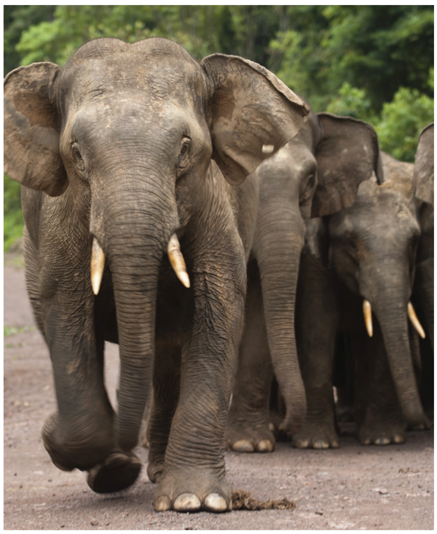
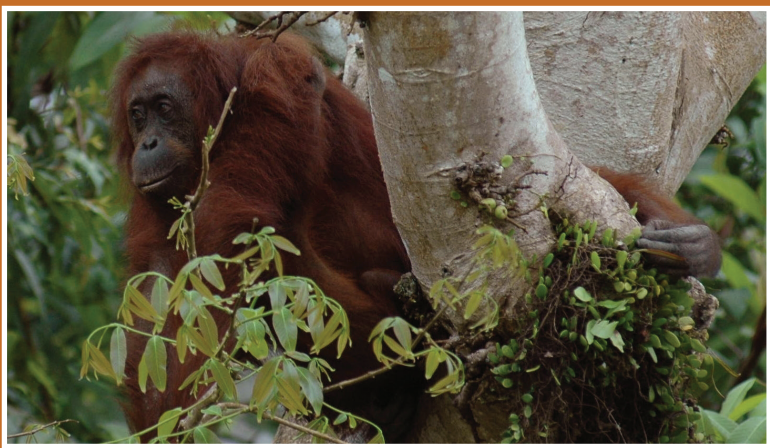
FIELD MANUAL: MONITORING LARGE TERRESTRIAL MAMMALS IN SABAH

Dr. Marc Ancrenaz

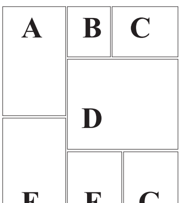




Sabah Forestry Department

HEART OF BORNEO INITIATIVE

Cover



A. Bornean elephant (*Elephas maximus*)
B. Malay Badger (*Mydaus javanensis*)
C. Slow Loris (*Nycticebus coucang*)
D. Orang-utan (*Pongo pygmaeus morio*)
E. Leopard cat (*Felis bengalensis*)
F. Sumatran rhinoceros (*Dicerorhinus sumatrensis*)
(Photo by Zainal Zahari Zainuddin, Borneo Rhino Alliance)
G. Proboscis monkey (*Nasalis larvatus*)

Opposite page: Sambar deer (*Cervus unicolor*)

FIELD MANUAL:
MONITORING LARGE TERRESTRIAL MAMMALS IN SABAH

Dr. Marc Ancrenaz

Sabah Forestry Department

Published by
Sabah Forestry Department
Locked Bag 68
90009 Sandakan
Sabah, Malaysia
Tel: 6089-242500
Fax: 6089-671303/672579
Website: www.forest.sabah.gov.my

First published 2013

FIELD MANUAL: Monitoring Large Terrestrial Mammals In Sabah
Dr. Marc Ancrenaz

ISBN:

Printed in Malaysia

TABLE OF CONTENTS

Chapter 4: Assessing the size of a wildlife population

FOREWORD

It is with great pleasure that I present to you this book entitled: 'A Field Manual for Monitoring Large Terrestrial Mammals in Sabah' as a reference.

This manual is in support of the efforts to strengthen wildlife monitoring by the Sabah Forestry Department, which also compliments the establishment of field outposts at strategic sites throughout the State forest reserves within the Heart of Borneo.

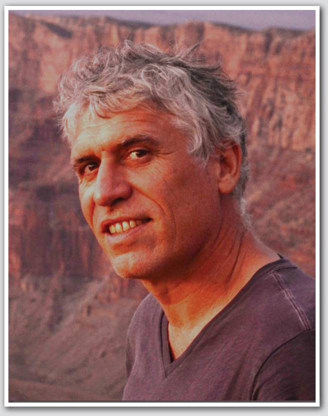
This manual was funded by the Heart of Borneo Project through the Federal Government. It comprises of a series of wildlife monitoring strategies, from the planning to the implementation of field activities in forest reserves. It is divided into two sections to efficiently serve its purpose as a guide in the field. Part I focuses on the planning and implementation of wildlife strategy and Part II focuses on the field activities applied.

