composition. Nguyen Tien Hiep et al. (2013) identified 15 types and subtypes of major plant communities in PBKN NP (see paragraph 3.3.2). Most of forest habitats in PNKB NP are limestone at primary or little affected status. Degraded habitats occur only in flat areas near the villages. The diversity of ecosystems creates biological diversity while the complexity and uniqueness of limestone forest ecosystems create rich endemism of flora in fauna in the area.

The forest type "Closed primary evergreen seasonal tropical submontane broad-leaved, mixed and coniferous forests (*Dacrydium elatum* and *Dacrycarpus imbricatus*)" in PBKB NP has unique strictly endemic nature and represents an unique forest type which can not find anywhere (Nguyen Tien Hiep et al. 2013). As mentioned above, primary coniferous forests all over the world and in Indochina represent one of the most endangered kind, extinction of which has presently catastrophic character. This forest type desired priority in conservation actions. Moreover, there is a notable dense 50 sq. km forest on limestone of about 2500 *Calocedrus rupestris* trees. It is the largest unique forest in Vietnam, and most of the trees are 500–600 years old. Species *Calocedrus rupestris* is enlisted in IUCN Red List at Near-threatened category (NT) (IUCN, 2016).

In HNN NCA, forests cover about 70% total area of the NCA (DoFRM, 2015) and 6 major forest types has been identified including Karst Forest, Semi-Evergreen Forest, Mixed deciduous Forest, Bamboo Forest, Riverine Forest and degraded Forest (Lamxay 2014). Except for bamboo forests and degraded forests, the forests are in primary or little affected status which harbors very rich biodiversity (Lamxay 2015). There is difference in vegetation between HNN NCA and PNKB NP, e.g. Mixed deciduous forest is distributed wider in HNN NCA while evergreen forest occurs only in PNKB NP.

4.1.2 Floral diversity and species of conservation priority

Limestone karst habitats are known for their distinctive hydrologic, climatic, geologic, geomorphic and biodiversity features (Williams, 2008; Clements et al., 2006; Hamilton-Smith, 2007). Due to the importance of climate in the characteristics of every single karst landscape (Williams, 2008) and their natural isolation, each one of these has extraordinary

high levels of species endemism (Clements et al., 2006; Day, 2011). As described above, habitats in PNKB-HNN region are mainly limestone habitats with very rich plant biodiversity. Un-comprehensive inventory has recorded 3,044 species of vascular plants belonging to 207 families (Annex 1). In PNKB NP alone, 2,804 species of 201 families were recorded while in HNN NCA, only 567 species of 121 families were recorded (Table 4.1). This fact indicates that number of plant species recorded in HNN NCA is possibly much lower than actual number and future inventories will add many more species to the plant list.

Table 4.2 Taxonomic statistics of flora in PNKB-HNN region

Area	No. of phyla	No. of families	No. of species
PNKB NP	6	201	2,804
HNN NCA	5	121	567
PNKB -HNN region	6	207	3,044

As mentioned above, vegetation in PNKB NP and HNN NCA is not the same due to climate is wetter in PNKB NP than in HNN NCA. This may lead to difference in species composition of each floras and thus increasing total species diversity of PNKB-HNN region.

Out of 2,804 plant species recorded in PNKB-HNN region, 490 species are of conservation priority including 90 species listed in 2015 IUCN Red List, 279 species in Vietnam Data Book in 2007, 279 species listed in CITES Appendix I and Appendix II, 46 species under Decree 32/2006/ND-CP of Vietnam Government and 88 species endemic to Vietnam, Laos or Indochina (Table 4.2). The flora contains 9 species under globally critically endangered category (CR) including *Dipterocarpus gracilis*, *Dipterocarpus hasseltii*, *Dipterocarpus turbinatus*, *Hopea chinensis*, *Hopea hainanensis*, *Hopea reticulata*, *Vatica diospyroides*, *Diospyros mun* and *Aquilaria crassna.*

Table 4.2. Number of conservation priority plant species recored in PBKB-HNN region

Area	Total (species)	IUCN (2015)	CITES	VNRB (2007)	ND 32 (2006)	Endemic
PNKB	**456**	84	254	116	25	88
HNN	**106**	32	56	35	17	11
PNKB & HNN	**490**	90	279	123	46	88

Note: VNRB: Vietnam Red Data Book in 2007, ND 32: Decree 32/2006/ND-CP of Vietnam Government.

