Japan International Cooperation Agency (JICA)

Sustainable Natural Resource Management Project (SNRM)

# BIODIVERSITY MONITORING MANUAL FOR LANGBIANG WORLD BIOSPHERE RESERVE


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# Chapter 1 : INTRODUCTION

***Why monitor biodiversity?***

Biodiversity is the variation at the genetic, species and ecosystem levels (Secretariat of the Convention on Biological Diversity, 2005). Biodiversity is an important part of the nature and provides us with essential services. For example, it is the source of food, medicine, construction materials, genetic resource for crops, etc. Biodiversity contributes to regulating water resource and climate balance. There are many more benefits that can be drawn from biodiversity.

There are many reasons to survey and monitor biodiversity as we would like to know how biodiversity changes in space and time and under different pressures (artificial and inartificial impacts). Understanding these trends will help us manage and use biodiversity reasonably and sustainably. This is crucial for managers of protected areas, such as Bidoup-Nui Ba National Park (BNBNP), to plan and develop suitable management measures for a long run.

***Sustainable Natural Resource Management Project***

The Sustainable Natural Resource Management Project (SNRMP) is a technical cooperation project funded by Japan International Cooperation Agency (JICA) which has been implemented in Vietnam since December 2015.The overall objective of the project is to enhance the capacity for sustainable natural resource management in Vietnam.

The project consists of four components, and Component 3 (Biodiversity conservation) aims to establish an integrated and collaborative ecosystem management system for sustainable conservation and management of the Langbiang Biosphere Reserve (LBBR) in Lam Dong province. Under the component, biodiversity baseline surveys were conducted during 2016-2017 in the core and buffer zone of the BNBNP, - the core zone of LBBR, which resulted in a digitized biodiversity database and a biodiversity monitoring framework for LBBR to monitor its biodiversity at both ecosystem and species levels. The proposed framework, which includes 20 indicators and many potential indicator species, was finalized through the consultation with relevant authorities includes MARD, MONRE, DONRE and experts considering the available human and financial resources that could be secured for biodiversity monitoring activities. It has been recommended to apply selected indicators given the resources available.

Accordingly, a Biodiversity Monitoring System (BMS) and Operation Plan has been proposed for application for the period of 2018 – 2019 in BNBNP, which will be developed with an aim to monitor the healthiness of its important forest ecosystems, and to provide the data on changes of biodiversity for manager/ decision makers to minimize its negative impacts.

***The role of this manual***

This manual provides standardized methods for biodiversity monitoring to the staff of BNBNP and help to improve the quality and consistency of works done at individual sites, so that the compatible biodiversity data from different sites is produced. In this way, it is expected to enhance the understanding on the biodiversity in LBBR and improve the scientific basis for its management.

# Chapter 2 : SCOPE OF THE MANUAL

***Approach***

The manual is composed of comprehensive methods to help BNBNPMB to conduct the BMS with minimum support by external experts, through providing a simple set of meaningful core biodiversity monitoring protocols, along with straightforward guidance for survey design (deciding on where to measure biodiversity in the landscape). The methods described in this manual can be used to conduct initial baseline studies or surveys of biodiversity at a site. Periodic re-measurement of the same sites will also help to understand how biodiversity is changing over time. The proposed methods in the manual will allow the computation of biodiversity metrics, such as the absolute or relative abundance of species, the encounter rates or forest structure.

The basic principles of the approach are indicated as follows;

- Field monitoring activities shall be carried out as part of the regular forest patrolling and monitoring works as well as using relevant patrolling reports of BNBNPMB so as to minimize additional financial burden on BNBNPMB.

- Simple, easy-to-apply, and less costly methods, such a field observation, camera trapping are employed as main methodologies for field monitoring activities.

- An emphasis shall be placed on monitoring key indicator species (i.e., endangered species, ecologically and/or economically valuable species, and invasive species) for detecting changes in the environment of the forest ecosystems of LBBR.

- Key indicator species are identified and selected from plants, mammals, birds, amphibians and insects based on the results of the biodiversity baseline survey conducted in 2016-2017 and transect survey carried out in May 2018.

- The biodiversity changes in the important ecosystem of BNBNP, i.e. evergreen broadleaf forests, shall also be periodically monitored at a long-term monitoring plot (1 ha) located in strictly protected sub-zone of BNBNP, established in May 2018. Cooperation and collaboration with external academic institutions shall be promoted for its periodical monitoring.

- Existing government programs and/or resources, which can be used as sources of data for monitoring, shall be utilized for and/or incorporated into the monitoring program.

The manual concludes by presenting analytic methods that can be used to calculate a set of core species and community parameters useful for describing the results of the monitoring. References and resources are listed at the end of the manual for readers who desire a more technical treatment of the methods described in the manual.

The focus of this manual is biodiversity in natural forest habitats, but many of the protocols described here would work in other types of natural habitats, or in degraded forests. Thus, the manual is mainly for BNBNP, but it is expected to be widely referred by other national parks in the country for developing each biodiversity monitoring system given the conditions of the resource availability in term of personnel, finance and time for an optimum achievement.

***Limitations of this manual and future directions***

As mentioned above, the objective of this manual is to provide a practical set of core biodiversity monitoring protocols that can be used for BNBNP. However, there are some applications for which this general methodology will not be suitable, and the reader will need to seek further guidance.

The following topics are not covered in this manual;

- Generating reliable estimates of the abundances of rare/inconspicuous species – such species are too rare or cryptic to be reliably detected with the general methods described in this manual, and require tailored methods designed specifically to their needs.
- Detailed guidance on conducting power analyses - general guidelines are given to ensure that sufficient samples are taken at a site, but a detailed statistical treatment is beyond the scope of the manual and the basic protocols.
- Biodiversity monitoring protocols for other taxa – methods for many other diverse and potentially important taxonomic groups are not included in this manual, as for fishes and fungi.
- Biodiversity monitoring protocols for rare or sensitive habitats – methods are not provided for habitats such as swamps, marshes, and disturbed areas.
- The human use of biodiversity - this manual does not include protocols for directly measuring anthropogenic pressures on biodiversity such as hunting, collection for the pet trade, and logging.
- Comprehensive description of possible *post hoc* statistical analyses - this manual describes how to calculate basic and meaningful metrics from survey data but does not provide a comprehensive and detailed technical treatment of all possible metrics that could be employed.
- Methods for assessing biodiversity below the level of species - the focus of this manual is the study of species, communities (assemblages of species), and forest structure. It does not provide guidance on the study of genetic diversity, for example.

We appreciate feedbacks from users on this manual so that future revisions can be made to meet their practical needs.

# Chapter 3 : BIODIVERSITY MONITORING SYSTEM OF BIDOUP – NUI BA NATIONAL PARK

## 3.1 OVERALL FRAMEWORK OF THE BIODIVERSITY MONITORING SYSTEM

The BMS is composed of the following monitoring and data management activities:

- Forest and vegetation cover monitoring
- Key indicator species monitoring in the target forest ecosystems
- Collection of basic biodiversity data and information
- Establishment of a long-term monitoring plot/ transects
- Record keeping and data management
- Reporting to LBBR-MB and data sharing with NBDS

The following flow chart indicates the overall framework of the BMS.

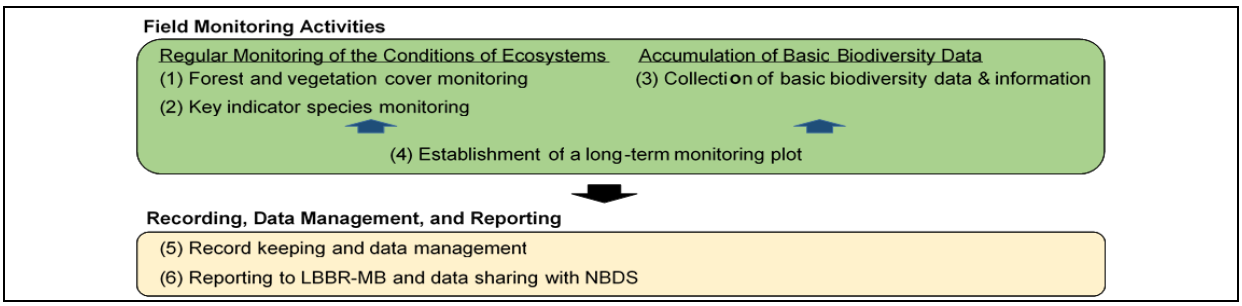


*Figure 1. Overall framework of the BMS*

## 3.2 TARGET FOREST ECOSYSTEMS

More than 85% of the total area of BNBNP are covered with natural forests. Among them, three forest types, namely Evergreen Broad-leaf Forests, Coniferous Forests, and Mixed Forests of Broad-leaf and Coniferous Forests, account for more than 80% of the area as tabulated below. Thus, these types shall be selected as target forest ecosystems of the BMS. The patrolling routes passing through such forest ecosystems shall be selected as transect walking routes for the key indicator species monitoring.

*Table 1. Forest and Vegetation Cover of BNBNP (2017)*

| Forest and Vegetation Covers | Area (ha) | Proportion (%) |
|---|---|---|
| 1. Natural forest | **60,493.7** | **86.4** |
| 1.1 Evergreen broad-leaf forest | 21,577.4 | 30.8 |
| 1.2 Mixed forest of broad leaf and coniferous forest | 16,258.5 | 23.2 |
| 1.3 Coniferous forest | 20,849.4 | 29.8 |
| 1.4 Mixed forest of trees and bamboos | 1,610.6 | 2.3 |
| 1.5 *Bambusa proceca* forest | 197.8 | 0.3 |
| 2. Plantation | **1,505.3** | **2.2** |
| 3. Land with no forest | **7,182.2** | **10.3** |
| 3.1 Bare land | 6,886.6 | 9.8 |
| 3.2Water bodies | 295.7 | 0.4 |
| 3.3 Farm land | 857.5 | 1.2 |
| **Total** | **70,038.8** | **100.0** |

*Source: Annual report of BNBNP (2017)*

## 3.3. MONITORING OF FOREST AND VEGETATION COVERS

Changes in forest and vegetation covers in the target forest ecosystems of BNBNP shall be regularly monitored and checked, as changes in vegetation covers will significantly affect habitats of important species including key indicator species. Monitoring of forest and vegetation covers in BNBNP shall be done by analyzing the data given by the National Forest Inventory and Statistics (NFIS) and those collected through regular forest monitoring and patrolling works by park rangers of BNBNPMB. The former data are to be updated as a government program once every five years, while the latter data are to be provided by forest and park ranger stations concerned on a monthly basis. The outline of forest and vegetation cover monitoring is summarized below.

*Table 2. Outline of Forest and Vegetation Cover Monitoring*

| Items | Descriptions |
|---|---|
| Objective | To monitor any changes in distribution, areas, and proportion as well as health of forest types and land use types in the respective target forest ecosystems in BNBNP. |
| Major activities | Every 1 to 6 months[1](depending on the regular administrative reports of BNBNPMB).<br>a. Collect data of forest monitoring, patrolling including the data from drone conducted by park rangers of BNBNPMB.<br>b. Reflect any changes in forest covers to the latest forest and vegetation cover map by the BNBNP's Technology & Science Research Section.<br>c. Clarify changes in forest covers in the respective target forest ecosystems in BNBNP.<br>Every 5 years<br>a. Collect NFI&S data covering the core and buffer zones of LB-BR from DARD/MARD.<br>b. Analyze the data and assess how forest and vegetation covers in the core and buffer zones have been changed.<br>c. Clarify cover changes in the respective forest ecosystems in the zones. |
| Data to be used | ■ Data of forest monitoring and patrolling done by park ranger stations concerned<br>■ NFIS Data (officially available from DARD of Lam Dong province) |
| Sources of data | ■ Ranger stations of BNBNPMB<br>■ Lam Dong's DARD or MARD<br>■ Drone pictures/clips |
| Parties responsible for monitoring | ■ Ranger stations of BNBNPMB<br>■ Lam Dong's DARD or MARD<br>■ WG members |
| Frequency | ■ Every 1 to 6 months<br>■ Every 5 years |

The data analysis of forest and vegetation covers should provide comprehensive information on the absolute (in ha) and relative (%) changes of forest types in BNBNP and their areas.

[1] The reporting interval depends on BNBNPMB's regular administrative reports of the forest status.

Based on a series of data over time, prediction of changes may be possible. It is important if trends and causes of changes can be reported.
As mentioned above, this manual shall focus on biodiversity monitoring targeting identified indicator species from taxonomic groups such as plants, mammals, birds, amphibians and insects in natural forest habitats. Thus, the monitoring of forest and vegetation covers are not elaborated further in this manual.

## 3.4. MONITORING OF KEY INDICATOR SPECIES IN THE RESPECTIVE FOREST ECOSYSTEMS

In order to collect and accumulate basic biodiversity data and information in BNBNP and contribute to updates of the National Biodiversity Database Systems, namely NBDS, park rangers of BNBNP shall conduct the field observation through walking on the selected routes as well as tracking by camera traps set at the strategic locations.

Total six forest patrolling routes (2 km x 5 m each) which cross the three target forest ecosystems(routes numbered 1 to 6 in Table 3**,**Figure 2&Figure 3**)** were selected as patrolling routes for monitoring key species of plants, mammals and birds as indicated below. Reptiles and amphibians may be opportunistically photographed by camera traps.

Amphibians will be monitored at the other six selected stream sections (200 m long each; numbered as route 7 to 12 seeFigure 4) in the evergreen broadleaf forest (Table 3).

***Table 3. Six Forest Patrolling Routes (2 km x 5 m) for Monitoring Plants, Mammals, Birds and Other Six Routes for Monitoring Amphibians***

| Route No. | Forest Type | Nearest Forest Ranger Station | GPS Coordinates (UTM) Start point | End point |
|---|---|---|---|---|
| 1 | Evergreen broadleaf forest | Giang Ly | N 12.186220° E 108.679372° | N 12.190979° E 108.687045° |
| 2 | Evergreen broadleaf forest | Hon Giao | N 12.185900° E 108.712739° | N 12.198168° E 108.712474° |
| 3 | Broadleaf and coniferous mixed forest | Giang Ly | N 12.191032° E 108.687136° | N 12.185175° E 108.696879° |
| 4 | Broadleaf and coniferous mixed forest | Hon Giao | N 12.186566° E 108.657476° | N 12.200353° E 108.646335° |
| 5 | Coniferous (pine) forest | Nui Ba | N 12.034008° E 108.420524° | N 12.045913° E 108.432208° |
| 6 | Coniferous (pine) forest | Nui Ba | N 12.027805° E 108.445427° | N 12.043238° E 108.449806° |
| 7 | Evergreen broadleaf forest (for monitoring amphibians) | Hon Giao | N12.186389° E108.714542° | N12.187178° E108.714070° |
| 8 | Evergreen broadleaf forest (for monitoring amphibians) | Hon Giao | N12.173823° E108.699285° | N12.173271° E108.700133° |
| 9 | Evergreen broadleaf forest (for monitoring amphibians) | Hon Giao | N12.176311° E108.697254° | N12.175067° E108.696031° |
| 10 | Evergreen broadleaf forest (for monitoring amphibians) | Hon Giao | N12.179743° E108.695911° | N12.179047° E108.697244° |
| 11 | Evergreen broadleaf forest (for monitoring amphibians) | Giang Ly | N12.181661° E108.684611° | N12.180803° E108.685380° |
| 12 | Evergreen broadleaf forest (for monitoring amphibians) | Giang Ly | N12.184701° E108.677003° | N12.186083° E108.676621° |