With this informative manual, I believe the respective users will be able to master the skills in wildlife monitoring and management.

Thank you.

Datuk Sam Mannan
Director of Forestry

PREFACE



Today, the state of Sabah is still blessed with significant wildlife diversity and abundance. Although this resource is important for both economic development (e.g., tourism) and ecological balance, it is in rapid decline.

The Wildlife Conservation Enactment (WCE, 1997) aims to protect the endangered species of fauna and flora in the State and control international trade of these species. The Sabah Wildlife Department (SWD) is in charge of its enforcement. However, major wildlife populations in Sabah also occur outside of protected areas, and wildlife management must also take place in areas which fall under the jurisdiction of other stakeholders (private sector, local communities and other government agencies). Substantial human and financial resources are needed for monitoring and managing wildlife resources. This can only be achieved through proper coordination and synergy between the many agencies involved in the management of areas that are home to significant wildlife resources in the state.

Recognizing the need for this synergy, the Sabah Forestry Department commissioned the development of a "Field Manual for Monitoring Large Terrestrial Mammals in Sabah" in 2011. This project came about as a response to a series of workshops and trainings on wildlife monitoring and management conducted in 2010 for the Heart of Borneo initiative. This Manual is intended for rangers and field staff from the Sabah Forestry Department and other agencies who are not professional wildlife managers. Field activities presented and developed in the Manual are simple, cost-effective, and easily implementable, thus increasing the likelihood for long-term implementation.

This Manual is divided in two complementary parts:

- Part 1 of the Manual provides background and theoretical information about wildlife monitoring and management. It is intended for wildlife managers and people in charge of developing and interpreting wildlife strategies.
- Part 2 of the Manual details the different methodologies that need to be conducted in the forest for wildlife monitoring. It is intended for field practitioners and is meant to be brought in the field.

Dr. Marc Ancrenaz

A. A group of Pig tail macaques (*Macaca nemestrina*) crossing a bridge for wildlife
B. Bornean elephant (*Elephas maximus*)
C. Wild boar or bearded pig (*Sus barbatus*)
D. Sun bear (*Helarctos malayanus*)
(Photo courtesy of Bornean Sun Bear Conservation Centre)
E. Common palm civet (*Paradoxurus hermaphroditus*)

PART 1:

PLANNING, DEVELOPING AND IMPLEMENTING A WILDLIFE STRATEGY

The Bornean elephant is endemic to Borneo and is mostly found in Sabah. Four Major Elephant ranges have been identified in the State. They live in matriarchal herds (i.e., dominated by female matriarchs) while adult males are often roaming on their own.

Chapter 1: INTRODUCTION

Ecosystems of South-east Asia are among the richest hotspots for terrestrial biodiversity on earth; they are also seriously threatened by human exploitation. The rate of deforestation here ranks amongst the highest in the world and land-use changes cause massive wildlife extinctions.

Sabah is no exception, and more than 40% of its original forests have been lost during the last century. However, today, forest ecosystems still cover about 52% of the landmass of the State. To better protect biodiversity, the State has established about 200 protected areas, representing 1,350,574.47 ha (SFD, 2013) or approximately 18.35% of the total landmass of the State. However, the long-term viability of these protected areas depends on the integrity of complex ecological processes that stretch well beyond their administrative boundaries; they depend on the highly modified and continuously evolving human-transformed landscapes that surround them.

Human exploitation of non-protected habitats is resulting in massive loss, degradation and transformation of natural ecosystems. Today, many forest ecosystems of the State are highly degraded and fragmented. In turn biodiversity is largely eroded and many wildlife populations are declining in numbers and in range. It is therefore crucial to understand the impact of these transformations on wildlife at the species and community level to be able to answer questions such as: what species is going to survive human disturbance and why? How is it possible to decrease the rate of biodiversity loss? What exploitation practices are compatible with wildlife conservation?

Wildlife is a crucial and an integral part of forest ecosystems. Animals ensure functions central to maintaining the integrity of natural processes and necessary for the maintenance of healthy forests: pollination, seed dispersal, predation, etc. Wildlife is also a crucial asset for numerous human groups either as a source of protein (game species); or as a source of financial income (honey, bird nests and other non-timber forest products). Importantly, the persistence of wild animals and wild places in Sabah is the major asset for the now booming tourism industry in the state. Wildlife tourism will not sustain the state economy unless we ensure the continuous survival of wild animal populations.

Simultaneously, wildlife presence and long-term persistence are also perceived as an indicator of good exploitation practices and quality of life. Last but not least, this resource is part of the natural heritage of Sabah and the people living on Borneo Island. Every necessary effort should be made to protect and ensure its long-term preservation.