4.1.3 Faunal diversity

Up to date, 899 species of vertebrate animals were recorded in PNKB-HNN region including 150 mammal species, 302 bird species, 120 reptile species, 58 amphibian species and 210 fish species (Table 4.3). Out of them, 752 species (143 mammal species, 302 bird species, 107 reptile species, 56 amphibian species and 117 fish species) were found in PNKB NP and 500 species (75 mammal species, 262 bird species, 43 reptile species, 20 amphibian species and 100 fish species) were found in HNN NCA. In addition, 270 butterfly species and many other insect species were also found in PNKB NP.

Table 4.3 Taxonomic statistics of vertebrate fauna in PNKB-HNN region

Animal group	PNKB - HNN region			PNKB (species)	HNN (species)
	Order	Family	species		
Mammals (Mammalia)	11	32	150	143	75
Birds (Aves)	17	58	361	302	262
Reptiles (Reptilia)	2	16	120	107	43
Amphibians (Amphibia)	2	8	58	56	20

Fishes (Fices)	12	38	210	117	100
Total:	**44**	**152**	**899**	**725**	**500**

PNKB-HNN region possesses a rich underground ecosystems which not only include many world famous caves by their length, spatial size and extraordinary beauty but also an unique cave fauna with many endemic species of high conservation value. Due to restrictive accessibility, cave fauna is still poorly investigated. In PNKB NP, preliminary studies have found 83 invertebrate species belonging to 55 families, 24 orders and 7 classes. Out of which, 48 species has cave-specialized life and 25 forms are possibly new species for science. One new genus (*Vietbocap*) along with two new species (*Vietbocap canhi* and *Vietbocap thienduongensis*) were discovered in PNKB NP (Lourenco & Pham 2010, 2012). Having more than 300 caves of various size, PNKB NP represents as natural museum of many endemic invertebrate species which have not been investigated (Pham Dinh Sac 2013).

In HNN NCA, the cave fauna is better investigated. A total of 261 cave fauanal taxa belonging to 37 orders, and 16 classes have been recorded (Steiner 2016). Two species new for science was described as *Troglokhammouanus steineri* and *Heteropoda steineri* (Lourenço 2007, Bayer & Jäger 2009). Generaly, the cave fauna of the HNN NCA is the most diverse in Laos and probably in mainland Southeast Asia as well. It contains a high percentage of endemic species, many charismatic and scientific significant species, constituting an outstanding universal value for the area (Steiner 2016)

4.1.4 Faunal species of conservation priority

In PNKB-HNN region, 188 animal species are identified as species of conservation priority. They are 75 globally threatened species (listed in 2015 IUCN Red List), 80 species nationally threatened in Vietnam (listed in Red Data Book of Vietnam in 2007), 90 species nationally threatened in Laos, 74 species under Decree 32/2006/ND-CP and Decree 160/2013/ND-CP of Vietnam Government (Table 4.4).

Table 4.4 Number of conservation priority animal species in PNKB-HNN region

Animal group	IUCN (2015)	VNRB (2007)	ND32 & ND160	LSR (1999)	End. & Rest.range	Total (species)
Mammals (Mammalia)	38	46	41	48	8	73
Birds (Aves)	10	13	17	25	7	41
Reptiles (Reptilia)	17	21	16	17	7	35
Amphibian (Amphibia)	1	4	0	0	1	6
Fishes (Fices)	6	4	0	0	17	25
Butterfly (Lepidoptera)	0	0	0	0	2	2
Cave animals	0	0	0	0	6	6
Total (species):	**72**	**88**	**74**	**90**	**48**	**188**

Note: IUCN: 2015 IUCN Red List, VNRB: Red Data Book of Vietnam in 2007, ND32: Decree 32/2006/ND-CP and ND160: Decree 160/2013/ND-CP of Vietnam Government, LSR: Lao's 1999 Wildlife Status Report (Duckworth et al. 1999). End: endemic species, Rest.range: Restricted-range species.