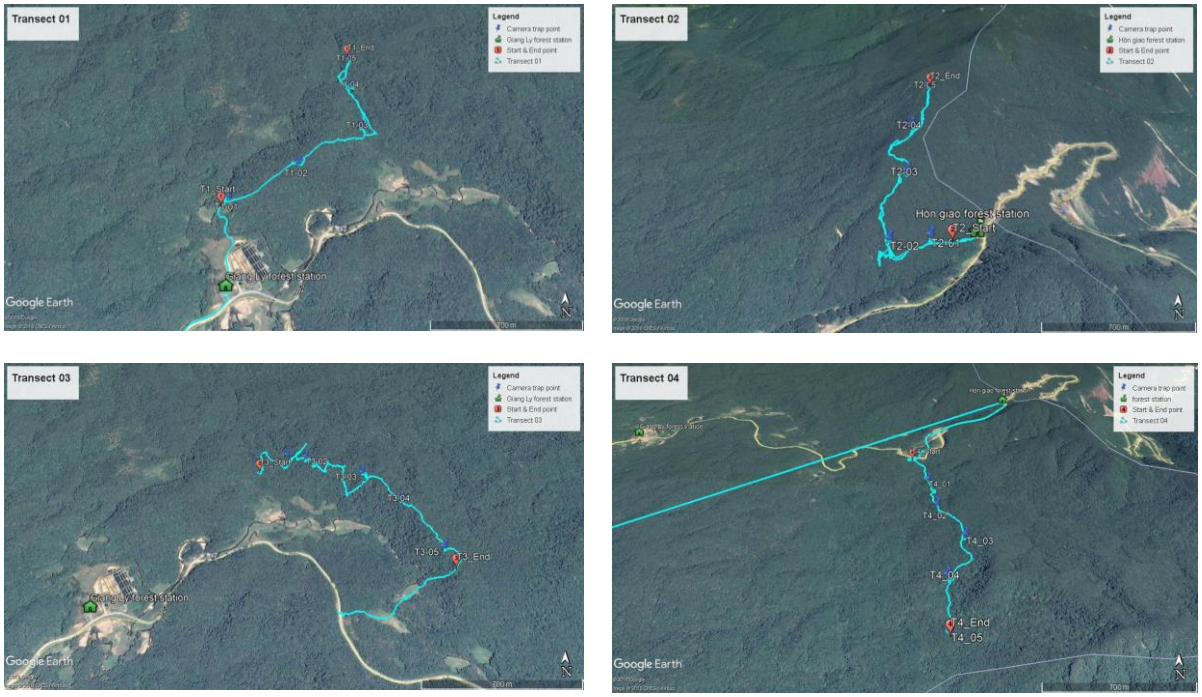


*Figure 2. Location of Routes 1 to 4*


*Figure 3. Location of Routes 5 and 6*

At the same time, at least 30 camera traps shall be strategically installed in the three target forest ecosystems at a rate of 10 camera traps per each ecosystem. The locations where camera traps are put in place shall be accessible from the patrolling courses so that park rangers can collect data of camera traps on a monthly basis but generally they should be established along the routes which are at least 500 – 1,000 m away from the main road. Regular human impacts must not be seen at the routes.

The benchmark/baseline survey shall be made along the respective routes so as to make an inventory of existing key plant species and finalize the indicator plant species with their

baseline data (e.g., geographical co-ordinates, size or number of communities, and growth conditions) of the indicator species confirmed along the respective routes. At the same time, photos of the indicator species observed shall be taken for a comparison purpose.


*Figure 4. Location of Routes 7 to 12*

The outline of key **plant and bird** indicator species monitoring through walking is summarized below:

*Table 4. Outline of Key Plant and Bird Indicator Species Monitoring*

| Items | Descriptions |
|---|---|
| Objective | To monitor the existence of key indicator species of **plants and birds** through patrolling on the selected routes crossing the target forest ecosystems in BNBNP. |
| Major activities | Monitoring of key indicator **plant species**:<br>a. Walk through the selected routes (5 m wide) and check the key indicator plant species whose existence and locations are confirmed and recorded at the time when the baseline survey is conducted. Trees of DBH≥10 cm will be measured for DBH and coordinates. Slipper orchids are counted for number of individuals.<br>b. Check if there is any change in the size, number, and conditions of communities of the species and record the observation in the format.<br>c. Take photos of the species.<br>d. Repeat b. and c. to check the existence and conditions of all indicator species confirmed in advance.<br>e. Record any other key indicator species which have not been recorded in the beginning.<br>f. Record any human impacts found.<br><br>Monitoring of key indicator **bird species**:<br>a. The line census method shall be employed. The spot census method is recommended and might be more practical as it might be difficult for park rangers to identify bird species from birdsongs in the beginning of monitoring. |

| Items | Descriptions |
|---|---|
| | b. Carefully listen birdsongs while walking the selected route routes.<br>c. Identify the indicator bird species from birdsongs and keep track of identified species with geographic co-ordinates, photographs, etc.<br>d. Identify and record other important bird species observed while route walking.<br>f. Patrolling reports of rangers relevant to illegal trapping. |
| Data to be used | ■ Observed data through route walking on the selected route routes |
| Parties responsible for monitoring | ■ Park rangers of BNBNPMB who engage in forest monitoring/patrolling |
| Frequency | ■ Once 3 months |

The outline of monitoring the indicator **mammal** species (plus birds) is summarized below:

*Table 5. Outline of Key Mammal Indicator Species Monitoring*

| Items | Descriptions |
|---|---|
| Objective | To monitor the existence of key indicator species of mammals through an analysis of data collected (photos taken) by camera traps set up in the target forest ecosystems in BNBNP. |
| Major activities | a. Collect data of camera traps installed on a regular basis (once a month).<br>b. Analyze data collected to identify types and species of mammals and birds, photographed by camera traps.<br>c. Record any human impacts found.<br>For the black-shanked doucs, direct observation is the applied method. |
| Data to be used | ■ Data (photos) taken by camera traps |
| Parties responsible for monitoring | ■ Park rangers of BNBNPMB who engage in forest monitoring/patrolling |
| Frequency | ■ Once a month |

The outline of monitoring the indicator **amphibian** species are outlined as follows:

*Table 6. Outline of Key Amphibian Indicator Species Monitoring*

| Items | Descriptions |
|---|---|
| Objective | To monitor the existence of key indicator species of amphibians on the selected routes (6 stream sections) in BNBNP. |
| Major activities | a. Collect data using the visual encounter method.<br>b. Analyze data collected.<br>c. Record any human impacts found. |
| Data to be used | ■ Observed data. |
| Parties responsible for monitoring | ■ Park rangers of BNBNPMB who engage in forest monitoring/patrolling |
| Frequency | ■ Once 3 months |

For **insects**, the outline of monitoring is summarized below.

*Table 7. Outline of Key Insect Indicator Species Monitoring*

| Items | Descriptions |
|---|---|
| Objective | To monitor the existence of key indicator species of insects at forest protection stations |
| Major activities | Monitoring of key indicator insect species:<br>a. The light trap method shall be employed at selected Forest Protect Stations.<br>b. Record number of individuals (male and female) of target species. |
| Data to be used | ■ Observed data through light traps. |
| Parties responsible for monitoring | ■ Park rangers of BNBNPMB |
| Frequency | ■ Once 3 months; January, April, July and October are recommended due to the species' life cycles. |

## 3.5. ESTABLISHMENT OF LONG-TERM MONITORING PLOT

In addition to regular monitoring and data collection through forest monitoring and management activities of BNBNPMB, the BMS proposes the establishment of a long-term monitoring plot (1ha). The plot was established in evergreen broad-leaved forest as one of the most important forest ecosystems for a long-term research on ecological characteristics of the target forest ecosystem. The actual works for the establishment of the plot are indicated in Chapter 4, 4.2. Development of the 1-ha permanent plot.

## 3.6. DATA RECORD, KEEPING AND MANAGEMENT

All the data and information collected by the field monitoring activities shall be gathered by the Technology & Science Research Section or/and ICTHER of BNBNPMB. The section shall check the collected data for verification. Particularly, the section shall analyze those collected from camera traps for identification of species with technical assistance of an/ external expert/s hired by SNRMP for the initial period of time. All the data shall be input into the BRAHMS as the database system of BNBNPMB after verification.

In case that the field monitoring activities indicate any sign of significant impacts on the target ecosystems or key indicator species, BNBNPMB shall lay out an in-depth survey or investigation to determine the extent of the impacts as well as possible causes of such impacts. The proposal of the in-depth survey shall be submitted to LBBR-MB for approval and endorsement to the PPC.

## 3.7. REPORTING AND DATA SHARING WITH NBDS

The results and data of the monitoring activities shall be periodically reported to LBBR-MB. Simultaneously, the Technology & Science Research Section or/and ICTHER of BNBNPMB shall share and transfer the collected biodiversity data with/to NBDS, in coordination with DONRE. Data sharing with the databases shall be undertaken in accordance with the protocols/procedures developed by the respective ministry.

# Chapter 4 : DEVELOPMENT OF A PERMANENT PLOT

## 4.1. PREPARATION WORKS

### 4.1.1. Getting to know the methods

The workers must read carefully to be familiar with the methods of establishing and inventorying the plot following the information given below. For the first baseline census of the plot, the staff should be trained on-the-job with experienced experts. For re-census, new staff must work together with those who have experienced the applied methods, e.g. those who have taken part in the first census as Training of Trainers (ToT) approach.

### 4.1.2. Equipment/materials

Establishment ofa1ha permanent plot requires the preparation of the following equipment and materials in advance.

*Table 8. Material for Establishment of a Permanent Plot (1 ha)*

| No. | Material | Unit | Quantity |
|---|---|---|---|
| 1 | Permanent tags | item | 1,500 |
| 2 | Steel nails | kg | 7 |
| 3 | Copper string for tagging | m | 1,000 |
| 4 | Calipers | item | 5 |
| 5 | Paint | kg | 12 |
| 6 | Nylon string | kg | 4 |
| 7 | Paint brush | item | 20 |
| 8 | Marker string | m | 100 |
| 9 | Safety trousers | item | 5 |
| 10 | Safety shirt | item | 5 |
| 11 | Paper for collecting specimens | kg | 50 |
| 12 | Cutters for collecting specimens | item | 2 |
| 13 | Labels for collecting specimens | item | 400 |
| 14 | Battery 2A | item | 30 |
| 15 | Battery 3A | item | 30 |
| 16 | Tape | item | 2 |
| 17 | Tape | item | 3 |
| 18 | Alcohol | litter | 10 |
| 19 | Rubber hammer | item | 2 |
| 20 | Hammer | item | 2 |
| 21 | Concrete marking pillars (1 m x 10 cm x 10 cm) | item | 4 |
| 22 | PVC marking pillar (1 m, | item | 150 |
| 23 | Cement | kg | 20 |
| 24 | Announcement board | item | 1 |
| 25 | Camera set for plant photographs | set | 1 |
| 26 | Camera trap | set | 5 |
| 27 | Printed forms and stationery | | |

## 4.2. FIELD WORKS

The 1-ha plot (100 x 100 m) is established following Alder and Synnott (1992) and Qie et al. (2017). Actual activities to be undertaken for the establishment of the plot are indicated as below (see 7.1.1 Monitoring at Permanent Plot for more details).

**Step 1: Selection of the site**

| Items | Specifications |
|---|---|
| Criteria for selection of the proposed site for the plot | a. The plot is located in the target ecosystem and has the typical ecological characteristics of the target ecosystem.<br>b. The plot has still intact forests without any human disturbance.<br>c. The plot is isolated from any existing trails but still accessible even during the rainy season. |

**Step 2: Plot demarcation and set-up of concrete pillars at the corners of the plot**

All four corners are permanently marked with concrete pillars which were geographically positioned using Garmin GPSMap 64s. At every 10 m, a PCV pole is fixed into the soil to avoid unexpected movements. All subplots and stripes are coded. Actual distances in the field are calibrated as follows:

$$\text{Actual distance (D)} = \frac{\text{Horizontal distance } (D_h)}{\text{Cosine (slope angle)}}$$

**Step 3: Set up the camera traps**

Previous camera trapping results in the LBBR showed a wide range of species, with at least 20 species of mammals and 10 species of birds including the selected indicators. Thus, by using this kind of system, we will have information for ground dwelling animals that are active around and inside the plot. In this project, in order to monitor the presence of the target mammals and birds (plus reptiles and amphibians *ad hoc*) in the plot, five camera traps are set up systematically. One camera trap will be deployed at each corner of the plot, and one more at the center (Figure 5&Figure 6).

- Cameras traps will be placed at a height of approximately 20 – 30 cm from the ground (Figure 6), allowing the capture for a wide range of bird and mammal species from small (murid, babbler) to medium (civets, pheasants) and large animals (muntjac, sambar).
- No baits are used.
- Camera traps will be programmed to run continuously for 30 days at each camera trap location and to take nine consecutive pictures per trigger with one-minute delay between triggers.
- Photos will be collected every month, identified and stored.

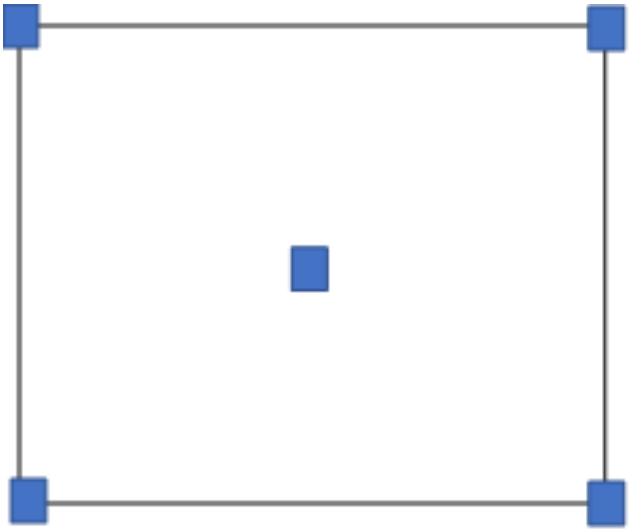

*Figure 5. Location to be set up five camera traps in the 1-ha plot*

*Source: Tran Van Bang/SIE*

*Figure 6. Installing a camera trap*

# Chapter 5 : DEVELOPMENT OF MONITORING ROUTES

## 5.1. PREPARATION WORKS

### 5.1.1. Route selection

The usual patrolling routes used by the forest rangers are those of monitoring plants and birds. Two routes of 2 km each are selected for each of the three forest types: evergreen broadleaf forest, coniferous (pine) forest, and broadleaf and coniferous mixed forest. They are at least 500 m away from the main road and do not experience regular human impacts.

As the target amphibians inhabit mainly at water courses, they will be monitored along streams. Most of streams in the park, which are at least 500 m away from the main road and do not experience regular human impacts, are located in the evergreen broadleaf forest. Monitoring amphibians requires field work in or around water courses at night, it is recommended to select monitoring stream sections of 200 m length each and the region from K'Long K'Lanh to Hon Giao forest protection stations appear to be the most convenient for monitoring.

### 5.1.2. Equipment/materials

GPS must be used to position the ends of each monitoring route. To facilitate the field work, a vegetation map of the park is prepared. A camera set is needed to take photograph of indicator species encountered in the routes. Yellow paint is used to mark the trees along the center of the routes and red paint is used for monitored trees. Depending on a specific group of species to be monitored, a set of equipment/materials is recommended to prepare for the field work. Please see Chapter 7 for details.

## 5.2. FIELD WORKS

The trees located along the patrolling route center from the beginning point to the end are marked with yellow paint. The transect will be marked at least every 50 m interval points or distinguish landmarks along the route. The marked location is geo-referenced by GPS. As these routes are used for monitoring plant and bird indicators of this project, existing key plant species and the indicator plants should be determined within a 5-m width along the routes. Similarly, the stream sections for monitoring amphibians will be marked with yellow paint on a large tree nearest the start and end points.

# Chapter 6 : INDICATOR SPECIES

## 6.1. PLANTS

Like the animal indicators in this project, although plant ones in BNBNP could be many, it has been agreed that in this project, the target plants for monitoring include the following species (Table 9) besides other threatened species encountered *ad hoc*.