Defining wildlife

Simply, wildlife can be defined as "all living things (except people) that are not domesticated".

Wildlife is typically split between invertebrates and vertebrates. Invertebrates represent about 95 percent of the number of animal species that have been identified to date. Invertebrates are characterized by the lack of a backbone and internal skeleton. They are generally of small size and include insects, arachnids, arthropods, mollusks, annelids, coelenterates, etc. In tropical forests, the biomass* (*words with* are explained in the glossary in Annex I*) of invertebrates exceeds that of vertebrates.

Vertebrates are characterized by the presence of an internal skeleton (backbone or spinal column). They include:

- Mammals (warm blooded; covered with hair; milk producing gland; giving birth to live babies);
- Birds (warm blooded; body more or less covered with feathers; egg laying; forelimbs modified as wings; beak);
- Reptiles (cold blooded; dry scaly skin; typically laying soft eggs on land; toes with claws);
- Amphibians (cold blooded; moist glandular skin; toes devoid of claws; distinguished by having an aquatic gill-breathing larval stage followed, typically, by a terrestrial lung-breathing adult stage);
- Fishes (cold blooded; body covered with scales; gills; water dependent).

Monitoring wildlife

Wildlife is an entity that shows tremendous fluctuation in responses to changes in natural factors such as food availability (itself depending on season, altitude, ecosystems); mating opportunities; ecological catastrophes (fire, flood, global warming, etc.). Wildlife is also greatly impacted and influenced by anthropogenic factors such as habitat destruction, ecosystem modification, pollution, disturbances, and hunting.

Ideally, all species of plants and animals that are found in an area should be identified and monitored (see Text Box A.1); while their response to disturbance and management activities should be assessed for adaptive management purposes. In practice however, the multiple specialized long-term studies required to achieve such knowledge is most often impractical as this would demand human capacity, time commitment and financial resources that are often not available.

Consequently, it is beneficial to use surrogate species* as proxies*, whose changes in presence and abundance fluctuate with ecosystem changes. These proxies are called bio-indicators, or "measures of biology and other features of the environment that reflect to some degree the state of ecosystems, habitats and components of biodiversity". In theory, bio-indicators are relatively abundant, easy to identify and sample, quick to reflect ecosystem changes, and possess a high and intrinsic popular value. The best proxies as predictors of community patterns are sensitive taxa that respond fast to forest disturbances (several taxa of frogs, birds or invertebrates).

It is important to note that mammals are generally considered poor indicators of biodiversity and community composition of other taxa. Indeed, most mammals show a rather high tolerance to degraded ecosystems and forest edges. In general, they are not highly sensitive to habitat disturbances, except for few highly specialized species with narrow niches (proboscis monkeys).

Despite this, there are many benefits to using mammals as proxies. Many mammal species show a high appeal value and unlike other taxa, are well known to the general public. Many have a large distribution range and their presence can be relatively easy to assess. Several umbrella species such as the orang-utan are now the emblem of the forest ecosystems we want to manage and to protect. Maintaining these species will thus benefit other wildlife species. Iconic species like orang-utans, elephants, or proboscis monkeys also provide socio-economic development opportunities through tourism activities, and economic instruments such as bio-banking. Finally, because of their size, large mammals are generally good indicators of hunting pressure.

For all these reasons, mammals remain a key element for developing and for implementing a sound wildlife strategy.

Scope of this Manual

The Wildlife Conservation Enactment (WCE 1997) is enforced by the Sabah Wildlife Department (SWD). This Enactment aims to protect the endangered species of fauna and flora in the State as well as control international trade of these species. However most species are found outside of protected areas and their management and conservation require the collaboration and the participation of a wide range of partners.

The need to develop this Manual was identified by the Sabah Forestry Department and its partners in charge of managing protected and non-protected forests, key wildlife habitat in the state. It came about as a response to a series of workshops and trainings conducted in 2010 within the "Heart of Borneo" initiative. This Manual targets rangers and field staff from the Sabah Forestry Department and other agencies who are not professional wildlife managers. Field activities presented and developed in the Manual are intended to be simple, cost-effective, and easily implementable in the field, thus increasing the likelihood for long-term implementation.

This manual is biased towards large terrestrial mammals for several reasons:

- It is unrealistic to cover all wildlife taxa in a single book;
- Most taxa selected in this Manual are well known and can be monitored with relatively simple techniques, not requiring special skills or expensive equipment;
- Some of these species are endangered and protected, making their monitoring a legal obligation;
- Most of these species are charismatic and attract local, national and international attention.