PNKB NP harbors 166 animal species of conservation priority including 68 species listed in 2015 IUCN Red List, 75 species listed in Red Data Book of Vietnam in 2007, 70 species under Decree 32/2006/ND-CP and Decree 160/2013/ND-CP of Vietnam Government, 77 species nationally threatened in Laos and 30 endemic species (Table 4.5)

Table 4.5 Number of conservation priority animal species recorded in PNKB NP

Animal group	IUCN	VNRB	ND32 &	LSR	End. &	Total

	(2015)	(2007)	ND160	(1999)	Rest.range	(species)
Mammals (Mammalia)	37	45	40	41	6	70
Birds (Aves)	9	12	16	21	6	35
Reptiles (Reptilia)	15	11	14	15	3	28
Amphibian (Amphibia)	1	4	0	0	1	6
Fishes (Fices)	6	3	0	0	16	23
Butterfly (Lepidoptera)	0	0	0	0	2	2
Cave animals	0	0	0	0	2*	2
Mammals (Mammalia)	**68**	**75**	**70**	**77**	**36**	**166**

Note: see note under table 4.4 for details. (*) 2 new species of cave scorpions: Vietbocap canhi and Vietbocap thienduongensis

HNN NCA is the home of 99 animal species of conservation priority including 47 species listed in 2015 IUCN Red List, 57 species in Red Data Book of Vietnam in 2007, 47 species under Decree 32/2006/ND-CP and Decree 160/2013/ND-CP of Vietnam Government, 51 species nationally threatened in Laos and 17 endemic species (Table 4.6). In general, fauna is HNN CNA is less investigated than fauna in PNKB NP. Giving two protected areas have similar habitat diversity, it is very likely that more species of conservation priority will be found in the HNN NCA in near future.

Table 4.6 Number conservation priority animal species recorded in HNN NCA

Animal group	IUCN (2015)	VNRB (2007)	ND32 & ND160	LSR (1999)	End. & Rest.range	Total (species)
Mammals (Mammalia)	31	34	28	35	8	48
Birds (Aves)	6	12	12	9	4	26
Reptiles (Reptilia)	8	8	7	7	0	15
Amphibian (Amphibia)	1	2	0	0	0	3
Fishes (Fices)	1	1	0	0	1	3
Butterfly (Lepidoptera)	0	0	0	0	0	0
Cave animals	0	0	0	0	4*	4
Total (species):	**47**	**57**	**47**	**51**	**17**	**99**

Note: *see note under table 4.4 for details,* (*) Cave blind fish *Bangana musaei*, Cave hunting spider *Heteropoda steineri,* Cave giand spider *Heteropoda maxima* and Cave scorpion *Troglokhammouanus steineri*

PNKB-HNN region supports the world largest and the only world viable populations of many threatened species such as Hatinh Langur *Trachypithecus hatinhensis,* Laotian Black Langur *Trachypithecus laotum,* Red-shanked Douc *Pygathrix nemaeus,* Southern White-cheeked Gibbon *Nomascus siki ,* Annamite Striped Rabbit *Nesolagus timminsi*, Flying squirrel *Biswamoyopterus laoensis,* Laotian Rock Rat *Laonastes aenigm*amus, Limestone Rat *Saxatilomys paulinae*, Sooty Babbler *Stachyris herberti,* Short-tailed Scimitar Babbler *Jabouilleia danjoui,* Limestone Leaf-warbler *Phylloscopus calciatilis,* Cyclornated box turtle *Cuora cyclornata,* etc.

4.2 BIODIVERSITY MONITORING IN PHONG NHA -KE BANG AND HIN NAM NO AREAS

4.2.1 Some key concepts

Biodiversity monitoring: Biodiversity monitoring means using observation techniques to determine change trend of ecological factors (vegetation, ecosystems, populations, ect.) under threat impacts caused by people and nature. The monitoring also identify threat types, their

intensity and change trend by spatial scope and overtime. Results of biodiversity monitoring show appropriateness and effectiveness of applied management measures. Based on monitoring results, managers will adjust management plan to meet conservation objectives and achieve required management effectiveness.

Keystone species and key species: "keystone species" refers to those species which play crucial role in maintaining an ecosystem structure and have large affect on other species in the ecosystem. If population of keystone species changes, the structure of the ecosystem will be changed or even destroyed. Keystone species may be dominant predators which control over population size of many prey species, species providing key food source for many other species in the ecosystem, species whose activities cause great change in environment conditions that affect many other species in the ecosystem.