***Table 9. List on Indicator Species (Plants)***

| Forest Type | Endangered spp. | Valuable spp. | Invasive spp. | Monitoring routes to be found the species |
|---|---|---|---|---|
| Evergreen broadleaf forests | - *Calocedrus macrolepis*<br>- *Taxus wallichiana*<br>- *Paphiopedilum appletonianum*<br>*Any other endangered species found *ad hoc* in the determined monitoring routes | - *Magnolia yunnanensis* & spp. | | 1, 2 |
| Coniferous forests | - *Codonopsis javanica* | - *Galium* sp.<br>- *Pinus kesiya* | - *Lantana camara* | 3, 4 |
| Mixed Conifer broadleaf forests | - *Pinus krempfii*<br>- *Pinus dalatensis*<br>- *Fokienia hodginsii*<br>*Any other endangered species found *ad hoc* in the determined monitoring routes | - *Magnolia yunnanensis* & spp. | | 5, 6 |

***Calocedrus macrolepis***

This tree is called *Bách xanh núi đất* in Vietnamese (Figure 7). It is a threatened conifer rare in the park. It occurs on rocky soils in the boundary of the park to Khanh Hoa Province. In the moment, this site is under responsibility of the Hon Giao Forest Protection Station.

*Source: Luu Hong Truong/SIE*

***Figure 7. Calocedrus macrolepis***

***Taxus wallichiana***

This conifer is a large tree that is known for its taxon – an anti-cancer substance. The tree has been logged and become rare in BNBNP (Figure 8). Therefore, it is a fortune to have it in the routes; it would rather be recommended to monitor through regular patrolling activities.

*Source: Luu Hong Truong/SIE*

***Figure 8. Taxus wallichiana***

***Paphiopedilum appletonianum***

One of the most popular slipper orchids is *Paphiopedilum appletonianum* (*Lan hài cuộn*) (Figure 9). All of the slipper orchids (*Paphiopedilum* spp.) in BNBNP are threatened species that are commonly harvested from the wild. They are distributed mainly in the evergreen and coniferous and broadleaf mixed forests and easily recognized due to their green leaves with white dots. The plants are grown as ornament as their flowers are large and nice looking.

*Source: Luu Hong Truong/SIE*

***Figure 9. Paphiopedilum appletonianum***

***Magnolia yunnanensis***

Chosen for monitoring, it is a valuable tree (*Kui dui*) that plays an important role in the forest ecosystem. Providing fruits for birds and squirrels, the plant is distributed in the pine and evergreen broadleaf forests (Figure 10). Keeping the tree in the forest will help maintain the food source for these animals and thus the balance of the forest ecosystems.

*Source: JICA SNRM Project (2017)*

***Figure 10. Magnolia yunnanensis***

***Codonopsis javanica***

Nationally threatened and used in medicinal medicine, the liana is called *Đẳng sâm*. It is found most in the pine forest. Most of the local people and forest rangers know this plant as it is a common non-timber forest product. It is hard to find it in the dry season as it is deciduous (Figure 11).

*Source: Luu Hong Truong/SIE*

***Figure 11. Codonopsis javanica***

***Galium* sp.**

This is a liana found in the pine forest. Its root is harvested for use in traditional medicine. It is called *Sâm đỏ* (red ginseng) due to the color of its root (Figure 12). Nevertheless, the species will be soon threatened due to the destructive harvesting method being employed.

*Source: JICA SNRM Project (2017)*

***Figure 12. Galium sp.***

***Pinus kesiya***

This is one of the most abundant pines in Asia and is the key tree in the coniferous forest in BDBNP. This kind of pine forest occupies the most area in the park (Figure 13). In BNBNP, the species is illegally cut or poisoned for agricultural expansion.

*Source: Luu Hong Truong/SIE*

***Figure 13. The three-needled pine - Pinus kesiya***

***Lantana camara***

Popularly called as *Ngũ sắc*, this is one of the world's most dangerous invasive plants. In BNBNP, it is common in opened areas, especially in the pine forest. No control activities have been employed. The plant is easily known by its colorful flowers (Figure 14).

*Source: Luu Hong Truong/SIE*

***Figure 14. Lantana camara***

***Pinus krempfii***

This two-leaf pine is special as its leaves are flat – unique in the genus (Figure 15). The species is endemic to the Langbiang Plateau and its surrounding areas. Like the above pine, this giant one is logged for its wood and thus threatened.

*Source: Luu Hong Truong/SIE*

***Figure 15. Pinus krempfii***

***Pinus dalatensis***

Named after Da Lat City, this threatened large tree pine is also called as *Thông năm lá* (five-leaved pine) (Figure 16). The species is recently found existing in other provinces in Central Vietnam and several sites in Laos. It is logged for its wood that is favored for furniture.

*Source: Luu Hong Truong/SIE*

***Figure 16. Pinus dalatensis***

***Fokienia hodginsii***

Globally and nationally threatened, this tree (*Pơ-mu*, Figure 17) is distributed in China, Laos and Vietnam. Distributed scattered in high slopes of the evergreen and coniferous and broadleaf mixed forests, it is a precious wood that is a target for illegal logging. The species is easily recognized by most of forest rangers of BNBNP.

*Source: Luu Hong Truong/SIE*

***Figure 17. Fokienia hodginsii***

## 6.2. MAMMALS

There are five mammal species proposed to be indicators for species and habitat monitoring including Black-shanked douc (*Pygathrix nigripes*), Stump-tailed macaque (*Macaca arctoides*), Owston's palm civet (*Chrotogale owstoni*), Common muntjac (*Muntiacus muntjak*) and Wild pig (*Sus scrofa*) (Table 10). These mammals are rare to fairly common in the Langbiang Biosphere Reserve and can be observed and recorded with equipment assistance.

***Table 10. List of Indicator Species (Mammals)***

| Ecosystems | Endangered spp. | Monitoring routes to be found the species |
|---|---|---|
| Evergreen broadleaf forests/ Mixed Conifer broadleaf forests | - Black-shanked douc (*Pygathrix nigripes*)<br>- Stump-tailed macaque (*Macaca arctoides*)<br>- Owston's palm civet (*Chrotogale owstoni*)<br>- Common muntjac (*Muntiacus muntjak*)<br>- Wild pig (*Sus scrofa*)[2] | 1 – 4 |
| Coniferous forests | - Common muntjac (*Muntiacus muntjak*) | 5 & 6 |

[2] This is not an endangered mammal but can indicate for the forest conditions and human impacts.

**Black-shanked douc (*Pygathrix nigripes*)**

Head-body length: 55 – 63 cm; Tail length: 57 – 73 cm; Weight: 11 kg (male), 8 kg (female).

Striking, with large, almond-shaped eyes surrounded by yellow circles that stand out against the blue-grey face. White muzzle fur, long, white whiskers, and black forehead fur frame the face, giving the monkey a wise appearance. The black forehead coloration extends over the head and onto the shoulders, where it fades to grey across the back and forelimbs, appearing palest on the belly. The hind limbs are black, and there is a white patch on the rump surrounding the extremely long, tasseled, white tail. Males have a circular white spot on either side of the rump and are easily distinguished from females by their blue scrotum and inner thighs, and bright pink penis (Figure 18).

Active during the day, the black-shanked douc is occasionally seen on the ground in the wild and spends much of its time feeding high in the forest canopy. It prefers unripe fruit and young leaves. The black-shanked douc typically lives in groups of 3 and 50 individuals.

*Source: Le Khac Quyet/SIE*

***Figure 18. Black shanked douc***

**Stump-tailed macaque (*Macaca arctoides*)**

Male Head-body length: 52 – 65 cm (male), 48 – 59 cm (female); Tail length: 0.3 – 6.9 cm; Weight: 9.9 - 10.2 kg (male), 7.5 - 9.1 kg (female).

The stump-tailed macaque, also known as the bear macaque, begins life with white, fluffy fur, but as it matures a thick, shaggy, dark brown fur develops on its body, excluding the face and tail. Its tail is so small that it can often appear absent. The stump-tailed macaque is sometimes also called the 'red-faced monkey', which describes this macaque's bright pink or red face. This bright coloring fades with age, becoming brown and black in response to sunlight. Males are considerably larger than females and also possess longer canine teeth; a feature which is used as a measure of dominance within social groups (Figure 19).

The stump-tailed macaque typically lives in groups of around 20 to 50, of both sexes. It has a diet largely comprised of fruit, seeds, young leaves and other vegetation, but it is also known to eat insects, bird eggs, frogs and crabs. It spends the daytime foraging for food and stores the food it collects in cheek pouches. Although the stump-tailed macaque can climb trees it is typically terrestrial and far more agile on the ground.


*Source: Le Khac Quyet/JICA SNRM Project (2017)*

***Figure 19. Stump-tailed macaque***

**Owston's palm civet (*Chrotogale owstoni*)**

Head-body length: 56 – 72 cm; Tail length: 35 – 47 cm; Weight: 2 – 3.5 kg.

Owston's palm civet has an elongate body, neck and tail, small head and long, tapering, whiskered snout. The coat is tawny buff-grey with a contrasting pattern of black or brown longitudinal stripes on the head, neck and shoulders, transverse black or brown bands on the back and tail, and scattered black spots on the sides and limbs. Owston's palm civets are easily identified by four dark dorsal bands, and the last two thirds of the tail are completely black. The civet's underside is pale creamy white and in males this is suffused with orange from the chest to the groin. In females, the orange coloration occurs mainly around their genitalia (Figure 20).

Ownston's palm civet is believed to be a solitary species that scent-marks its territory. It forages on ground mainly and feeds on earthworms, which appear to form the bulk of the natural diet, as well as small vertebrates, invertebrates, including fish, frogs and insects and fruit.

*Source: Le Khac Quyet/JICA SNRM Project (2017)*

***Figure 20. Ownston's plam civet***

**Common muntjac (*Muntiacus muntjak*)**

Head-body length: 89 – 135 cm; Shoulder height: 40 – 65 cm; Tail length: 13 – 23 cm; Weight: 14 – 35 kg.

Common muntjac, also called red muntjac and barking deer, has small antlers present in males which are relatively short with long burrs. The females have tufts of hair and small bony knobs that are in the location of the antlers in males. They have a short coat of hair. The color of the coat is golden tan on the dorsal side, white on the ventral side, and the limbs and face are dark brown. The ears have very little hair. These deer also possess tusk-liked upper canines measuring about 2.5 cm in males. The males tend to be larger than the females (Figure 21).

When they sense the presence of a predator, they emit sounds that sound like a dog barking. They may bark for more than an hour to make a predator show itself or leave the area. The muntjac may bark more frequently when its ability to see its surroundings is reduced as a result of the environment. The adult male and female muntjacs are solitary. Muntjacs are omnivorous, feeding on herbs, fruit, birds' eggs, small animals, sprouts, seeds, and grasses. They use their canines to bite and their forelegs to deliver strong blows in order to catch small warm-blooded animals.

*Source: Nguyen The Truong An/SIE*

***Figure 21. Common muntjac***

**Wild pig (*Sus scrofa*)**

Head-body length: 153 – 240 cm; Shoulder height: 40 – 90 cm; Tail length: 21 – 38 cm; Weight: 65 – 270 kg.

Adult wild pigs have a thick, coarse coat of hair covering their bodies. Their coat ranges in color from black to brownish-red to white. They may also have longer bristly hairs that grow down the middle of their backs. At birth, young pigs generally have yellowish-brown stripes running down their backs that disappear into an even coloration within about 4 months (Figure 22).

Wild pigs are typically social animals, living in female-dominated sounders consisting of barren sows and mothers with young led by an old matriarch. Males leave their sounder at the age of 8–15 months, while females either remain with their mothers or establish new territories nearby. Subadult males may live in loosely knit groups, while adult and elderly males tend to be solitary outside the breeding season.

Wild pigs are omnivorous. They predominantly eat plant matter, particularly crops, fruits, nuts (mast), roots, and green plants. They have also been known to consume bird eggs, carrion, small rodents, insects, and worms.

*Source: Tran Van Bang/SIE*

***Figure 22. Wild pig***

## 6.3. BIRDS

There are six bird species proposed to be indicators for habitat monitoring including Collared Laughingthrush (*Trochalopteron yersini*), Black-hooded Laughingthrush (*Garrulax milletti*), Mountain Imperial Pigeon (*Ducula badia*), Vietnamese Cutia (*Cutia legalleni*) and Necklaced Barbet (*Psilopogon auricularis*) for evergreen and mixed conifer broadleaf forest; and Red Crossbill (*Loxia curvirostra*) and Vietnamese Cutia (*Cutia legalleni*) for pine forest (Table 11).

***Table 11. List of Indicator Species (Birds)***

| Ecosystems | Endangered spp. | Useful spp. for tourism | Monitoring routes to be found the species |
|---|---|---|---|
| Evergreen broadleaf forests | - Collared Laughingthrush (*Trochalopteron yersini*)<br>- Black-hooded Laughingthrush (*Garrulax milleti*) (2)<br>- Vietnamese Cutia (*Cutia legalleni*) | | 1 & 2 |
| Coniferous forests | - Red Crossbill (*Loxia curvirostra*)<br>- Vietnamese Cutia (*Cutia legalleni*) | | 5 & 6 |
| Mixed Conifer broadleaf forests | - Mountain Imperial Pigeon (*Ducula badia*)<br>- Necklaced Barbet (*Psilopogon auricularis*) | N/A | 3 & 4 |

These bird species are rare to fairly common in the LBBR and can be observed and heard with equipment assistance.

**Collared Laughingthrush (*Trochalopteron yersini*)**

A large Laughingthrush (26-28 cm long) with orange-brown wings and breast, black-hood and silver ear-patch (Figure 23).

Their song is repeated, loud, rising *wueeeeoo*, *u-weeeeoo*, *uuuu-weeoo or wiu-weeeu*, often answered with low, mewing *wiaaah*, *ayaaa* or *ohaaaah*. Subdued, harsh, slurred *grreet-grreet-grreet-grreet-grrr-rr* when alarmed. Their songs can be heard from 100-150 m away.

The bird forages in lower canopy and on the ground and feeds on insect and caterpillars. In breeding season (March to May), they are found in pairs, out of breeding season, small flocks are found. Home range and territorial behavior are poorly known, but the species is quite sensitive to response to playback songs.

*Source: Le Duy/SIE*

***Figure 23. Collared Laughingthrush***

**Black-hooded Laughingthrush (*Garrulax milletti*)**

*Garrulax milleti* is confined to the Da Lat and Di Linh plateaus, the Kon Tum plateau of Vietnam, and Xe Kong and Attapeu provinces of Laos**.**

The species is large black, grey and white laughingthrush. The species in LBBR has head to nape, ear-coverts and breast glossy blackish, feathers of forehead and above eye pointed (Figure 24).

This species is usually found in flocks in dense undergrowth of broadleaf evergreen forest between 800 and 1,650 m. It is easy to recognize by their appearance as well as their calls. The calls are very loud outbursts of extended rapid cackling laughter, incorporating prolonged, rapid rattling and can be heard from a distance of 100-150 m. The breeding season is from May to June.

The bird forages in lower canopy and on the ground and feeds on insect and caterpillars.
Home range and territorial behavior of the Black-hooded Laughingthrush are poorly known, but the species is quite sensitive to response to playback songs.


*Source: Hoang Minh Duc/SIE*

***Figure 24. Black-hooded laughingthrush***

**Vietnamese Cutia (*Cutia legalleni*)**

A small (17.5-19.5 cm) and distinctive, short-tailed babbler. Male has forehead to nape bluish-tinged slate grey, broad black mask, whit throat, bright rufous-chestnut upperparts and barred underparts. Female has white throat and barred underparts but lacks the striking bluish grey crown and chestnut upperpart features of the male (Figure 25).

**Voice:** Variable, distinctive whistles *wuyeetwuwi woo* repeated every 3-6 seconds, *wuyeetwuweeit-wu* and other similar calls.

The species is most often found in broadleaf evergreen forest, mixed broadleaf and pine forest, and sometimes pure pine forest. It is typically seen in the canopy and sub-canopy of primary forest, travelling either in pairs or groups of up to 10 birds feeding amongst epiphytes or moss-covered branches and around bowls in large trees (J. C. Eames *in litt.* 2007).

Home range and territorial behavior of the Vietnamese Cutia are poorly known, but the species is quite sensitive to response to playback songs.

*Source: Hoang Minh Duc/SIE*

***Figure 25. Vietnamese cutia***

**Red Crossbill (*Loxia curvirostra*)**

A small bird (14–20 cm; 23–53 g) with large head, plump body, short legs and short, forked tail; distinctive large broad-based bill with pointed mandible. Males are variably brick or orange-red on head, underparts, mantle and rump, mantle with some brown, wings and tail black. Females are olive to yellowish-green, rather greyer on head and face, brighter green on rump, with dark wings and tail (Figure 26).