Last but not least, this Manual encourages the incorporation of results of field activities into management actions, for the improvement of management and protection of remaining biodiversity. Too often, wildlife strategies are unable to bring the results of monitoring activities to the policy and decision-making levels, making it difficult for such strategies to contribute to effective wildlife conservation.

The Manual is divided in two complementary parts:

- Part 1 gives background information about the theory of wildlife monitoring. It targets wildlife managers and people in charge of developing and interpreting wildlife strategies;
- Part 2 targets wildlife practitioners and details the different methodologies that need to be conducted in the forest for wildlife monitoring. This part is meant for use in the field and provides guidelines for all field activities targeting wildlife monitoring.

This primate, endemic to Borneo, is mostly found in mangrove areas and riparian forests. The basic social unit, called "One Male Units" is an association of one dominant male and a group of females and their young. Adult females (picture) are smaller than adult males and are recognized by their small pointy nose. and their smaller size.

Chapter 2: PLANNING, DEVELOPING AND IMPLEMENTING A WILDLIFE STRATEGY

2.1. What is a wildlife strategy?

A wildlife strategy is a series of activities that are established to assess wildlife presence, abundance and fluctuation in a given area in order to manage the resources efficiently. Wildlife management and monitoring is not an end in itself, but a means to an end. The aim of any wildlife strategy should be to provide guidelines for making decisions on how best manage and exploit natural resources for the benefit of people and at the same time to maintain wildlife diversity and abundance. Wildlife strategies can be divided into three types, based on the purpose of the strategy.

2.1.1. Wildlife inventory or wildlife assessment (also called "Distributional Survey").

An inventory is essentially a description of wildlife resources found in a given area. The main objective is to map the presence, range, and distribution of a given species/ population within a predetermined boundary. At minimum, these surveys record basic Presence/Absence data, and identify key wildlife components and features that need to be protected and that will become the focus of management action (vegetation types, key feeding, watering or breeding areas, "High Conservation Value Forest", etc.).

Presence/Absence data collection has its limitations. Although "Presence" of species A in area B is a straightforward concept, it is important to recall that "Absence" is difficult to assess with certainty in the field. Indeed, the absence of record for species A in area B does not necessarily mean that A is not present in B: on the contrary, the team may have failed to detect signs of presence. Despite this, wildlife assessments can still provide some measure of relative abundance, sources of threats and seasonal movement patterns.

Assessments and inventories are primarily conducted through following methods:

- Literature review;
- Rapid field surveys;
- Interview surveys;
- Community consultation.

These methods are usually easy to undertake and do not require huge financial and human resources. However these methods are prone to detectability biases and therefore cannot generate absolute density estimates. Good assessments also consider socio-economic features and other factors that affect wildlife and associated biodiversity components (e.g., current and potential threats). These assessments will provide a baseline of data upon which a monitoring program can be developed and implemented.

Over the past few years, new approaches and statistical tools utilizing Presence/ Absence data have been developed: the "occupancy methods". Occupancy models use essentially the same type of data but account for variation of detectability, and can thus generate unbiased estimates of distribution and abundance. By the collection of systematic and precise Presence/Absence data, these models can inform on the status of wildlife population as well as on general trends. Additional models ("predictive distribution"; "logistic regression") can also inform on the status of wildlife populations but they can lead to severely biased results when applied to Presence/Absence data (see below).

Text Box A.1: Distributional survey conducted for a High Conservation Value Assessment

A lot of wildlife species occur today outside of protected forests, in areas that are exploited for timber, mining or agriculture. Forest areas of outstanding importance for biodiversity are increasingly referred as HCVF, or "High Conservation Value Forest". Adoption and implementation of best and sustainable management practices outside of protected areas require the identification of HCVF, and the protection of its conservation value.

The conservation value of a HCVF can be divided into several types, including areas containing: globally, regionally or nationally significant concentrations of biodiversity values (HCV 1); globally, regionally or nationally significant large landscape-level forests (HCV 2); forest areas that contain rare, threatened and endangered ecosystems (HCV 3); forests that provide basic services and environmental services (e.g. water catchment; erosion control) (HCV 4); forests that fulfill basic needs of local communities (HCV 5); forests that are critical to local communities' traditional cultural identity (HCV 6).

Theoretically, proper identification of HCVF requires the documentation of status (e.g. diversity, abundance, distribution) of **all** living species found in a given area. However, this requires time and monetary resources that are usually not available. In practice, "sample" or "expert"-based approaches are generally used to document biodiversity and identify HCVF. These surveys are conducted over a short period of time by a team of specialists in relatively small areas that are assumed to be representative of the entire area. These short-term assessments focus mainly on protected species and neglect others; and produce outputs which consist of species lists (presence/absence); accumulation curve at the community level; occupancy rates; etc.