"Key species" is a relative meaning concept. Identification of key species depends on ecosystem management objectives. In ecosystems managed for biodiversity conservation, key species are those which have high conservation priority such as threatened species, endemic species, rare species, recently discovered species, prey species of conservation priority species, etc. In many cases, keystone species are also as key species, but may key species are not keystone species. Both keystone species and key species are often selected as monitoring species in biodiversity monitoring programme

The aim of biodiversity monitoring is to create sound scientific basis for adjustment of management plans for ensuring biodiversity conservation objectives of protected area in concern. Biodiversity monitoring is implemented through monitoring of ecological factors which are indicators of: a) status of key species population or key habitats in the protected areas, b) Scope and severity of negative impacts to the biodiversity components and c) Effectiveness of applied management measures. Monitoring indicators maybe biological factors (such as animal and plant species, ecosystems, sensitive habitats, etc.) or non-biological factors (such as illegal logging, wildlife hunting, mining, etc.). Monitoring indicators and indexes must be chosen carefully. Monitoring indicators and indexes must have following features:

(1) *Measurable:* It must be possible to measure the quantity or the quality of the indicator.

(2) *Sensitive:* The indicator must reflect accurately the changes that are the focus of the monitoring strategy

(3) *Consistent:* It must be possible to measure the indicator in the same way throughout the entire monitoring programme: the indexes must not be changed over time, and neither should the method of measurement of the indexes.

(4) *Precise:* The measurements must be defined in such a way that everyone can understand what the data are demonstrating.

There is no single format for all monitoring programmes. The content of monitoring plan depends on management requirement of each protected area, at each management periods, conditions of monitoring areas and available resources. Monitoring plan may be very simple as a systematic gathering biodiversity information/data by forest rangers during their routine patrolling or maybe very complicated one which contains many monitoring species and large number of monitoring indexes. At present, the scope of monitoring in most Asian protected areas are generally limited to observing the condition and threats to key habitats and key species in specific locations, as well as selected management programme outputs (Leverington et al. 2007).

4.2.2 Selection of monitoring species

The most important objective of PNKB NP as well as HNN NCA is conservation of biodiversity values of its natural ecosystems. Therefore, key species should include species of high conservation value such as globally and nationally threatened species, endemic species and new species recorded in the respective protected areas. However, the number of key species is high (see Annexes 2, 4, 6, 8) while resources for any monitoring plans in the protected areas are limited. Thus, certain criteria must applied to select the most relevant species for the monitoring plans.

Nguyen Xuan Dang et al. (2013) developed following set of criteria for selecting monitoring species in PNKB NP. In order to be selected as monitoring species, the species must satisfy all following criteria:

- *Criterion 1 (high conservation significance)*: Having high conservation significance, population in PNKB NP has national or global importance; OR as indicator of primary and little-affected forests in PNKB NP; and satisfying following sub-criteria:
    + Mammal species: being listed in Vietnam Red Data Book (2007) or IUCN Red List at CR or EN categories, OR endemic or nearly endemic to PNKB area or Vietnam
    + Bird species: Being listed in Vietnam Red Data Book (2007) or IUCN Red List at CR, EN and VU categories, indicator of primary and little-affected forests in PNKB NP; OR endemic and nearly endemic to PNKB NP or Vietnam.
    + Reptile and Amphibian species: Having high conservation significance and population in PNKB NP has national or global importance.
    + Plant species: Precious timber species of high conservation significance
- *Criterion 2 (under intensive illegal exploitation)*: Being illegally hunted / exploited in PNKB NP and adjacent areas
- *Criterion 3 (relatively easy to identify)*: Easy or relatively easy for staffs of PNKB NP to identify in forests after short training
- *Criterion 4 (possible detection)*: Can be detected in the field directly or indirectly through signs of the species activity

By using these criteria, 20 animal species and 7 plant species are selected as candidates for biodiversity monitoring plans in PNKB NP (Annex 14).

Regarding HNN NCA, Lamxay (2014) recommends a list of 67 plant species for biodiversity monitoring plans in the NCA including 45 orchid species (Orchidaceae). However, monitoring of orchid species is very difficult in such complicated topography of HNN NCA, so we temporary exclude orchid species from monitoring candidates. Using above mentioned criteria, we identifies 16 animal species as candidates for monitoring in the area. Thus, the list of species recommended for biodiversity monitoring in HNN NCA comprise 38 species (16 animal species and 22 plant species) (Annex 14).