In the LBBR, the species occurs pine forests.

The breeding season is generally determined by food abundance but varies by region. In the LBBR, its nest is a deep cup of conifer twigs, bark or rotting wood strips, plant fibers, grass, moss, lichens, animal hair and feathers. The species is resident and a partial migrant (Clement and Christie 2016).

*Source: Le Duy/SIE*

***Figure 26. Red crossbill***

**Mountain Imperial Pigeon (*Ducula badia*)**

The mountain imperial pigeon is the large pigeon (43–51 cm long) with a fairly long tail, broad, rounded wings and slow wing-beats. The head, neck and underparts are vinous-grey with a contrasting white throat and brownish-maroon upperparts and wings, though the upper part of the body can be duller. It is quite easy to recognize this species thanks to a distinctive appearance of the maroon back and its large size (Figure 27).

This species is solitary but sometimes found in groups numbering up to 20. They can be difficult to see since they spend their time usually in high canopy but can be recognized by its distinctive call.

The breeding season is from January to May. The nest is usually in a fairly small tree, about 5 to 8 m off the ground, and is a flimsy platform. One or, rarely, two eggs are laid, and both parents incubate. They only leave the nest if highly pressed. They feed on fruits and berries, especially figs, which are plucked and swallowed whole.

*Source: Hoang Minh Duc/SIE*

***Figure 27. Mountain Imperial Pigeon***

**Necklaced Barbet *Psilopogon auricularis***[3]

Necklaced Barbet is a small Asian barbet, just about 22.5 cm in length. It is a plump bird, with a short neck, large head, heavy bill and short tail. The bill is dark, and the body plumage is green. The adult has red on forehead and nape, golden on crown and throat, black eye stripe, white lower face neck, and some blue behind the ear coverts (Figure 28). Male and female are similar.

Necklaced Barbet lives in evergreen forest, mixed broadleaf and pine coniferous forest and coniferous forest at elevations of 900 to 2,565 m, and primarily feed on fruits and some flowers, but will also eat a wide range of insects, such as ants, cicadas, dragonflies, crickets, locusts, beetles, moths and mantids.

They nest in tree holes. The females lay 2 to 4 eggs (BirdLife International 2018, HBW Alive 2018).

*Source: Hoang Minh Duc/SIE*

***Figure 28. Necklaced Barbet***

[3] The subspecies of *Megalaima franklinii**auricularis* is now considered as a good species, the Necklaced Barbet, and put into genus *Psilopogon, P. auricularis* (del Hoyo and Collar 2014)

## 6.4. AMPHIBIANS

There are five amphibian species proposed to be indicators for monitoring, all for Evergreen broadleaf forests (Table 12). They are described below.

*Table 12. List of Indicator Species (Amphibians)*

| Forest Type | Endangered spp. | Useful spp. for tourism& food | Monitoring routes to be found the species |
|---|---|---|---|
| Evergreen broadleaf forests | - *Rhacophorus calcaneus*<br>- *Raorchestes gryllus* | - *Odorrana graminea*<br>- *Limnonectes poilani*<br>- *Raorchestes gryllus*<br>- *Brachytarsophrys intermedia* | 7-12 |

**Annam Spadefoot Toad (*Brachytarsophrys intermedia*)**

This species was discovered in Langbiang Plateau in 1921 (Smith, 1921) and therefore it represents a historical scientific discovery for the region. Size very large, SVL up to 100 mm; head round, broader than long; nostril with flip of skin, midway between tip of snout and eye; canthus rostral is very sharp; eye large; upper eyelid with tubercles and a long, pointed dermal protruding, forming a leaf shape projection upon the eye; tympanum covered by skin; supratympanic fold distinct, extending from posterior of eye to above level of insertion of forearm into body; a pair of dermal hems, continue or broken, commencing from shoulder to middle of dorsum, nearly parallel with the supratympanic fold; dermal tubercles being on dorsum and flank; upper part of flank tubercular; chin and throat smooth with tiny granules; belly smooth. Limbs short and robust; tips of fingers and toes blunt and swollen; fingers short, without webbings; toes webbing; hind limbs short, with tibio tarsal articulation nearly touching tympanum (Figure 29).

Dorsal surfaces of head and anterior part of dorsum bronze or dark brown; posterior part of dorsum with flecks or reticulations with dark brown; dorsolateral region lighter; dark bars below eye; a dark brown patch on tympanal region; transverse dark brown cross-bars on limbs present. Young individuals are yellowish with more distinguished markings(Smith, 1921; Bourret, 1942).

*Source: Tran Thi Anh Dao/JICA SNRM Project (2017)*

***Figure 29. Brachytarsophry intermedia***

**Large Odorous Frog (*Odorrana graminea*)**

Females much larger than males; head longer than wide; nostril closer to tip of snout than to eye; canthus rostral is distinct; tympanum distinct; supratympanic fold indistinct; dorsolateral fold indistinct; skin smooth dorsally and ventrally; fingers free of webbing; toes fully webbed; tips of finger and toes with large discs, with circum marginal grooves; subarticular tubercles on fingers prominent; tibio tarsal articulation beyond tip of snout; heels strongly overlapped when legs are folded at right angles to body (Figure 30).

Dorsum green or brownish olive with or without spots; lateral head greenish brown; edge of upper lip golden; upper part of flank brownish olive or brown, lower part of flank greyish white; ventral surface whitish; transverse cross-bars on upper limbs brown; dorsal surface of discs light grey; dorsal tibia with few small, green flecks; webbing light grey; iris golden (Bain et al., 2003).

The species is used as food by local communities.

*Source: Tran Thi Anh Dao/JICA SNRM Project (2017)*

***Figure 30. Odorrana graminea***

**Poilane's Frog (*Limnonectes poilani*)**

Body stocky and so used as food by local communities; size large; head large with two large swellings in occiput region and two tusks on lower jaw present in males; nostril round, closer to tip of snout than to eye; canthus rostral is indistinct; eye large, shorter than snout length; tympanum round and very distinct; supratympanic fold thickly prominent; skin dorsally smooth or granular, with some large, round tubercles and short glandular folds; ventral surface of body and limbs smooth. Fingers free; toes fully webbed; tops of fingers and toes round, swollen; tibio tarsal articulation extending to eye or nostril; heels overlapped when legs are folded at right angles to body (Figure 31).

Top brown or dark grey; a light and dark brown bar crossing between upper eyelids; some dark brown or black patches or reticulations, covering part of dorsal tubercles; side of head light brown; large, dark brown patches on lips present; upperpart of tympanum dark brown and lower half light brown; supratympanic fold dark brown; upper part of flank with some large, irregular shapes, dark brown blotches, lower part of flank whitish or yellow; chin and throat white marbling with dark brown patches; chest and belly white or whitish yellow; cross-bars on back of limbs dark brown (Bourret, 1942).

*Source: Tran Thi Anh Dao/JICA SNRM Project (2017)*

***Figure 31. Limnonectes poilani***

**Langbian Bubble-nest Frog (*Raorchestes gryllus*)**
Size small to medium (SVL up to 28 mm in males, 34 mm in females); head as long as wide; snout pointed in dorsal view; nostril round, midway between tip of snout and eye; canthus rostral is distinct; tympanum visible; supratympanic fold distinct; dorsal skin with tubercles, ventral skin coarsely granular; dermal fringes along outer edges of fore and hind limbs well developed; small tubercles on heel present; fingers free of webbing; toes webbed; tips of fingers and toes with enlarged round discs, with peripheral grooves; tibio tarsal articulation reaching to eye (Figure 32).

Color pattern varies depending on sexual and individual. In males, dorsal surface light brown staining with reddish brown or with bright green marbling on head, dorsum and limbs; a bright green triangle patch, on anterior part of upper eyelid and snout, sometimes this patch combining with the posterior bright green marbling or just staining and mixing with the background as some small green scraps; a dark brown lateral dorsal long mark, in “)(“ or “M” shape, from rear of eye to groin, present or absent; color pattern of upper part of flank similar to that on dorsum, lower part fleshy, with irregular dark brown spots or dark brown oblique stripes; venter white; upper parts of limbs with dark brown transverse bars (Smith, 1924 and Orlov et al., 2012).

The species was first found in the Langbiang Plateau (Smith, 1921). This species has recently been ranked as Vulnerable in the IUCN Red List because of their decline in population (IUCN, 2017). They have an especially loud voice that may attract ecotourists.

*Source: Tran Thi Anh Dao/JICA SNRM Project (2017)*

***Figure 32. Raorchestes gryllus***

**Vietnam Flying Frog (*Rhacophorus calcaneus*)**
Size up to 45.8 in males, 60.2 mm in females; Head as long as wide; snout pointed in dorsal view; canthus rostral is distinct; supratympanic fold distinct; skin smooth above and granular at bottom; dermal fringes along outer margins of the fourth finger, lower arm, fifth toe, and foot distinct; projection on heel pointed and long; fingers and toes well webbed; tips of fingers and toes flat, enlarged into round discs with circum marginal grooves; tibio tarsal articulation extending to eye or between eye and tip of snout; heels overlapped when legs held at right angles to body (Figure 33).

Dorsum pale green to dark green or dark brown with many small, white or yellow spots; a pair of yellow dorsolateral stripes, stretching from posterior corners of eyes to groins; another medium yellow stripe, extending from behind the middle of dorsum towards cloaca, present or absent; a triangle on the dorsal surface of head; flank yellow to orange; ventral surface bright yellow two black patches present on axilla and groin. In female, the bright bluish patterns on axilla, groin and front of the forearm are more obvious and extending to the middle of flank, covered nearly the whole anterior surface of the forearm(after Tran et al., 2011; Orlov et al. 2012).

This species is ranked as Endangered in the IUCN Red List because of their continuing decline in population and habitat (IUCN, 2018).

*Source: Tran Van Bang/JICA SNRM Project (2017)*

***Figure 33. Rhacophorus calcaneus.***

## 6.5. INSECTS

Four target insects were chosen for the long-term monitoring, including long-tailed moth (*Actias chapae bezverkhovi*), five-horned rhinoceros beetle *(Eupatorus gracilicornis)*, long-armed beetle (*Cheirotonus gestroi*), and Vietnam largest moth (*Archaeoattacus vietnamensis*) (Table 13).

***Table 13. List of Indicator Species (Insects)***

| Forest Type | Endangered spp. | Forest Ranger Stations |
|---|---|---|
| Evergreen broadleaf forests | - Moth: *Archaeoattacus vietnamensis*<br>- Beetle: *Eupatorus gracilicornis*<br>- Beetle: *Cheirotonus gestroi* | Hon Giao Forest Protection Station |
| Mixed Conifer broadleaf forests | - Moth: *Actias chapae bezverkhovi*<br>- Beetle: *Eupatorus gracilicornis*<br>- Beetle: *Cheirotonus gestroi* | Giang Ly Forest Protection Station |

The information about the species and their ecology is as follows:

**Long-tailed Moth (*Actias chapae bezverkhovi*)**

The subspecies was an indicator of pristine mountainous forests in southern Central of Vietnam. Their larvae feed on pines and the mature hide in nearby evergreen broadleaf forests. They have two life cycles per year, the early beginning in March and the later beginning in September. Males and females mate in forest sand at night they are attracted by light (moon in nature) and fly up the canopy for spreading out their population (Figure 34).

*Source: Do Manh Cuong/SIE*

***Figure 34. Actias chapae bezverkhovi***

**Five-horned rhinoceros beetle (*Eupatorus gracilicornis*)**

This is a large beetle (Figure 35) that is found in all the target three forest types in southern Vietnam. They are common and easy to observe. They spend long time in the larvae status before turning to the mature form that emerges from the forest soil in the heavy raining season.

*Source: Do Manh Cuong/SIE*

***Figure 35. Eupatorus gracilicornis, male (left), and female (right)***

**Long-armed Beetle (*Cheirotonus gestroi*)**

This is another large beetle (Figure 36) that is found in high mountainous primary forests in southern Central of Vietnam. They are not so common but easy to be observed. Larvae of the species live in holes with decay layers of large trees. Their presence, therefore, could be a good indicator of healthy forests.

*Source: Do Manh Cuong/SIE*

***Figure 36. Cheirotonus gestroi***

**Vietnam largest moth (*Archaeoattacus vietnamensis*)**

This species is endemic to the Southern Annamites (Figure 37). They are common in evergreen broadleaf forest, easy to observe and often attracted by light. The presence of the species is a good indication of the stability of the forest.

*Source: To Van Quang/SIE*

***Figure 37. Archaeoattacus vietnamensis.***

# Chapter 7 : FIELD MONITORING WORKS

## 7.1. MONITORING OF PLANTS

### 7.1.1 Monitoring at Permanent Plot

The first census (baseline survey) becomes a foundation for future monitoring of possible changes. Already the first census was conducted in May 2018 with support by SNRMP and the results are summarized in Table 14.

*Table 14. Summary information on the 1-ha permanent plot established*

| **Parameters** | **Trees** (DBH ≥ 10 cm) | **Poles** (DBH = 5 - <10 cm) | **Saplings** (DBH < 5 cm; height ≥ 1.5 m) | **Seedlings** |
|---|---|---|---|---|
| Coordinates of the zero corner | N12.06752° E108.65082° | | | |
| Inventory area ($m^2$) | 10.000 | 2.000 | 400 | 80 |
| Total basal area ($m^2$) | 50 | 0.63 | 0.074 | - |
| Average individual basal area ($cm^2$) | 667.5 | 37 | 1.8 | - |
| Total number of individuals | 749 | 170 | 402 | 255 |
| Height *max* (m) | 35.5 | 10.5 | 9.5 | - |
| Height *average* (m) | 12.8 | 7.1 | 2.5 | - |
| Height *min* (m) | 4.5 | 2 | 1.5 | - |
| Average diameter (mm) | 239 | 67 | 13 | - |
| Total number of species | 101 | 48 | 49 | 39 |
| Simpson's index (*D*) | 0.96 | 0.93 | 0.89 | 0.96 |
| Shannon-Wiener's index (*H'*) | 3.90 | 3.24 | 2.93 | 3.34 |
| Jielou's evenness index (*E*) | 0.85 | 0.84 | 0.75 | 0.91 |

It is expected that the next re-census will be conducted in 2023, but the frequency of future re-census will depend on target indicators and more importantly, available resources. This section indicates the required procedures for the census.

Trees and other plants were surveyed at different classes in coded subplots and stripes. Measurements include Diameter at Breast Height (DBH), top and branching heights and dimension of crown (Figure 38).All measured trees must be marked with red paint at DBH for further re-measurements. Trees ≥ 5 cm in DBH are measured with diameter tape and the smaller with caliper. All individuals were identified, and all unknown species were sampled (Figure 39).

*Figure 38. Measuring tree diameter at breast height (DBH). For trees with buttress, breast height is plus the height of the buttress*

All trees, poles and saplings are tagged with 5-digit numbers, of which the first two are the number of the five columns in the plot and the last three digits are the number of the tree censused. For example, number "01.001" indicates the first tree measured in the first column, or 02.005 indicates the fifth tree measured in the second column. Tagging starts from the first tree measured in each column following the direction below.

Field data is recorded using Forms 1 – 5 in Appendix 1.

*Figure 39. Measuring tree height*

- **Measurements of trees with DBH ≥ 10 cm (class A)**

All 25 subplots of 20 m x 20 m each (Figure 40) shall be surveyed. The inventory starts from the most southwestern subplot (A1) and then goes to the next subplot northwards. By this way, each column can be censused without any intervention.