What should be remembered is that **HCVF assessments alone do not improve management practices**. Increased emphasis needs to be given to the use of this information towards the management process itself.

2.1.2. Wildlife surveillance and monitoring.

Surveillance is "the collection and analysis of repeated observations through space and time without predetermined objectives". Surveillance intends to measure key ecological attributes (both wildlife and ancillary data) in a given area over an extended period of time and assess wildlife population trend through time.

Monitoring is "surveillance undertaken to ensure that formulated standards are being maintained". By nature, monitoring is a dynamic and adaptive exercise. A wildlife monitoring strategy will first set targets (or management objectives), and then evaluate changes in condition and progress toward these management objectives.

Population monitoring contributes to understanding the impact of threats on a given population. Ideally, large mammal monitoring programs should include regular surveys to allow for easy and rapid detection of population changes. Ideally, there should be short intervals between successive surveys. However, the actual time between surveys will be determined based on both the species ecology as well as the resources available for the program (financial, human and equipment): see chapter 6 of the Manual.

Proper wildlife monitoring programs document threats, as well as management activity outcomes and effectiveness. They also include extensive biodiversity inventories.

Text Box A.2: Wildlife surveillance and monitoring in Lower Kinabatangan

Surveillance and **monitoring** are two different concepts but they can be carried out by the same teams of people in the field. An example of this can be seen from the rangers from the Sabah Wildlife Department and Honorary Wildlife Wardens who regularly patrol the Lower Kinabatangan Wildlife Sanctuary (LKWS). Species, number of individuals and location of wildlife sightings detected during these patrols, as well as types of encroachment (if any), are recorded in specific data sheet or log books. These data are recorded opportunistically in the field and compiled monthly. This *surveillance* gives an overview of wildlife population dynamic and distribution in the area.

On the other hand, *monitoring* activities in Lower Kinabatangan aim at better understanding how wildlife populations can be sustained in the area. Specific protocols have been developed to investigate questions such as what impact fragmentation and degradation of the forest habitat has on the composition and abundance of wildlife communities; what impact do tourism activities have on proboscis monkey or elephant populations; what are the patterns and drivers of spatio-temporal fluctuations observed with wildlife abundance, or; is the orang-utan population in Kinabatangan stable. These activities can be conducted by the same teams of people, but following specific protocols and pre-established schedules.

2.1.3. Intensive study area.

Intensive study areas are usually of relatively small size and are used to collect precise information about the ecology and the behavior of a given species (e.g., density, movements, activities). Often, field researchers follow and study the behavior of known individuals that have been habituated or marked. If the subset of individuals studied is representative of the general population, the information gained within the study site can be extrapolated to the population to a certain extent.

Text Box A.3: The KOCP Orang-utan intensive study area

In 1998, the *Kinabatangan Orang-utan Conservation Programme* (KOCP) and the SWD developed an intensive study area to investigate whether and how wild orang-utans could adapt to heavy forest disturbance. This 6 km^2 site was established in Lot 2 of the LKWS. Initially, the teams of research assistants mapped the site and assessed forest structure and composition. Next, wild orang-utans were habituated to close human presence. Every day, teams of field observers enter the study area in search of orang-utans. Upon detection, focal animals are followed continuously from nest-to-nest. During these follows, information is recorded using 3 minute-scans (recording type of behavior; type of locomotion; height in the forest and location in the study site; plant species used; etc.). To date, KOCP has secured more than 15,000 hours of direct observation of wild orang-utans in this study site, making the Kinabatangan orang-utan population one of the best studied in the world. However, this study represents a massive effort; approximately ten dedicated full-time field research assistants are involved in orang-utan observation and data collection here. The results of this study inform about the ranging pattern of the animals, their feeding behavior and diet in degraded forest, their breeding dynamics and social system, among other things. This allows for a better understanding on how the species copes with forest degradation and fragmentation. Finally, this knowledge can be translated in better forest and land-use management practices.

2.2. Logical steps to plan a wildlife strategy.

Collecting reliable data about wildlife is difficult and time consuming. Consequently, questions that we want to address and activities that we need to implement in the field need to be precisely identified and designed. A proper planning is necessary to achieve our final goals.

A good Plan is **efficient** (meaning that data are collected with as little cost and effort as possible) and **effective** (provision of answers to the management issues that were identified and need to be monitored).