4.2.3 Selection of monitoring threats

Monitoring of acute threats caused by people is an indispensable part of biodiversity monitoring plan, because the quantity and quality of information available about acute threats is perhaps the single most telling indicator of management effectiveness of Protected area Management Board. Bleisch et al. (2012) identify 13 categories of threats, listed below in order of their seriousness and the severity of their impacts on the values of PNKB NP:

1. Wildlife hunting and trapping
2. Illegal timber logging
3. Non-timber forest product exploitation
8. Cattle grazing in the Park
9. Fishing
10. Forest land encroachment

4. Destructive tourism
5. Infrastructure developments inside the Park
6. Invasive and alien species
7. Firewood collection
7. Khai thác gỗ củi
11. Cinnamomum oil extraction
12. Forest fire
13. Natural disasters

In HNN NCA, six (6) following direct threats are identified by Vongkhamheng (2014), Lamxay (2014) and DoFRM (2015):

1. Wildlife hunting and trapping
2. Illegal timber logging
3. Non-timber forest product exploitation
4. Forest land encroachment for agricultivation
5. Forest fire
6. Natural disasters (floods)

The monitoring of threats will be implemented through recording the threat evidence (monitoring indicators) during field patrolling. Monitoring indexes includes encounter rate and distribution range of recorded threat evidences. Table 4.7 shows threat evidences to be recorded during threat monitoring plan in PNKB-HNN region .

Table 4.7 Monitoring threat indicators and indexes in PNKB HNN region

Các đe dọa	Chỉ thị giám sát
Wildlife hunting and trapping	• Hunters found in the protected area • Hunting huts found in protected area • Traps/snares found in Protected area • Hunting gunshootings heard in protected area
Illegal timber logging	• Timber sawing platforms • Volume of logged wood • Species of logged trees • Villagers carrying logs
Non-timber forest product exploitation	• Villagers harvesting NTFPs • Huts of NTFP collectorrs • Kind of harvested NTFPs
Cattle grazing in the protected area	• Cattle species found in protected area • Number of cattle found in protected area
Forest land encroachment	• Type and status of cleared forests • Area of cleared forests • Aim of forest clearance • What people did forest clearance
Forest fire	• Area of burned forests • Type of burned forests • Causes of the forest burning

4.2.4 Monitoring methods

There are 2 monitoring approaches which can be used in PNKB NP and HNN NCA:

1) Community-based monitoring approach when monitoring is conducted jointly by staff members of protected areas and local villagers. The monitoring team will cover large number of patrol trails in protected area and use simple methods to collect monitoring data. This approach allows to conduct long-term monitoring at lower cost, however, the collected data on population status are not very consistent and less precise.

2) Intensive researcher led monitoring approach when monitoring is conducted by scientists in collaboration with staff members of the protected area. The monitoring team use standard, more complicated methods to collect data on species population status and threats. This approach allows to collect more consistent and precise data,

however, the cost is higher, therefore, this monitoring approach should focus on only some indicator species and threats.

There are various data collecting methods that can be used in biodiversity monitoring plan. The selection of appropriate monitoring methods depends on monitoring objectives, selected indicator species and available monitoring resource (man powers, budget, technical capacity, etc.). The methods commonly used in biodiversity monitoring plans are line-transect sampling, plot sampling, animal sign counting, live-trapping survey, camera-trapping, etc.

Of both above mentioned monitoring approaches, if such surveys are repeated at appropriate frequencies they can be also used to assess trends over time using the *occupancy estimation method* (MacKenzie et al. 2006). This approach is now recognized as a viable and statistically sound alternative for biodiversity monitoring programs in areas of low wildlife density as well as difficult terrain. The occupancy parameter can be technically defined as the probability that a sampling unit is occupied by a species, but when using occupancy as a state variable it is typically interpreted as the proportion of area occupied or, when home range size is large relative to the size of the sample unit, the proportion of area "used" (MacKenzie et al. 2005; Royle & Dorazio 2008). The computer-based program called "PRESENCE" is now freely available and easy to use for the data analysis.