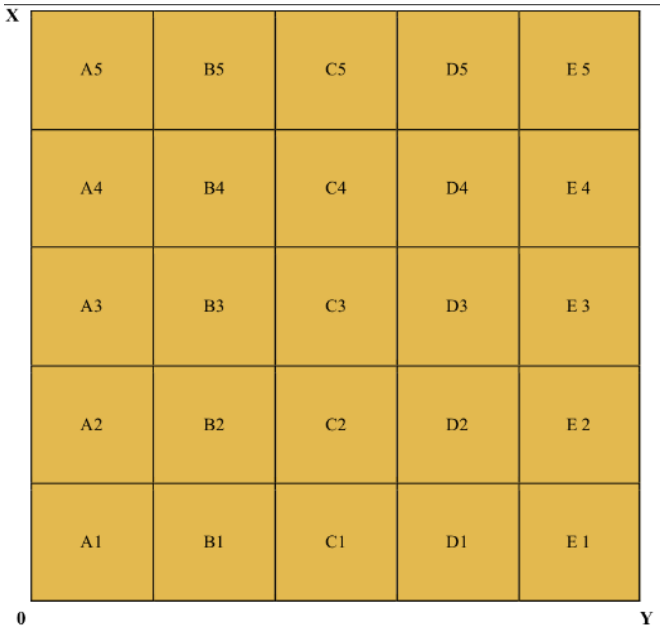


*Figure 40. Trees with DBH ≥ 10 cm (class A) measured in all subplots*

Each subplot of 20 m x 20 m is divided into quarter using nylon strings. The inventory should be done in the clockwise direction within each subplot starting from the southwestern subplot of 10 m x 10 m (Figure 41&Figure 42).

*Figure 41. Subplots determined using nylon string*

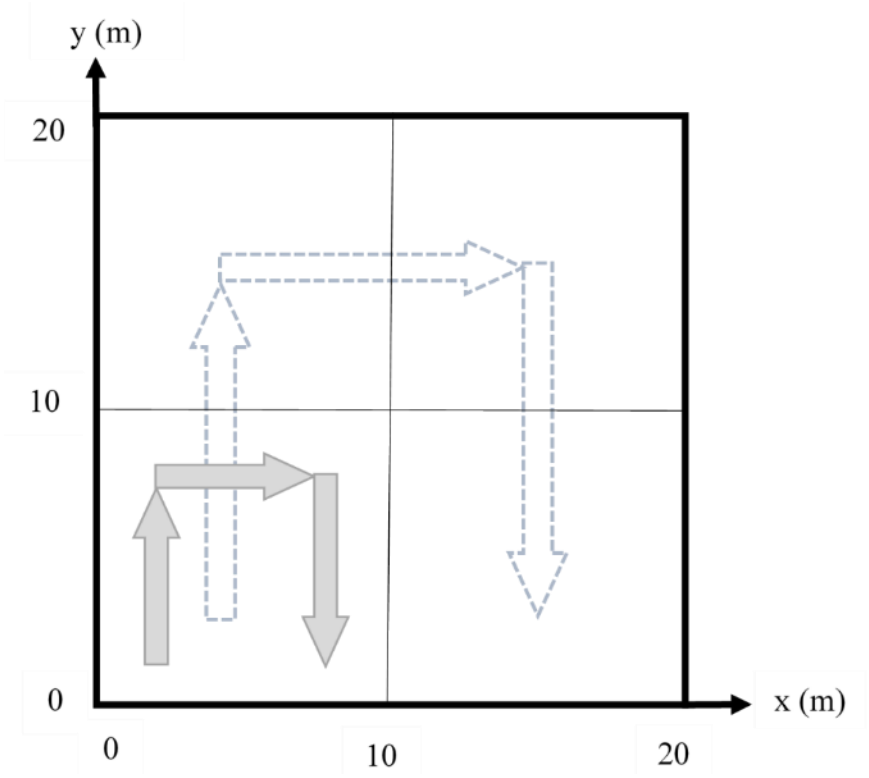


*Figure 42. Direction for inventory of trees with DBH ≥ 10 cm within subplots of 20 x 20 m*

- **Measurements of poles with DBH = 5-<10 cm (class B)**
  Five central subplots of 20 m x 20 m shall be surveyed (Figure 43).

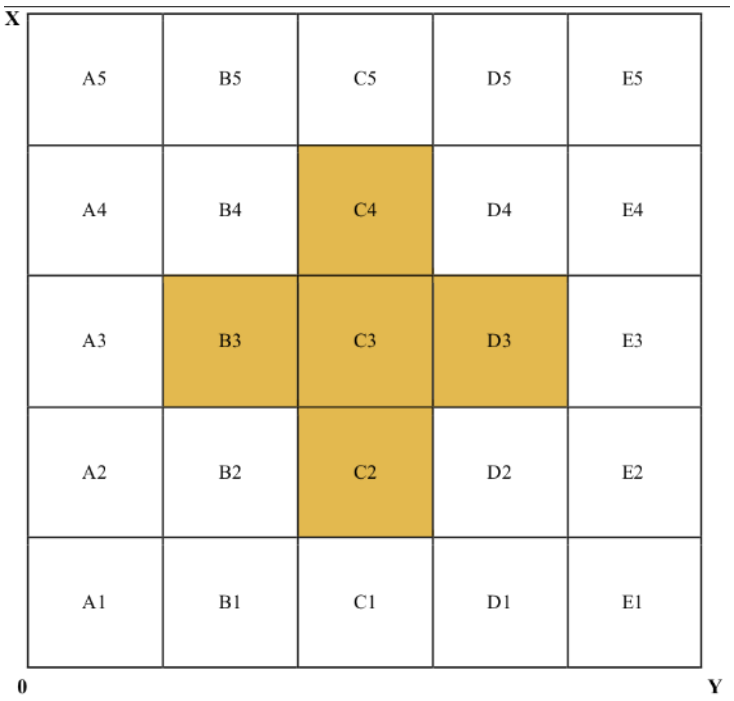


*Figure 43. Trees with DBH = 5-<10 cm (class B) measured in 5 central subplots*

The inventory in each subplot of 20 m x 20 m follows the same direction as in Figure.

- **Measurements of saplings with DBH <5 cm and height ≥1,5 m (class C)**
  The central subplot of 20 m x 20 m shall be surveyed (Figure 44).

  This central subplot should be divided further using nylon string. The inventory of saplings of class C should follow the clockwise direction within each subplot starting from the southwestern subplot of 5 m x 5 m (Figure 44&Figure 45).

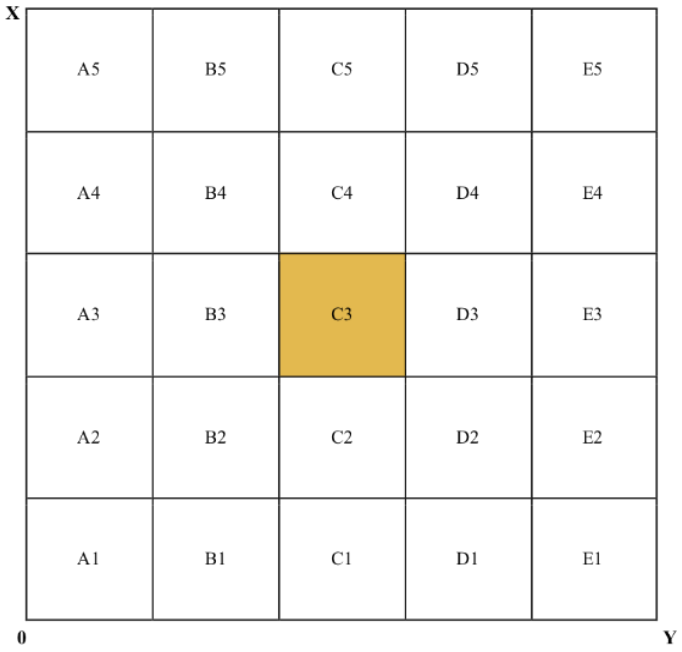


*Figure 44. Trees with DBH <5 cm and top height ≥ 1,5 m (class C) measured in the central subplot*

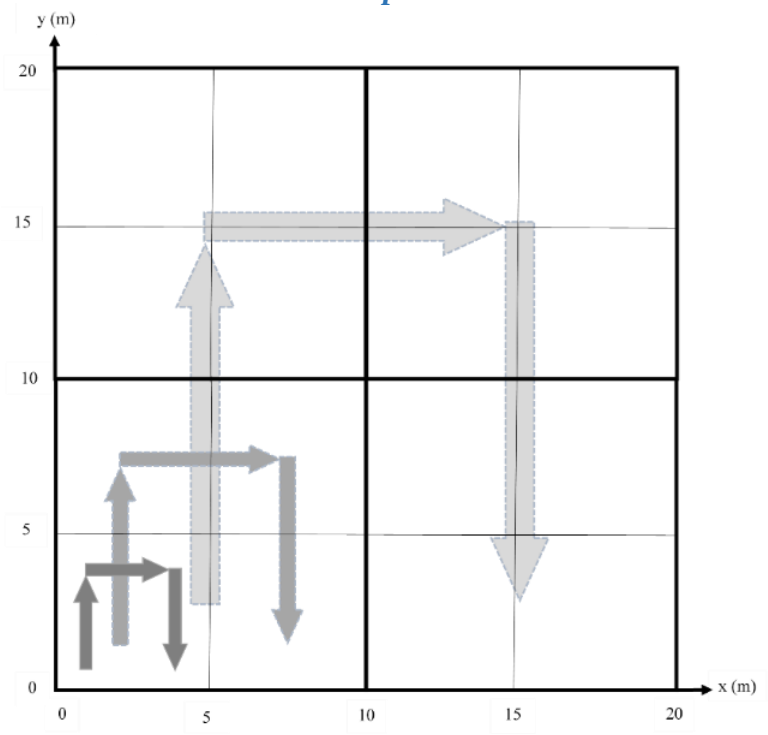


*Figure 45. Direction for inventory of trees of class C within the central subplot*

- **Measurements of seedlings (class D)**
  For each species, estimating the cover of each species (in $m^2$) in 4 stripes of 20 m x 1 m each (Figure 46). All were located within the central subplot.

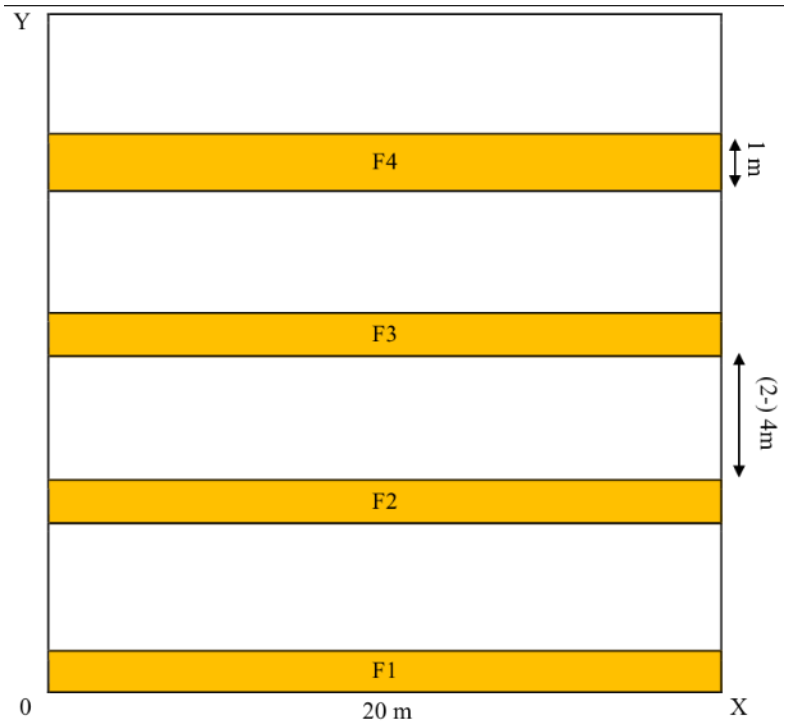


*Figure 46. Saplings (class D) inventoried in 4 stripes of 20 m x 1 m in the central 20 m x 20 m subplot*

Note 1: Measurements of saplings (class D) should be done before the tree measurement to avoid damage to samplings. Nevertheless, care should be taken to minimize damage to all plants in the plot.

Note 2: To avoid missing plants, measurements of saplings (class D) should be done in the same direction (for example to West to East) for all four stripes while measurements of trees (classes A, B and C) should follow the clockwise direction.

Note 3: Tree inventories should strictly follow the clockwise direction as stated above.

### 7.1.2 Monitoring at Monitoring Routes

The baseline data (e.g., geographical co-ordinates, size or number of communities, and growth conditions) of the indicator species are recorded along the respective routes. At the same time, photos of the indicator species observed shall be taken for a comparison purpose.

In the first time, walk through the selected monitoring route and check the key indicator plants encountered within both 2.5 m wide sides of the route. Trees of DBH ≥ 10 cm (DBH ≥ 20 cm for *Pinus kesiya*) will be measured for DBH and coordinates. Each monitored tree is red painted and tagged. Shrubs/herbs/lianas are estimated for their cover area (in $m^2$) and record their coordinates. Field data will be recorded using Forms 6 and 7 in Appendix 1.

In the later monitoring of every three months, check if there is any change in the size, number, and conditions of communities of the species and record the observation in the format. The species are taken photos.

Every five years repeat measuring DBH ≥ 10 cm of the target trees. Note any emerging individuals of indicator species which have not been recorded in the beginning.

For all monitoring times, record any human impacts found.

- **Equipment/material**

Paint will be used to mark all trees to be found in the monitoring routes. Permanent tags will be used for those trees during the next patrolling; the number of the tags needed will be determined after the first (baseline) survey. GPS should be available to position all monitored individuals. Stationery and form should be prepared in advance to be used to note all the plants and their monitored characteristics.

## 7.2. MONITORING OF MAMMALS

### 7.2.1. Monitoring at permanent plot

Monitoring is conducted by camera traps.

### 7.2.2. Monitoring at monitoring routes

- ***Visual encounter***

Visual encounter method is applied to daytime surveys of Black shanked doucs (a target species) and other mammals. The surveys will be conducted from early morning (6:00–7:00 am) to late afternoon (16:00–17:00 pm). Survey team of two surveyors will walk in the selected routes with slow speed of 1–1.5 km/h. Field data will be recorded using Form 8.

- ***Camera traps***

At least 10 camera traps will be set along or near the monitoring routes for each target forest ecosystem. They are along or at every 200 m along each transect. The location of camera traps will be geo-referenced by GPS and described by data sheet form. The camera traps will be checked every month and replace their memory cards and batteries if necessary. Camera trap setting protocol and guideline is presented in Appendix 2.

- **Equipment/materials**
  - 01 set of digital camera having high-power zoom lens (e.g. Nikon P900) and its memory cards, spare batteries for each monitoring team.
  - 01 binoculars for each surveyor/monitor
  - 01 GPS for each monitoring transect: use for mark locations of encounter individuals and survey transects)
  - 01 compass for each group.
  - 01 notebooks & 02 pencils for each surveyor/monitor
  - Data sheets for recording information.

## 7.3. MONITORING OF BIRDS

### 7.3.1. Monitoring at permanent plot

Monitoring is conducted by camera traps.

### 7.3.2. Monitoring at monitoring routes

- ***Visual encounter***

Visual encounter is the most common method for bird survey. The surveys will be conducted in early morning (between 06:00 and 09:00) or late afternoon (15:00 to 17:00) when birds are most active. Each group of two people conducts surveying, following the selected routes. The average speed is about 1.0 to 1.5 km/hr. Field data will be recorded using Form 9.

- ***Playback methods***

  - Call playback is a method to attract birds by using their own calls. This is a technique of playing back a sound to which a most often unseen bird responds by calling back and/or coming close to the source of the sound. It can be achieved by playing back pre-recorded calls or recording of a bird call in the field and playing it back, or by playing back a hostile call which can be a predator call (Owls for example) or a mobbing sound.

  - The equipment used can be tape recorders, compact-disc players, iPod's or even smart phones. These devices are often coupled with external speakers to boost the signal and can include the use of portable megaphones. To be effective the sound system used as an audio lure should produce 90–110 dB of sound. The equipment should be able to broadcast sounds over a distance of 200–400 meters; one technical description of a recommended player has a frequency of about 40 Hz to 12 kHz and power output of 1.2 watts at 1 kHz".
  - Playback is recommended to implement of three series of 20 second calls followed by a 30 second break for a total of 2.5 minutes. However, the length/duration of playback depends on species and habitat.