Successive steps can be followed to develop a simplified logical process for planning a wildlife strategy:

STEP 1: Identify the key biodiversity features and the question(s) you want to address as specifically and precisely as possible.

In other words, we need to have a clear idea of what we want to achieve and why.

Key biodiversity features (also called key environmental features) include habitats, species, and community assemblages recognized as being important for the site. For each feature we select, based on our overall goals (see Part 2, Chapter 7), we need to identify exactly what we want to know, and we need to translate and to formulate these decisions as a series of questions. These questions must be clear, relevant, and concise. Suitable questions are those for which there are specific answers (see Text Box 4).

STEP 2: What data are needed to complete these analyses?

Questions identified previously are answered by a series of data collected in the field. Thus, we need to consider how these data can be collected in the field; how much are needed; how easy they are to collect; etc. This stage intends at identifying what the major constraints for carrying out the project are.

- Physical: determine size of the area, accessibility, need for stratification, etc.;
- Political and social: identify stakeholders and ways to engage with them;
- Financial: estimate a general budget, prioritize features to be monitored and protocols to be used with different budgets;
- Human resources: determine number of available staff, skills, training needs, etc.;
- Time: estimate time needed to complete the field activities and adjust the entire protocol accordingly - a calendar is a very useful tool to plan the entire field activities.

Time and financial constraints are important parameters to consider when determining monitoring frequency.

STEP 3: What protocol is required to obtain the data?

The most appropriate method for measuring the features should be the most cost-effective, and provide an adequate assessment of the questions being asked. A simple logical framework can be used as guidelines: see Figure A.1.

Methods used in the field have to be clear and well understood by the field staff to minimize misunderstandings and maximize the quality of the observations. The methods need to be documented, discussed, understood, and tested by the teams before going to the field. Practical data sheets also need to be developed by field staff at the beginning of the project. Thorough preparation is the best way to ensure that usable data is collected. Unfortunately, it is not uncommon for wildlife managers to end up with a set of data that is unsystematic and biased, and therefore unanalyzable.

Statistical protocols are also part of a wildlife strategy since they will be tools used to derive precise estimates and information from available data. Their design requires the assistance of professional statisticians. It is however beyond the scope of this Manual to go into these details (see Annex II for some basic information about statistics).

Text Box A.4: What do we want to achieve and why?

To establish the scope of a plan, you should ask the following questions (before developing or upgrading an existing management plan):

- √ Why do we need a management plan?
- √ Who is going to use the plan?
- √ What limits were identified in a previous plan available for the area?
- √ What key wildlife species do we want to include in the plan?

If we are interested in **maintaining and protecting the biological diversity in an area**, the question should not be "what is the ecology of species A in this area?": this is far too broad. On the contrary, you could ask questions such as:

- √ Where is species A distributed?
- √ Where are key natural resources in need of protection located?
- √ What is the population size of species A?
- √ What are the major threats impacting species A?
- √ Is species A declining through time?
- √ What can we realistically do to reverse those declines?

If the priority of the plan is **to promote sound management practices for sustainable timber production**, or **to ensure a continuous certification**:

- √ What are the changes of relative abundance of selected wildlife species in compartments subjected to different logging regimes?
- √ Where are the High Conservation Value Forests in need to be protected?
- √ How different management techniques are impacting movement of wildlife?
- √ What are the factors limiting the implementations of best management practices identified for a given area?

If the priority of the plan is **to contribute sustainable tourism development:**

- √ What species and other natural resources can be used for tourism activities?
- √ Where are these species and resources located?
- √ Where are the key areas where tourism activities can be sustainably developed?
- √ Are tourism activities responsible for the decline of species A?
- √ What tourism infrastructure is going to have the least impact on wildlife?

If the plan **is to develop sustainable hunting:**

- √ What game resources are available in the area?
- √ Where are the game species distributed?
- √ What are their population sizes?
- √ Are resource users willing and able to develop/abide by such a plan?
- √ What is the current level of yield on the populations and are current hunting practices sustainable?
- √ Where can a "Community Utilitarian Zone" be established?

STEP 4: Monitoring and evaluating the wildlife strategy.

The teams involved in field activities need to evaluate and revise the plan regularly in order to adapt it to conditions and opportunities encountered on the ground. But this has to be done carefully since changing surveillance methods can preclude any comparison between new and old data. Adjustments should be done at the early stages of the monitoring programs; if they are too frequent, these adjustments will jeopardize the continuity of the entire program.

Field protocols need also to be evaluated and monitored regularly to ensure that the changes recorded during wildlife surveillance are true variations of the variables and not simply a variation of measurements taken by different people or under different protocols.