4.3 FURTHER BIODIVERSITY STUDIES IN PHONG NHA - KE BANG AND HIN NAM NO

PNKB-HNN region is famous as one of world largest conservation limestone karst landscape. Most part of the landscape is covered by primary tropical forests with very rich biodiversity. Due to very large area and restrictive access of these habitats, most karst habitats have not yet been explored comprehensively. To date, biodiversity surveys has just covered relatively easy accessible areas, while large remote areas of rich biodiversity, especially along Vietnam-Laos border remains un-surveyed. During recent years, many new species were described including many biological groups such as plants, invertebrate animals, fishes, birds, amphibians, reptiles and mammals (Kottelat et al. 1999, Jenkins & Robinson 2002, Robinson et al. 2003, Jenkins et al., 2005, Musser et al., 2005; Dawson et al. 2006, Heidrich et al. 2007, 2008; Lourenço 2007, 2009; Jenkins et al. 2009; Woxvold et al. 2009; Ziegler et al. 2009; Lourenço et al. 2010, 2012; Kottelat & Steiner, 2010; Loos et al. 2012; Sanamxay et al. 2013; Luu et al. 2013, 2014, 2015, 2016;...). Thus, further studies in future need to comprehensively understand the biodiversity of PNKB-HNN region and for development of conservation and sustainable use strategies.

4.3.1 Further biodiversity studies in Phong Nha - Ke Bang National Park

To date, large number of plant species (2,804 species) were recorded in PNKB NP (Annex 1). However, given very high species richness and endemism of limestone habitats (Clements et al., 2006); there is high potential for records of additional species and discoveries of new species in PNKB NP. Therefore, further studies need to develop a more comprehensive list of plant species, identify species of conservation priority (rare, endangered, endemic and new species) for conservation and sustainable management.

Further studies need to assess population status and distribution range within National Park of conservation priority plant species (locally endemic, nationally and globally threatened species, especially threatened species facing high pressure of illegal exploitation) (see Annex 2 and Annex 14 for the list of those species). Assessing main threats to the species population and their habitats are also of importance.

Similarly, further inventory of faunal diversity (mammals, birds, reptiles, amphibians, fishes, insects, invertebrates) is necessary to build a more comprehensive list of faunal species in PNKB NP, identify species of conservation priority (rare, endangered, endemic and new

species) for conservation and sustainable management. Regarding studies of mammal fauna, priority should be given to small mammal groups such as Rodents, Bats, Insectivores because these groups are poorly studied. Given very complicated, restrict-accessible topography and most area is covered by primary or little-affected forests, PNKB NP should harbor rich fauna of small mammals and many of them remain un-described. Indeed, new species for science were continuously discovered in PNKB NP during recent studies (see Nguyen Xuan Dang et al. 2011, 2013; Nguyen Xuan Nghia et al. 2013; Vu Dinh Thong et al. 2012).

In comparison with other faunas in PNKB NP, herpetofauna is the most intensively studied and contains the highest number of new for science species discoveries (about 20 species, see Table 3.8). Nevertheless, herpetological surveys so far have not covered remote restrictive areas of the National Park, further surveys are necessary and should focus on the remote areas to discover additional species and identify conservation priority species for conservation and management purposes.

Cave fauna in PNKB NP has just been preliminarily studied. The fact that out of 300 caves presently known in PNKB NP, only 21 caves are preliminarily surveyed, but 2 species new for science were described (Lourenço et al. 2010, 2012) indicates very low coverage of recent studies on one hand and high potential of further discoveries of new species on other hand. Thus, further studies of cave fauna need to get butter understanding of the fauna and for development of appropriate management strategies.

Along with faunal inventory, further studies should focus on conservation priority species, including estimate of their population size, identification of their distribution pattern within National Park, assessment of threats to their populations and habitats, monitoring change trend of their populations. Species of the highest priority for these studies are Primates (Hatinh langur *Trachypithecus hatinhensis*, Laotian Black langur *Trachypithecus laotum*, Red-shanked Douc *Pygathrix nemaeus*, Southern White-cheeked gibbon *Nomascus siki*) and large carnivore species (Tiger *Pathera tigris*, Clouded leopard *Neofelis nebulosa*, Sun bear *Helarctos malayanus*, Asiatic Black Bear *Ursus thibetanus* , etc.)