While walking along route for observation, at every 200 m marked on route, following activities are performed:

- Open playback song of the first target species in one to two minutes then stop and listen to response calls (if any) of the target species in two minutes. Record the time of open and stop playback song and the time of response calls in format hh:mm:ss.
- Record true bearing or compass bearing and estimate distance of each response call.
- Record number of individuals (if see)
- Repeat playback song for three times for each species until response call are heard.
- Open playback song of the second target species and following the same procedure above.
- Repeat surveys in three consecutive days each season/year.

- **Equipment/materials**
  - 01 binoculars for each surveyor/monitor
  - Voice recorder/loud speaker cellphones (01 for each survivor)

- Digital files of birds' songs (will be provided at the training course)
- 01 GPS for each monitoring route: use for mark locations of encounter individuals and survey routes)
- 01 compass for each group.
- A set of 01 notebook and 02 pencils for each surveyor
- Data sheet for recording information
- 01 set of digital camera having high-power zoom lens (e.g. Nikon P900) and its memory cards, spare batteries for each monitoring team.

## 7.4. MONITORING OFAMPHIBIANS

### 7.4.1. Monitoring at permanent plot

Camera traps don't work well with reptiles and amphibians because the infrared sensor of the camera trap cannot recognize poikilothermic animals. Their body sizes are also too small for motion sensor of the camera trap. However, photos of reptiles and amphibians collected *ad hoc* besides birds or mammals are useful for the updated reptile and amphibian checklist of BNBNP.

### 7.4.2. Monitoring at monitoring routes

The monitoring method employed is visual encounters. The surveys will be conducted at night (between 18.00 and 02.00) by group(s) of two persons, following the selected monitoring routes(stream sections) for amphibians, in about 30 minutes for each 200 m long route. The surveys will be repeated every 3 months.

At the beginning of the route, the surveyors take a few minutes to scan for the target species, the surveyors walk slowly along the route and visually search the banks, rocks, logs, and pond/stream bottom (if possible) within a few meters of the surveyor's location. Frogs can be found on the bank, on/in rocks, swimming, climbing on the trunk, sitting on the ground or tree branch, hiding under barks near the water's edge, or hiding in a grass or brush partly submerged along the water's edge. After walking 5 – 10 m, the surveyor should stop and scan ahead before advancing further. The surveys are conducted either by walking in the water or, if necessary, along the adjacent banks (around 3–5 m far from the water body). The surveyors should walk on the bank in following cases: (1) the bottom is steep, muddy, or slippery; (2) the water is running too swiftly; or (3) the water is remarkably clear, as with some mountain lakes and ponds.

For streams less than 2 m wide, one person can survey the entire width of the stream. This allows one person to search upstream while the other searches downstream. If the stream is wider than 2 m, two people can walk parallel to each other on opposite sides of the stream. During the survey, the surveyors should walk upstream to avoid turbidity caused by walking in the water body. Small ponds can be either surveyed by one person who walks entirely around the periphery or by two people walking in opposite directions.

During each survey, the total survey time is determined only during the period of searching for amphibians. The survey time should not count for recording data, moving around obstacles, photographing, and conducting other activities. All the species and number of target species' individuals seen during searching should be recorded, including their microhabitat and activities (if possible). Field data will be recorded using Form 10.

➢ **Equipment/materials**

- Headlamps (01 for each survivor)
- 02 GPS with monitoring transect routes: use for mark locations of encountered individuals and survey transects
- 02 digital cameras for taking photos the encounter individuals as evidence and identification
- Data sheets
- 02 weather meter or temperature/humidity datalogger: use for recording temperature and humidity conditions during the survey periods
- Water thermometer and pH meter
- 10 notebooks & 10 pencils: use for field notes
- At least 2 – 3 catalogues for target species and/or mark individuals identification
- At least 2 – 3 lists and catalogues of recorded species within the survey area
- Batteries: use for headlamps, GPSs, cameras and other equipment
- Plastic bags

## 7.5. MONITORING OF INSECTS

### 7.5.1. Light Trap

Giang Ly and Hon Giao Stations are the two locations were chosen to set up a long-term monitoring for insects of the Bidoup-Nui Ba National Park.

The light-trap is the suitable method and easily applied for this such kind of monitoring. However, each species has different time frame in life cycle and, therefore, it is essential to choose the right time to observe the target species. Field data will be recorded using Form 11. Hereafter are the time-frame and data collection type for monitoring each species.

➢ **Long-tailed moth (*Actias chapae bezverkhovi*)**

- Time-frame: 3 nights (no full moon time), on April and October. Turn on the light from 6:00 pm to 11:00 pm.

- Data collect: count number of individuals (male and female), collect both male and female samples. The male can be killed to keep in scientific collection of National Park or Education centers, while the female will be kept (alive) in an insect envelop until she lays all her eggs (about 2 or 3 days) before being dead. The eggs can be release to nature (pine tree forests nearby the station).

- Monitoring data: Number of the populations of Long-tailed moth reflect the stability of host plant populations, evergreen broadleaf forest and balance of this species with its predators' populations (bats and birds are main predators of this species).

➢ **Five horns beetle (*Eupatorus gracilicornis*)**

- Time-frame: 3 nights (no full moon time), on January and July. Turn on the light from 6:00 pm to 11:00 pm.

- Data collect: count number of individuals (male and female). The males can be collected to keep in scientific collection of National Park or Education centers, while the female must be released after marked in case to be re-recorded as she may fly back to the light trap again. Because the beetles copulate in nature before they come to the light trap, collection of the male never affect their population in nature.

- Monitoring data: The populations size of five horn beetles reflect stable forests for a long time and they can be compared over years or among difference places. The trend of the populations can be an indicator for that of stable forests.

➢ **Long-armed beetle (*Cheirotonus gestroi*)**

- Time-frame: 03 nights (no full moon time), on January and July. Turn on the light from 6:00 pm to11:00 pm each night.

- Data collect: Count number of individuals of the beetle (male and female), the males can be collected to keep in scientific collection of National Park or Education centers, while the female must be released after marked in case to be re-recorded as she may fly back the light trap again. Because the beetles copulate in nature before they come to the light trap, collection of the males never affect to their population in the nature.

- Monitoring data: Number of the populations of long arm beetles reflects pristine forest with big and old trees. The trend of the populations can be an indicator for that of stable forests.

➢ **Vietnam largest moth (*Archaeoattacus vietnamensis*)**

- Time-frame: 3 nights (no full moon time), on April and October. Turn on the light from 6:00 pm to 11:00 pm.

- Data collect: count number of individuals (male and female), collect both male and female samples. The male can be killed to keep in scientific collection of National Park or Education centers, while the female will be kept (alive) in an insect envelop until she lays all her eggs (about 2 or 3 days) before being dead.

- Monitoring data: Number of the populations of Vietnam largest moth reflect the stability of host plant populations in evergreen broadleaf forest.

➢ **Equipment/materials**
  - 02 light traps of 250W standard white light
  - Electric power sources and plugs
  - Data sheets
  - 02 digital cameras and their memory cards.

# Chapter 8 : ANALYSIS OF COLLECTED DATA

## 8.1. DATA ANALYSIS OF PLANTS

### 8.1.1. Data analysis of plants in the 1-ha permanent plot

The data recorded from the plot is input to computers verified by the expert and analyzed to calculate the following basic indices using MS Excel:

**Number of species recorded:**

This number indicates the diversity of species found in the plot. It can be classified further according to the habit (liana, tree, herbs, epiphyte, etc.) or diameter classes (for example: 1-<5 cm, 5-<10 cm, 10-<20 cm, and so on).

**Total basal area (BA):**

This is calculated simply by sum of total individual basal area for each species, diameter classes and the whole plot.

**Diameter distribution:**

For each diameter class (for trees ≥ 20 cm with 10 cm or 20 cm interval), the total basal area of all species is calculated as the sum of all basal areas of all species. Then this is plotted in form of chart to visually illustrate the distribution (Figure 47).

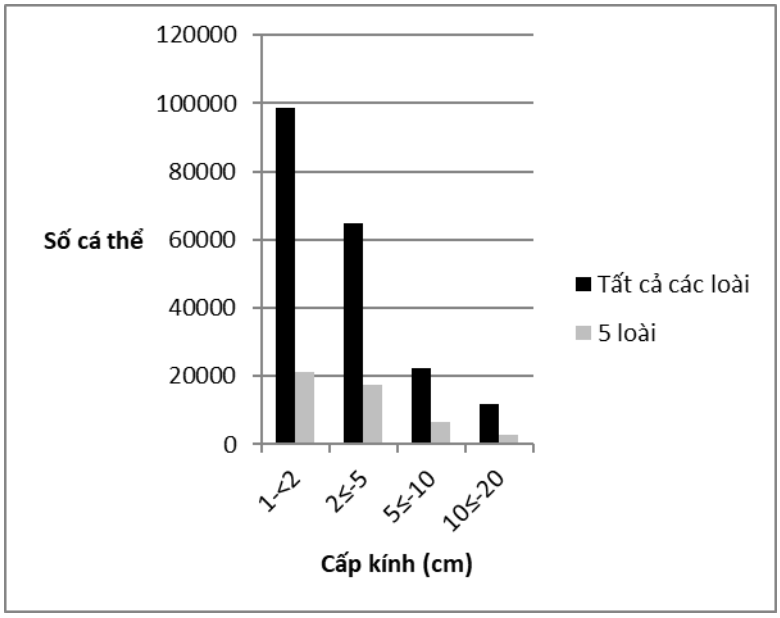


*Figure 47. Example of diameter distribution plotting*

**Simpson's diversity index (*D*):**

*D* is a popular index of species diversity and calculated for diameter classes and the pooled plot as follows (Simpson, 1949):

$$D = 1 - \sum_{i=1}^{S} (n_i / N)^2$$

where: $n_i$: total individual number of species "*i*";
*N*: total individual number of all species;
*S*: total number of species.

*D* indicates the possibility of finding two random individuals of different species.

**Shannon-Wiener's diversity index (*H'*)**

Like Simpson's index, the Shannon-Wiener's (*H'*) is one of the most popular indices of diversity that can be calculated for diameter classes or pooled data. It is calculated as follows (Shannon & Wiener, 1949):

$$H' = -\sum_{i=1}^{S} P_i \ln(P_i)$$

$$P_i = \frac{n_i}{N}$$

where: $n_i$: total individual number of species "*i*";
*N*: total individual number of all species;
$P_i$: abundance of species "*i*";
*S*: total number of species.

**Pielou's evenness index (*E*):**

After calculating the Shannon-Wiener's index, one can estimate the evenness of species in the plot (or the so called Pielou's balance index) as follows (Pielou, 1969):

$$E = \frac{H'}{H \max} * 100$$

where: *H'*: the Shannon-Wiener's index;
$H_{max}$: maximum diversity index ($H_{max} = \ln S$)

E ranges from 0 to 1,0; $E = 1{,}0$ when all species have equal abundance, and $E = 0$ when the plot is occupied by only one species.

**Importance Value Index (IVI):**

*IVI* is the sum of the relative density, the relative frequency and the relative dominance of each species in the community (Curtis & McIntosh, 1950 & 1951). As we have one plot, IVI

is calculated as the sum of the relative density (*P*) and the dominance (*G*) (following Pascal & Pelissier, 1995 and Blanc et al., 2000):

$$IVI = P + G$$

where: *P* = (total individual number of species "*i*" / total individual number of all species) x 100
*G* = (Total basal area of species "*i*" / total basal area of all species) x 100

Therefore, the total IVI of all species is 200.

For the trees in the monitoring routes, the absolute density (*AD*) should be calculated as number of individuals per ha. For the other plants, total cover is summed up for each species in the monitoring route.

Almost the indices can be calculated using MS Excel, Primer 5.0 (*PREMIER*Biosoft International, USA) and/or R packages or noted otherwise.

### 8.1.2. Data analysis of plants in the six monitoring routes

Dominant species must be determined for each forest type.

For the indicator species, their number of individuals and population structure (i.e. diameter distribution, see above) must be calculated and illustrated via charts. In addition, their individual distribution in the plot should be mapped and plotted using MS Excel or GIS softwares.

## 8.2. DATA ANALYSIS OF MAMMALS

### 8.2.1. Data analysis of mammals in the 1-ha permanent plot

Basically, the data of mammals in the 1-ha permanent plot is retrieved from the five camera traps. Photos will be used to detect the indicator species and recorded event. One recorded event is defined as the interval between two records. If the interval is greater than 30 minutes, we consider they are two independent events; otherwise, they belonging to one event.

The number of independent events (contacts) and number of occupied stations (traps) of each species will be recorded for each species. The present and absent index will be calculated and monitored over time using the number of independent events and number of occupied stations. These numbers will illustrate the range of each target species as well as their relative abundance each month.

In addition, we can use this to calculate the relative abundance index of each species. This index is calculated by the number of events that the species is recorded per month. As such, the results will reflect the monthly abundance of species in the plot. This index can be summarized by the following equation:

$$RAI = (Total\ of\ events) \times 100 / (Total\ of\ trap\text{-}nights)$$

Otherwise, data of mammals collected by camera traps can be used to calculate/estimate population size, effective area sampled, and density of indicator species:

- ***Population size*:** For estimating the population size of target species using a mark-recapture framework, the program CAPTURE (Rexstad & Burnham, 1991) is commonly used. The software and manual can be downloaded for free at http://www.mbr-pwrc.usgs.gov/software.html. CAPTURE generates estimates of abundance using several different models, which vary in their assumed sources of variation in capture probability such as individual heterogeneity ($M_h$), behavioural response ($M_b$), time ($M_t$), and a combination of these factors ($M_{bh}$, $M_{th}$, $M_{tb}$ and $M_{tbh}$). A constant parameter model ($M_0$) is also calculated (and is often ranked as the highest model), but this model does not take into account the various underlying assumptions that affect capture probability (Karanth *et al*., 2006). Nichols & Karanth (2002a) suggest $M_h$ as the most suitable model on the basis that heterogeneous capture probabilities exist among individual target species due to their social organization and unequal access to camera-traps. After inputting this data into CAPTURE, it will then calculate the population estimate (*N*), associated confidence intervals and capture probabilities, in addition to the mean and standard error. Do note that CAPTURE does not actually calculate density; it only provides estimates of abundance.

- ***The effective area sampled*:** Because not all animals 'captured' have their entire home range within the intensive sampled area (also known as the edge effect), using the actual area which was sampled (*A*) will lead to severe overestimation of density estimates (Otis *et al.*, 1978). To account for this, a buffer (*W*) has to be added to the polygon connecting the outermost camera-trap locations. Using the 'half' mean maximum distance moved (MMDM) method of Wilson & Anderson(1985), the buffer width is calculated as half of the mean maximum distance between captures of each target species photographed at more than one location, averaged for all individuals (Nichols &Karanth, 2002). The intensive sampled area plus the added buffer is then taken as the effective sampled area, *A*(*W*).

- **Density:** Assuming we have already calculated the population size (*N*) and effective sampled area, *A*(*W*), we can then obtain the estimated population density ($D_m$) with the following equation: $\boldsymbol{D_m = N / A(W)}$**.** The density estimate derived is only applicable for the area sampled.

### 8.2.2. Data analysis of mammals in the six monitoring routes

The same relative abundance index will be calculated for the monitoring routes. However, the data are averaged or pooled for each forest type.

## 8.3. DATA ANALYSIS OF BIRDS

### 8.3.1. Data analysis of birds in the 1-ha permanent plot

Photos will be identified to genera or species (if possible). Number of independent event (contacts) and number of occupied stations (traps) of each species will be recorded. The present and absent index will be calculated and monitored over time using the number of independent events and number of occupied stations. These numbers will illustrate the range of each target species as well as their relative abundance.

We will also apply the method developed by Rowcliffe et al. (2008) to estimate the density for indicator species. The estimated density of a certain species is a function of trapping rate (the number of photographs per unit time, *y/t*), animal speed of movement (*v*) and the dimensions of the camera detection zone (*r* and $\theta$):

$$D_b = \frac{y}{t}\frac{\pi}{vr(2+\theta)}$$

where: $D_b$ is density, y is the number of contacts, *v* is animal speed of movement, *r* and $\theta$ is the radius and angle of the detection zone of the camera trap.