Long-term evaluation and monitoring protocols are needed for a variety of reasons:

- Insurance for surveillance and monitoring programs to meet national or international standards of quality;
- Production of credible results;
- Detection of fluctuations recognized during the surveillance activities;
- Making comparisons possible between different sites, agencies and over time.

Monitoring and evaluation are further discussed in Part I - Chapter 6 of the Manual.

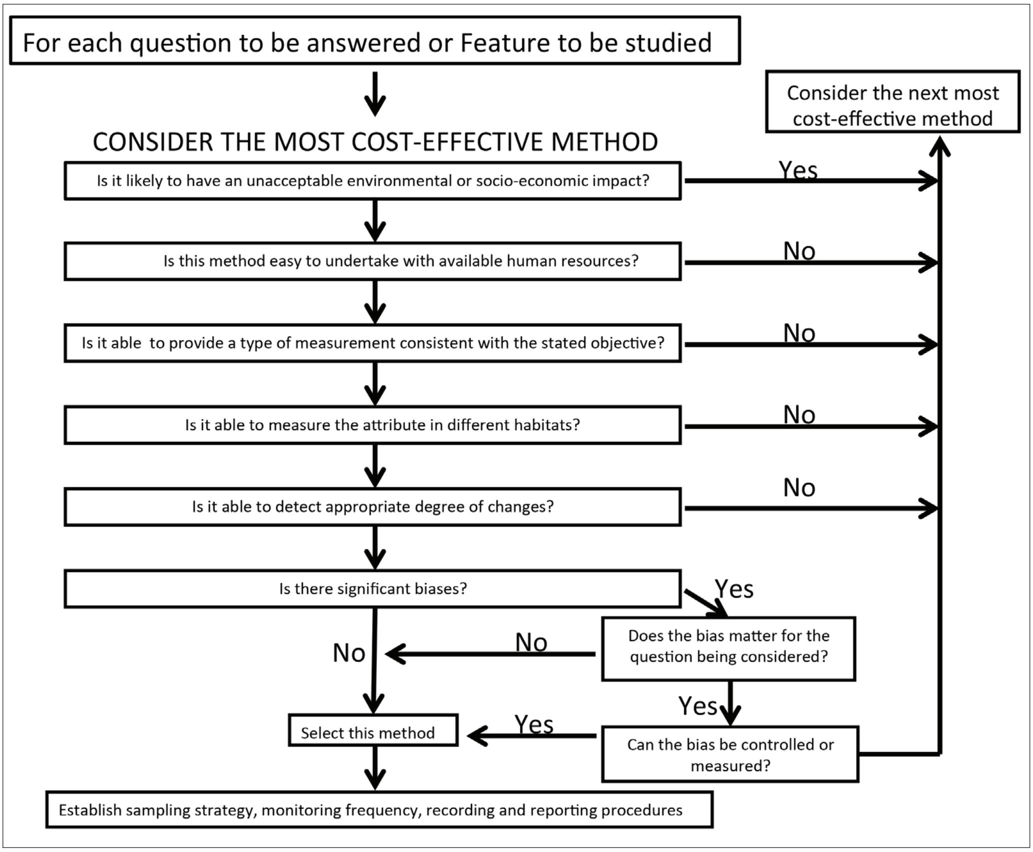


Figure A.1: Decision tree to select protocols for data collection.

A good monitoring protocol consists of two parts:

- The "Narrative" of the Plan provides the rationale of the program (described in Part 1 of this manual). The narrative should:
  - 1. Detail the objectives and why they were selected;
  - 2. Describe the sampling design;
  - 3. Explain field methodology including data collection, handling, analysis and reporting;
  - 4. Identify resources needed to achieve the final goals of the program (time, financial, human);
  - 5. Develop adequate evaluation tools to monitor the strategy and how this impacts management actions.

- The "Standard Operating Procedures" (SOP) give a practical and simple description of the activities that will be undertaken under the Plan and provides supplementary materials needed for data collection, analysis and management. This mostly refers to the Second Part of this manual.

2.3. Key mammal species to be included in a wildlife strategy in Sabah.

Current knowledge increasingly indicates that the best indicators of forest ecosystems are some taxa belonging to bird, invertebrate or frog communities rather than mammal species. It would therefore seem logical to include non-mammal species in a biodiversity monitoring strategy.

Unfortunately, studying and monitoring these taxa is often difficult. It requires resources that are not necessarily available to the teams of field rangers who are in charge of monitoring wildlife and forest ecosystems. Simultaneously, most of these bio-indicator species are largely unknown by the general public and the land deciders we want to inform. Conversely, many mammal species have a recognized iconic and appealing value. **Experience shows that to inform policy makers and other stakeholders, it is easier to use iconic and well-known species rather than obscure species known by only a handful of scientists**. In addition, it is relatively easy to record data on many mammal species and to minimize biases, making mammals good potential candidates for general wildlife monitoring.