Laotian Rock Rat *Laonates aenigmamus*, an endemic species of PNKB-HNN Region is the only living species of ancient mammal family Diatomyidae which was thought to be extinct 11 million years ago (Jenkins et al. 2005, Dawson et al. 2006, Nicolas et al. 2012). Up to date, this species is found only in limestone karst forest habitat in Khammuoane Province, Laos (Jenkins et al. 2005, Rivière-Dobigny et al. 2011, Nicolas et al. 2012) and PNKB NP in Quang Binh Province, Vietnam (Nguyen Xuan Dang et al. 2012, Nguyen et al. 2014, Le et al. 2015). Genetic studies reveal multiple evolutionary distinct lineages within the species, and indicate an ancient isolation, from *ca*. 8 to 12 MYA, between major clades from Laos and Vietnam (Nicolas et al. 2012, Le et al. 2015). Long temporal separation within a small distribution range is especially interesting, implying local adaption to micro-habitat of the lineages. Further morphometric and genetic studies need to clarify level of genetic isolation between Vietnamese and Laotian clades. This studies implicate high conservation significance. Furthermore, Laotian Rock Rat is facing high hunting/trapping pressure through its distribution range both in Vietnam and Laos (Vongsa 2010, Nguyen Xuan Dang et al. 2012, Nguyen et al. 2014). Therefore, further studies need to clarify status and distribution range of each populations and the species ecological requirement for development of effective conservation actions

4.3.1 Further biodiversity studies in Hin Nam No National Conservation area

Up to date, biodiversity in HNN NCA has been very little investigated. Further studies should focus on comprehensive species inventory of all key biotic groups both in terrestrial and subterranean ecosystems. The surveys should cover various habitat types and territories

within HNN NCA to inventory as many as possible biodiversity components. Then, use the results of these studies to evaluate national and global conservation importance of HNN NCA; identify species of high conservation significance (threatened species, endemic species, species new for science and species other special importance); identify biodiversity "hotspots" within NCA and threats to biodiversity for undertaking relevant conservation actions. At the same time, the studies should highlight outstanding universal values of HNN NCA with respect to World Heritage Criterion ix and x (UNESCO, 2013) to contribute to nomination HNN NCA as World Heritage Site. Bolger (2014) and Coudrat (2015) give following notes on the need of further biodiversity studies in HNN NCA:

- There is a need for an up to date and as comprehensive as possible inventory of vegetation species in HNN NCA, including visits to the different habitat types in the interior of the NCA. Given the specificity of the limestone habitat, characterized by unique soils, the levels of vegetation endemism and species richness is high; there is high potential for discoveries of new species in HNN NCA.
- Land snails in limestone karst habitats are known to be highly diverse with high levels of endemism due to their low dispersal capacity (Clements et al., 2006). There is a need for a preliminary inventory of land snail and arthropod species in HNN NCA, covering as many habitat types as possible.
- There is a need for an up to date and as comprehensive as possible inventory of reptile and amphibian species in HNN NCA. Given so far little survey coverage of Hin Nam No for reptiles and amphibians, and the recent new findings, there is high potential for new species discoveries and/or new country records in the NCA.
- In the past few years, two new species of birds were described from limestone habitats in Laos, including the limestone leaf warbler *Phylloscopus calciatilis* recorded in both Laos and Vietnam (Alstrom et al., 2010) and the bare-faced bulbul *Pycnonotus hualon* discovered in limestone karst in central Laos and Central Vietnam (Woxvold et al., 2009, Le Trong Trai et al. 2013). There is the possible occurrence of latter species is HNN NCA. There is a need for an up to date and as comprehensive as possible inventory of bird species in HNN NPA. The potential for new species discoveries is high.
- Previous mammal surveys did not focus on small mammals. Giving that during the recent years, several small mammals were discovered in the nearby Phou Hin Poun Limestone habitat: *Hylomys megalotis* (Jenkins and Robinson, 2002), a murid rodent *Saxatilomys paulinae* (Musser et al., 2005), a rat *Laonastes aenigmamus* (Jenkins et al., 2005). There is a need for an up to date inventory of small mammal species in HNN NCA. The research will assess the presence/absence of these recently discovered species in HNN NCA and the potentially occurrence of additional species yet to be recorded locally, nationally and/or globally.
- There is a need for an up to date and as comprehensive as possible inventory of bat species in HNN NCA. The potential for new species discoveries at the local, national and/or global level is high.

Cave fauna is especially interesting animal groups in limestone landscape like PNKB-HNN region. To date, studies of cave fauna in HNN NCA has focused only in Tham Xe Bang Fai cave system. This cave system contains the most diverse in Laos and probably in mainland Southeast Asia as well that need further investigation, however, further cave faunal studies should cover also other cave systems in HNN BCA for more comprehensive database of the cave fauna.

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