### 8.3.2. Data analysis of birds in the six monitoring routes

**Encounter frequency:**

- number of individuals of each species recorded along route/(distance of route x number of walking time).
- relatedness between encounter frequency and environmental condition (if possible)

**Estimated density:**

The following parameter will be defined using mark-recapture package in R:

- Number of groups/individuals recorded at each playback post.
- Probability of a group calling in one day and probability of a group call within three-day monitoring.
- Maximum distance hearing from listener to species.
- Estimated density (average and standard deviation).

Density can be estimated using methods developed for gibbons (Jiang et al. 2006) as below:

- Bird calling frequency (p) at each survey area was calculated by summing the calls from all playback posts in that area for a single day, on average, divided by the sum of the cumulative calls of all posts over the three-day period. The cumulative proportion of the total number of bird groups heard calling over three survey days at listening posts (calling probability p(m)) can subsequently be determined by the equation:

$$p(m) = 1 - [1 - p]^m$$

  where p = calling frequency and m = number of survey days, i.e. 3 in this study.

- The total estimated number of bird groups at each playback post (Xi) was then estimated using the equation:

$$X_i = \frac{n_i}{P(m)}$$

where $n_i$= cumulative number of bird groups heard in the three-day period at playback post *i*, *P(m)* = calling probability over three survey days.

The density of bird groups at each playback post ($D_i$) was then calculated using the equation:

$$D_i = \frac{X_i}{a_i}$$

where *Xi* = estimated number of bird groups at playback post *i*; $a_i$ = survey area at playback post *i* excluding overlapped area between posts.

To estimate total population, the average number of individuals per group observed directly during field survey is used. In the breeding season, the number of individuals per group is two.

Changes can be found by comparison of density between habitats, survey time, and environmental conditions.

## 8.4. DATA ANALYSIS OF AMPHIBIANS

All photos taken from the surveys will be identified to genus or species. Catalogue of motoring species with variations of color, shape, and figure patterns will be obtained. Updated anuran check list of the survey area will be achieved also.

Encounter frequency for each target species after every survey can be calculated as follow:

F = number of target species individuals/ number of surveyor* time of survey

Species diversity of the community in each habitat can be calculated by using Shannon-Wiener's index (H) and Shannon's equitability ($E_H$) as follow (Shannon & Wiener, 1949):

$$H = -\sum_{i=1}^{S} pi * \ln(pi)$$

$$E_H = \frac{H}{\ln(S)}$$

where: S: total number of recorded species (including target species and nontarget species).

$$P_i = \frac{Total\ individual\ number\ of\ species\ i}{total\ individual\ number\ of\ all\ recored\ species}$$

Ecological distance between sites/times during monitoring period can be accessed by using Bray-Curtis Dissimilarities (Kindt and Coe, 2005):

$$D = 1 - 2\frac{\sum_{i=1}^{s} min(ai, bi)}{\sum_{i=1}^{s}(ai + bi)}$$

where *s*: number of the target species
*a*: number of individuals of the target species *i* of site A / time A
*b*: number of individuals of the target species *i* of site B / time B

Value of D range from 0 to 1, when D = 0, communities at two sites are completely similar for every species, when D = 1, communities at two site are not share any species.

Heath status evidence of target species during monitoring period will also be recorded (if possible).

## 8.5. DATA ANALYSIS OF INSECTS

The insects can be monitored for their population changes by counting the number of individuals of each species in each surveying time. Comparing these numbers and ratios of sexuality will be used to indicate changes in their population size and structure.

Estimation of population size of each species via the Schnabel index:

$$N = \frac{\sum_{i=1}^{m} M_i C_i}{\sum_{i=1}^{m} R_i}$$

where N: species' estimated population size
$M_i$:total number of individuals marked of i-th night
$C_i$:number of individuals captured of i-th night
$R_i$:number of individualsrecaptured of i-th night

# Chapter 9 : DATA MANAGEMENT AND REPORTING

## 9.1. DATA RECORDING AND MANAGEMENT

All the data and information collected by the field monitoring activities shall be gathered by the Technology & Science Research Section or/and ICTHER of BNBNPMB.

Monitoring teams must submit their collected data and memory cards from the camera traps to the Technology & Science Research Section of BNBNP right after the monitoring activity is done. The section shall verify the collected data and is responsible for data storage and analysis. All the data shall be input into the database system of BNBNPMB after verification. Staff of BNBNPMB will be trained in using BRAHMS for biodiversity databasing; for this a manual will be prepared separately and provided to the trainees. Nevertheless, a backup of all data is recommended for safety reason.

Particularly, the section shall analyze those collected from camera traps for identification of species with technical assistance of an/ external expert/s hired by the JICA Project for the initial period of time.

The results from the data analysis of the monitoring activities shall be periodically reported to BNBNPMB. A quarterly reporting scheme may be recommended. The report should not be too long but at least it covers the following foundational information:

- Date of reporting
- Date of survey/monitoring activities
- Plot and monitoring routes covered
- All the mentioned indices calculated from the present monitoring for each group of target indicators in the plot and monitoring routes:
    - Plants
    - Mammals
    - Birds
    - Herps
    - Insects
- Trend of any found changes, causes and comments, including species not found in the last quarter compared to the corresponding former period.
- Update of any new records of species/distribution to the database
- Any human impacts found
- Any remarks/recommendation, including possible management implications.

## 9.2. DATA SHARING WITH THE NATIONAL BIODIVERSITY DATABASE SYSTEM

The Technology & Science Research Section or/and ICTHER of BNBNPMB shall share and transfer the collected biodiversity data with/to the national biodiversity database system developed by MONRE, in coordination with DONRE if needed. Data sharing with the databases shall be undertaken in accordance with the protocols/procedures developed by the ministry, for which a training course was taken for many national parks including BNBNP in Da Lat in April 2018.

# Chapter 10 : USE OF MONITORING DATA FOR MANAGEMENT OF THE NATIONAL PARK

One of the key aims of biodiversity conservation is to maintain basic functions of the ecosystems. This requires understanding about the forest structure and species diversity, and their changes in time. Furthermore, such changes may reflect the effectiveness of management measures. As ecosystems are complex, monitoring helps to know about what drives changes and support sound predictions based on which, suitable measures of management can be drawn.

In this monitoring program, forest ecosystems of BNBNP are monitored through several measures. A permanent forest plot is established for one of the main forest ecosystems of BNBNP: the evergreen broadleaf forest and can be duplicated for the other ones. Important useful metrics can be derived from the permanent plot. For example, the IVI derived can reflect changes in composition of ecologically dominant species, especially the large trees with high IVI that play the key role on shaping and driving the monitored forest ecosystems. The increase or decline in their population structure can be known by comparison of the diameter distributions among censuses. Similar comparisons can be made for all other indices mentioned in this document. However, in many cases, changes in tree composition and population/community structure can only be seen in long time, possibly after several censuses. For smaller plants, changes may be known in shorter courses.

Meanwhile, changes in forest and vegetation cover can be found in shorter time from the data provided from DARD/MARD. These changes may reflect natural succession or positive/negative impacts by human and non-human activities to the target ecosystems. For more “real time” changes in forest and vegetation cover, the regular field patrolling activities should be done as usual to help record and report timely changes.

Several threatened, ecologically and economically important or invasive species are monitored in this program. Monitoring data will provide information on the changes of their populations during the monitoring period, including:

- Distribution;
- Frequency;
- Density;
- Population structure (age and sex ratios, diameter distribution, etc.);
- Growth rate;
- Prevalence or intensity of threats.

When any changes are detected, BNBNPMB shall lay out an in-depth survey or investigation to determine the extent of the impacts as well as possible causes of such impacts and draw appropriate actions. As changes may be caused by natural factors or human impacts, additional notes in the field work (human activities, phenology, etc.) can provide useful information. Active conservation interventions such as more often patrolling, controlled fire, control of weeds or predators, breeding, etc. can be employed effectively if the causes are correctly determined.

Besides, all data collected should be used to enrich the database of biodiversity for BNBNP which has been initiated as an important source of biodiversity information. More species and distribution can be expected to discover from the monitoring activities. In return, the database can be used as a baseline for monitoring species in the park.

Last but not least, data from the monitoring program could be used in education of biodiversity and conservation, including raising the public awareness of biodiversity and conservation at BNBNP. A more awareness is hoped to support more participation of the people in conservation activities. Students can participate in the monitoring activities to develop their study and essays.

## Recommended references


Alder, D. & Synnott, T.J., 1992. Permanent sample plot techniques for mixed tropical forests. Oxford Forestry Institute Tropical Forestry Paper. Vol. 25. Oxford Forestry Institute, Oxford University, Oxford.

Bain R. H., Lathrop, A., Murphy, R. W., Orlov, N. L. and Ho, C. T., 2003. Cryptic species of a cascade frog from southeast Asia: taxonomic revisions and Mô tả of six new species. American Museum Novitates. 3417: 1–60.

BirdLife International, 2012. *"Ducula badia". IUCN Red List of Threatened Species. Version 2013.2. International Union for Conservation of Nature. Retrieved 26 November2013.*

BirdLife International, 2017. *Cutia legalleni* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2017: e.T22734578A110989571. http://dx.doi.org/10.2305/IUCN.UK.2017-1.RLTS.T22734578A110989571.en. Downloaded on 31 March 2018.

BirdLife International, 2017. *Garrulax milleti* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2017: e.T22715628A110800631. http://dx.doi.org/10.2305/IUCN.UK.2017-1.RLTS.T22715628A110800631.en. Downloaded on 31 March 2018.

BirdLife International, 2018. Species factsheet: *Ducula badia*. Downloaded from http://www.birdlife.org on 31/03/2018.

BirdLife International, 2018. Species factsheet: *Psilopogon auricularis*. Downloaded from http://www.birdlife.org on 17/11/2018.

Blanc, L., G. Maury-Lechon & J.-P. Pascal, 2000. Structure, floristic composition and natural regeneration in the forests of Cat Tien National Park, Vietnam: an analysis of the successional trends. Journal of Biogeography, 27: 141-157

Bourret, R. 1942. Les Batrachiens De L'Indochine. Gouvernement General de L'Indochine. 547 pp

Curtis, J.T. & McIntosh, R.P., 1950. The Interrelations of Certain Analytic and Synthetic Phytosociological Characters. Ecology, 31: 434-455.

Curtis, J.T. & McIntosh, R.P., 1951. An Upland Forest Continuum in the Prairie-Forest Border Region of Wisconsin. Ecology, 32: 476–496.

Hill, D., Fasham, F., Tucker, T., Shewry, M. & Shaw P. (eds), 2005. *Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring*, Cambridge University Press, New York, 573 pages.

del Hoyo, J., Collar, N. & Kirwan, G.M. (2018). Necklaced Barbet (*Psilopogon auricularis*). In: del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A. & de Juana, E. (eds.). *Handbook of the Birds of the World Alive*. Lynx Edicions, Barcelona. (retrieved from https://www.hbw.com/node/467439 on 17 November 2018).

del Hoyo, J., Collar, N.J., Christie, D.A., Elliott, A. and Fishpool, L.D.C., 2014. *HBW and BirdLife International Illustrated Checklist of the Birds of the World*. Lynx Edicions BirdLife International, Barcelona, Spain and Cambridge, UK.

Dowding, J., 2012. Introduction to bird monitoring. Inventory and monitoring toolbox: birds. Department of Conservation of New Zealand.

Gibbs, D., Barnes, E., Cox J. (2012). *A Guide to the Pigeons and Doves of the World*. Yale University Press (2001), ISBN 0-300-07886-2.
http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T58850A63900266.en.
Downloaded on 21 November 2018.
http://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T48103132A87891016.en.
Downloaded on 18 November 2018

IUCN SSC Amphibian Specialist Group, 2017. *Raorchestes gryllus. The IUCN Red List of Threatened Species 2017: e.T58850A63900266.*

IUCN SSC Amphibian Specialist Group, 2018. *Rhacophorus calcaneus. The IUCN Red List of Threatened Species 2018*: e.T48103132A87891016.

Jiang, X.L., Luo, Z.H., Zhao, S.Y., 2006. Status and distribution patterns of black crested gibbon (*Nomascus concolor jingdongensis*) in Wulian Mountains, Yunnan, China: implications for conservation. Primates 47:264-271. DOI 10.1007/s10329-005-0175-3

Kindt, R. and Coe. R., 2005. Tree diversity analysis. A manual and software for common statistical methods for ecological and biodiversity studies. Nairobi: World Agroforestry Centre (ICRAF)

Le, M.H., 2012. Introduction to some birds of Vietnam. Natural Science and Technology Publishing House. Hanoi.

MacLeod, R, Herzog, S.K., Maccormick, A., Ewing, S.R., Bryce, R., Evans, K.L., 2011. Rapid monitoring of species abundance for biodiversity conservation: Consistency and reliability of the MacKinnon lists technique. Biological Conservation 144: 1374-1381.

Nguyen, C., Le, T.T., Phillipps. K., 2000. Birds of Vietnam. BirdLife International *Vietnam* Programme. Hanoi.

Nichols, J. D. and Karanth, K.U., 2002. Statistical concepts: Estimating absolute densities of tigers using capture–recapture sampling. Pages 121–138 in K. U. Karanth and J. D. Nichols, editors. Monitoring tigers and their prey: A manual for researchers, managers and conservationists in tropical Asia. Centre for Wildlife Studies, Bangalore, India.

Orlov N. L., Poyarkov, N. A., Vassilieva, A. B., Ananjeva, N. B., Nguyen, T. T., Sang, N. N. and Geissler, P., 2012. Taxonomic notes on Rhacophorid frogs (Rhacophorinae: Rhacophoridae: Anura) of southern part of Annamite mountains (Truong Son, Vietnam), with description of three new species. Russian Journal of Herpetology 19 (1): 23–64. Attachments: Forms/Formats/Tools to be used for the monitoring activities of the BMS

Pascal, J.P. & Pelissier, R., 1995. Structure and floristic composition of a tropical evergreen forest in south-west India. Journal of Tropical Ecology, 12: 191-214.

Pielou, E.C., 1969. An introduction to mathematical ecology. Wiley Interscience. John Wiley & Sons, New York.

Qie, L. et al., 2017. Long-term carbon sink in Borneo's forests halted by drought and vulnerable to edge effects.

Redtad, E. & Burnham, K.P. (1991). User's guide for interactive program CAPTURE. Abundance estimation of closed animal populations . Colorado State University, Fort Collins.

Robson, C. (2010). A Field Guide to the Birds of South-East Asia. Bloomsbury Publishing Plc.

Rowcliffe, J.M., Field, J., Turvey S.T., Carbone C., 2008. Estimating animal density using camera traps without the need for individual recognition. *Journal of Applied Ecology* 45, 1228–1236 doi: 10.1111/j.1365-2664.2008.01473.x

Schnabel, Z. E. 1938. The estimation of total fish populations of a lake. Am. Math. Monthly 45: 348-352.

Secretariat of the Convention on Biological Diversity, 2005. Handbook of the Convention on Biological Diversity Including its Cartagena Protocol on Biosafety, 3rd edition, (Montreal, Canada).

Shannon, C.E. & Wiener, W., 1949. The Mathematical Theory of Communication. University of Illinois press, Urbana, USA.

Simpson, E.H., 1949. Measurement of diversity. Nature, 168: 688.

Smith, M. A., 1921. New or little-known reptiles and batrachians from southern Annam (Indo-China). Proceedings of the Zoological Society of London. 91 (2): 423–440.

Sutherland, W.J., Newton I and Green R.E., 2004. Bird Ecology and Conservation: *A Handbook of Techniques.* Oxford University Press., New York.

Tran, D.T.A., Nguyen, T.T., Phung, T.M., Ly, T., Boehme, W., Ziegler, T., 2011. Redescription of Rhacophorus chuyangsinensis Orlov, Nguyen & Ho, 2008 (Anura: Rhacophoridae) based on new collections from new south Vietnamese provincial records: Lam Dong and Khanh Hoa. *Revue suisse de Zoologie,* 118(3): 1-9.

Wilson, K.R. & Anderson, D.R., 1985. Evaluation of two density estimators of small mammal population size. Journal of Mammal. 66, 13–21.

## Appendix 1: Forms for records of field data.

**Form 1: Data recorded for trees of class A**

Permanent plot name: ……Team leader: ……

Co-workers …….

Date of record …… Sheet number: ……/……

| Tree no. | Sub plot | Tree class | Tree code | Full name | Family | DBH (mm) | Top height (m) | Branching height (m) | Crown max (m) | Crown min (m) | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | A1 | A | 01.001 | | | | | | | | |
| 2 | A1 | A | 01.002 | | | | | | | | |
| 3 | A1 | A | 01.003 | | | | | | | | |
| 4 | A1 | A | 01.004 | | | | | | | | |
| 5 | A1 | A | 01.005 | | | | | | | | |
| 6 | A1 | A | 01.006 | | | | | | | | |
| 7 | A1 | A | 01.007 | | | | | | | | |
| 8 | A2 | A | 01.008 | | | | | | | | |
| 9 | A2 | A | 01.009 | | | | | | | | |
| 10 | A2 | A | 01.010 | | | | | | | | |
| 11 | A2 | A | 01.011 | | | | | | | | |
| 12 | A3 | A | 01.012 | | | | | | | | |
| 13 | | | | | | | | | | | |
| 14 | | | | | | | | | | | |
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| 18 | | | | | | | | | | | |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 21 | | | | | | | | | | | |

**Form 2: Data recorded for trees of class B**

Permanent plot name: ……Team leader: ……

Co-workers …….

Date of record …… Sheet number: ……/……

| Tree no. | Sub plot | Tree class | Tree code | Full name | Family | DBH (mm) | Top height (m) | Branching height (m) | Crown max (m) | Crown min (m) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| … | B1 | B | 02…. | | | | | | | | |
| … | B1 | B | 02…. | | | | | | | | |
| … | B1 | B | 02…. | | | | | | | | |
| … | B1 | B | 02…. | | | | | | | | |
| … | B1 | B | 02…. | | | | | | | | |
| … | B2 | B | 02…. | | | | | | | | |
| … | B2 | B | 02…. | | | | | | | | |
| … | B2 | B | 02…. | | | | | | | | |
| … | B2 | B | 02…. | | | | | | | | |
| … | B3 | B | 02…. | | | | | | | | |
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**Form 3: Data recorded for trees of class C**

Permanent plot name: ……Team leader: ……

Co-workers …….

Date of record …… Sheet number: ……/……

| Tree no. | Sub plot | Tree class | Tree code | Full name | Family | DBH (mm) | Top height (m) | Branching height (m) | Crown max (m) | Crown min (m) | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|
| … | C5 | C | 03…. | | | | | | | | |
| … | C5 | C | 03…. | | | | | | | | |
| … | C5 | C | 03…. | | | | | | | | |
| … | C5 | C | 03…. | | | | | | | | |
| … | C5 | C | 03…. | | | | | | | | |
| … | C5 | C | 03…. | | | | | | | | |
| … | C5 | C | 03…. | | | | | | | | |
| … | C5 | C | 03…. | | | | | | | | |
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**Form 4: Data recorded for trees of class D**

Permanent plot name: ……Team leader: ……

Co-workers …….

Date of record …… Sheet number: ……/……

| TT | Stripe | Full name | Family | No of individuals | Cover area (m2) | Notes |
|---|---|---|---|---|---|---|
| 1 | 1 | | | | | |
| 2 | 1 | | | | | |
| 3 | 1 | | | | | |
| 4 | 1 | | | | | |
| 5 | 1 | | | | | |
| 6 | 1 | | | | | |
| 7 | 1 | | | | | |
| 8 | 1 | | | | | |
| 9 | 1 | | | | | |
| 10 | 1 | | | | | |
| 11 | 2 | | | | | |
| 12 | 2 | | | | | |
| 13 | 2 | | | | | |
| 14 | 2 | | | | | |
| 15 | 2 | | | | | |
| 16 | 2 | | | | | |
| 17 | 3 | | | | | |
| 18 | 3 | | | | | |
| 19 | 3 | | | | | |
| 20 | 3 | | | | | |
| 21 | 4 | | | | | |
| 22 | 4 | | | | | |
| 23 | 4 | | | | | |

**Form 5: Data recorded for other (non-layer) plants**

Permanent plot name: ……Team leader: ……

Co-workers …….

Date of record …… Sheet number: ……/……

| Species no. | Full name | Family | Habit | Forest layer | Phenology | Other notes |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
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| 6 | | | | | | |
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| 21 | | | | | | |
| 22 | | | | | | |

**Form 6: Data recorded for trees (DBH ≥ 10 cm; for *Pinus kesiya*: DBH ≥ 20 cm)**

Monitoring route name: ……Team leader: ……

Co-workers …….

Date of record …… Sheet number: ……/……

| No. | Name | Code | DBH (mm) | Phenology | Coordinates | | Notes (impacts, etc.) |
|---|---|---|---|---|---|---|---|
| | | | | | N | E | |
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| 22 | | | | | | | |
| 23 | | | | | | | |
| 24 | | | | | | | |

**Form 7: Data recorded for shrub/herb/liana**

Monitoring route name: ……Team leader: ……

Co-workers …….

Date of record …… Sheet number: ……/……

| No. | Name | Cover area (in $m^2$) | Phenology | Coordinates N | E | Notes (impacts, etc.) |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
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| 22 | | | | | | |
| 23 | | | | | | |
| 24 | | | | | | |

**Note: 1 $dm^2$ = 0,01 $m^2$**

**Form 8: Mammal Survey and Monitoring**

## Mammal Survey and Monitoring Datasheet

*Sheet No.:*

| ***Date:*** | *Time/beginning:* | *Time/ending:* |
|---|---|---|
| **Name of Area:** | | **Name of Transect:**<br>*GPS start:* *GPS end:* |
| **Name of Surveyors/Monitoring:** | | |

**Mammal recorded:**

| **GPS ID#** | **GPS coordinates** (UTM) | **Time** | **Location** | **Species** | **Number** | | | **Recorded by** | | | **Notes** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Adult(s) | Juvenile(s) | Infants(s) | Observation | Tracks | Vocals | |
| 000 | 000000N 0000000E | 00h00 | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

**Human activities and impacts:**

| **GPS ID#** | **GPS coordinates** (UTM) | **Time** | **Location** | **Type of Violation** | **Name and address of violator(s)** |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

**Form 9: Bird Survey and Monitoring Datasheet**

# Bird Survey and Monitoring Datasheet

*Sheet No.:*

| ***Date:*** | *Time/beginning:* | *Time/ending:* |
|---|---|---|
| **Name of Area:** | | **Name of Transect:**<br>*GPS start:* *GPS end:* |
| **Name of Surveyors/Monitoring:** | | |

**Bird recorded:**

| **Location** | **GPS ID#** | **GPS coordinates** (UTM) | **Time** | | **Species** | **Angle** | **Distance** | **Observed Individuals** | | | **Notes** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | Male(s) | Female(s) | Unknown | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

**Human activities and impacts:**

| **GPS ID#** | **GPS coordinates** (UTM) | **Time** | **Location** | **Type of Violation** | **Name and address of violator(s)** |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
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**Form 10: Amphibian Survey and Monitoring Datasheet**

# Amphibian Survey and Monitoring Datasheet

*Sheet No.:*

| ***Date:*** | *Time/beginning:* | *Time/ending:* |
|---|---|---|
| **Name of Area:** | | **Name of Transect:**<br>*GPS start:* *GPS end:* |
| **Name of Surveyors/Monitoring:** | | |

**Environmental conditions and habitat description**

| | Temperature ($^{o}$C) | Humidity (%) | pH | Vegetation | Habitat & Notes |
|---|---|---|---|---|---|
| Air | | | | | |
| Water | | | | | |

**Target species:** for each encountered individual during every survey/monitoring

| **Time** | **GPS coordinates** (UTM) | **Species Name** | **Sex** | | **Stage** (eggs/tadpoles/ juvenile/adult) | **Weight** (g) | SVL (mm) | **Photo(s)** | **Notes** (abnormal, activities, human impacts, etc.) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | | | | | |
| 00:00 | | | | | | | | | |
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**Form 11: Entomological Survey and Monitoring Datasheet**

# Entomological Survey and Monitoring Datasheet

*Sheet No.:*

| | | | |
|---|---|---|---|
| ***Date:*** | *Time/beginning:* | *Time/ending:* | |
| **Name of Area:** | | | |
| **Name of Surveyors/Monitors:** | | | |

| Temperature (°C) | Humidity (%) Rain/Dried | Habitat & Notes |
|---|---|---|
| | | |

**Target species:** for each encountered individual during every survey/monitoring

| **Time** | **GPS coordinates** (UTM) | **Species Name** | **Sex** | | **Photo(s)** | **Notes** (collected or mark and release) |
|---|---|---|---|---|---|---|
| | | | Male | Female | | |
| 00:00 | | | | | | |
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## Appendix 2. Camera Trap Protocol

**1. Personnel**(2-3 persons)

Monitoring team members should have:

- Have extensive field experience
- Be familiar with the area and target species
- Be trained to set up camera traps in the field

**2. Equipment Preparation**

All camera traps of SRMN projects will be prepared and checked for fully working functions in advance. User-guide of camera traps will be circulated to team members for learning how to operate and maintain.

Each camera trap should be externally marked with a unique identification number. The serial number of each camera trap can be easily found by opening the camera trap and looking for a white sticker underneath the front panel.

Purchase enough batteries for all camera trap as needed.

**3. Preparation of the camera trap**

It is crucial that all camera traps are set up correctly and with the same settings to ensure standardization of the data being collected. Before taking the camera traps to the field, every single camera trap must be checked, as described below:

Forms needed during these steps:

- *Camera Trap Checklist*: to be filled out and signed by the project manager or team leader.
- *Camera Trap Setup Form*: for to record the number of the camera trap and the serial number of the memory card in each camera with following steps:
    - **Wash your hands**. Always make sure your hands are clean before handling the camera traps and memory cards. Small bits of dirt may easily become lodged in the contact points resulting in a poor connection to the camera and card failure.
    - **Write on the camera trap number**. Each camera trap should be externally marked with a unique identification number. Clearly write down this number in the Camera Trap Number column on the *Camera Trap Setup Form*.
    - **Set the date and time**. IMAGES ARE USELESS WITHOUT AN ACCURATE DATE AND TIME STAMP. MAKE SURE THE CORRECT DATE AND TIME ARE SET IN THE CAMERA TRAP. WITHOUT THIS, ALL RESULTING PHOTOS WILL BE USELESS!! REFER TO THE CAMERA TRAP MANUAL, TO LEARN HOW TO SET/VERIFY THE CURRENT DATE AND TIME ON THE CAMERA TRAP.
    - **Record information about the memory card**. Take out a memory card from its case and locate its serial number. If no serial number can be found, number the card sequentially with a non-erasable marker so that each card has a unique number. Also, write down this serial number in the column Memory Card Serial Number (*Camera Trap Setup Form*) in the corresponding row of the Camera Trap Number column (same form). Insert the memory card in the slot located in the camera trap.
    - **Set up the camera trap** having full batteries**.**

    - **Turn the camera on**: Move the camera switch to the ON position.
    - **Test the camera trap unit** to ensure the camera trap working properly.
- *Other equipment and supplies:*
    - **GPS unit**: to ensure the maximum precision possible to obtain access to a GPS unit so that each camera trap point can be geo-referenced.
    - **Camera trap point** is established and geo-referenced it needs to be marked.
    - Field forms:
        - *Camera Trap Setup Forms* to be filled with the Camera Trap Number, and Memory Card Serial Number. Record other information on this form when installing the camera trap in the field.
        - *Camera Trap Point Form* to complete all appropriate data about the camera trap points (i.e., camera trap point identification number, date, time, etc.).

**4. General field guidelines**

- Use maps of the study area with the expected locations of the camera trap
- points to explain to the team.
- The monitoring team should be prepared for fieldwork (equipment, suppliers, foods, etc.).
- When packing and carrying the camera traps to the field **do not store them with food** or any other substances that might attach odors to the camera trap. Food or other smells might attract animals to the camera trap in the field, biasing the estimates of detection probability.

**5. Field trip to setting up the camera traps**

- Locating the best place for the camera trap point in the field. **Choose the exact location to give the highest probability of obtaining useful photographs within 10-20 meters of the original point**.
    - **Choose a "wildlife-friendly" site**. Team members should search for the nearest location such as trails, roads, stream banks, and paths to water that animals use on a regular basis and with a good chance of animal visits. Look for signs of animals (feces, tracks, etc.) nearby.
    - **Try to determine the travel path**. Team members should choose a site where the travel path is limited to the area that the camera trap can photograph.
    - **Consider the sensor's range and field of view**. A wide trail has more places at which wildlife can cross a sensor and thus, the greater the area that must be covered by the sensor's field of view. The maximum distance to the far side of the trail should not be farther than the distance covered by the flash. The distance should also be considerably less than the maximum range of the sensor.
    - **Consider the terrain**.
    - **Find a suitable tree in which to set the camera traps**. Try to minimize direct sunlight exposure to the camera traps by pointing it north or south; direct sunlight to the sensor will trigger false photographs and excessive heat can reduce the sensitivity of the heat sensor. Camera traps should be set back at least 2 meters from the nearest point at which wildlife might travel across the sensor. This allows for clear, focused pictures and a large enough field of detection from the sensor.
    - **Set up the "stage" for the camera trap** by cutting some brush as needed to maximize detection within the field of view of the camera trap. Try not to

disturb the trail or lay down too much vegetation to force animals to pass in front of the camera because some animals will turnaround if faced with obstructions.

- Make sure every camera trap to be geo-referenced by GPS
- Setting up the camera trap at the location
    - Roughly calculate the field of view
    - Clear debris from the camera trap field of view. Clear big leaves and other obstructions between the camera trap location and the travel path.
    - Fix the camera trap to the designated tree. Try to avoid pointing the camera trap at objects in direct sunlight such as large rocks or sunlit streams that may absorb heat and trigger sensors. Also try to avoid orienting the camera trap facing exactly west or east since the sun will shine directly on it in the morning or afternoon, causing potential false-positive shots. Direct sunlight may also cause damage to the temperature sensor.
    - Turn the camera on and type in the camera trap point ID.
    - Secure the camera trap to the tree. Pass the cable lock through the small hole in the back of the camera trap and around the tree. Secure the lock and do not leave the key. Write down the number of the key in the Key Number column (Camera Trap Setup Form).
    - Take a test picture.
    - Go to the next camera trap point. Walk to the next camera trap point and start the entire process described again.

**6. Data Retrieval and Check of Camera Traps**

- After setting up all camera traps in 30 days, the data (photographs) need to be retrieved and the camera traps to be checked and replaced with new memory card and new batteries.
- Retrieve all data of photographs taken by camera traps into digital storage (i.e., hard drives) in BNBNP/LBBR.

# Camera Trap Checklist

| Camera number | Memory card serial number | Is memory card empty? | Are batteries new/full? | Correct DATE and TIME? | Correct camera settings? | Case, seals and protection box in good condition? | Lock and key marked and checked? | Notes |
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Date:
Name of Person checking:

Signature:

# Camera Set-up Field Form

| | |
|---|---|
| ***Date:*** | |
| **Name of Area:** | **Name of Transect:**<br>*GPS start:* *GPS end:* |
| **Name of Person(s) setting up camera:** | |

| **Point ID** | **GPS coordinates** (UTM) | **Camera number** | **Memory card serial number** | **Start Date/Time** | **Startup photo taken?** | **Key number** | **Notes** |
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# Camera Pick-up Field Form

| | |
|---|---|
| ***Date:*** | |
| **Name of Area:** | **Name of Transect:**<br>*GPS start:* *GPS end:* |
| **Name of Person(s) picking up camera:** | |

| **Point ID** | **GPS coordinates** (UTM) | **Camera number** | **Memory card serial number** | **End Date/Time** | **Camera working?** | **Camera missing?** | **Camera damage?** | **Notes** |
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