Because of these reasons, this Manual is primarily focused on emblematic and endangered terrestrial mammal species in Sabah that can be studied relatively easily. If managers need to develop a more in-depth biodiversity monitoring strategy, non-mammal taxa as bio-indicators of the ecosystems must be included as well. For more information on this topic, refer to the list of field manuals listed in Annex IV.

"Key mammal species" may include:

- Species with broad international and national conservation priorities; all threatened species (identified at http://www.iucnredlist.org/) should be included in a management strategy and should be monitored regularly;
- Species which are rare and/or endemic to Sabah or to Borneo;
- Species that provide ecosystem services (pollination, seed dispersal and germination, etc.); that are agricultural pests; or of financial interest (tourism, hunting).

Additional key features that are important to record include rare ecosystems of exceptional value, ecosystem components that are directly linked to wildlife survival (salt-licks, wallows, nesting sites), and human activities that impact directly ecosystem values (hunting, forest restoration/degradation).

For each key species or features, we need to identify specific and descriptive objectives and performance indicators that will be used to monitor the features (see also Chapter 7).

Thus, it is necessary to identify and define "specific attributes" that will be used to evaluate the status of each key species. These attributes are traits related to animal's life history that are indicative of their response to the changing condition of the environment. Ideally, these attributes should be easy to observe and to record. Examples of these attributes are: group size and group structure; call frequency; presence of nests; feeding signs and other signs. For each key species included in the wildlife strategy, the corresponding list of attributes to be monitored in the field must be known and understood precisely by the team of field rangers.

At this stage, it is also essential to identify the major factors that are impacting the key species to make sure that these factors are considered in the monitoring strategy. In order to achieve positive conservation results (e.g., to maintain or to improve the status of the considered species), these factors need to be kept under control.

The major mammal species that need to be considered for a wildlife strategy in Sabah include:

- Totally protected species in Sabah (Schedule 1);
- Protected species in Sabah (Schedule 2);
- Protected species in Sabah for which hunting license is required (Schedule 3);
- Additional features that impact wildlife populations in a given area.

2.3.1. Totally protected species in Sabah (Schedule 1).

Eleven species are totally protected in Sabah:

- No one may hunt these animals;
- No one may possess these species, or any part or product from them without written authorization from the State Minister for Tourism Culture and Environment.

Any person who is found to be in violation shall be liable on conviction to a mandatory term of imprisonment between 6 months and 5 years.

Terrestrial species falling under this level of protection include the Orang-utan, Proboscis monkey, Sun bear, Clouded leopard, Sumatran rhinoceros, Tembadau, as well as the Bornean elephant recently upgraded from Schedule 2 to Schedule 1. Aquatic species under Schedule 1 include the Dugong, False gharial, Hawksbill turtle, and Green turtle.

All these species MUST be included in a wildlife strategy if they occur in the area of interest.

Orang-utan, *Pongo pygmaeus morio* - Primates, Pongidae	
Conservation Status	IUCN Red List Endangered – CITES Appendix 1
Justification	• Endemic to Borneo • Very high intrinsic appeal (e.g., tourism; investment schemes) • Umbrella species • Seed dispersal and seed germination • Possible source of conflicts with people
Attributes of interest	• General population size • Population structure (age, sex, birth rate) • Plant species consumed • Location of nests and long calls • Spatio-temporal fluctuations of food resources • Presence and extent of conflicts with people
Threats	• Low food resources (habitat degradation and fragmentation) • Habitat compaction (leading to social stress) • Population fragmentation and presence of bottlenecks leading to inbreeding and genetic drift • Poaching (bush meat, conflicts)
Conservation objectives	• Eradicate poaching (if any) and conflicts • Maintain or increase population size • Alleviate recognized bottlenecks • Increase forest productivity
Field methodologies	**Assessment:** • Recce walks • Nest counts along line transects • Aerial surveys **Monitoring:** • Aerial surveys • Permanent line transects
Expected outputs	• Precise distribution • Relative and absolute abundance estimates and seasonal fluctuations • Nest decay rate • Occurrence of conflicts • General population structure (existence of a breeding population) • Presence of bottlenecks and ways to alleviate them

Proboscis monkey, *Nasalis larvatus* - Primates, Cercopithecidae	
Conservation Status	IUCN Red List Endangered – CITES Appendix 1
Justification	• Endemic to Borneo • Very high intrinsic appeal (e.g., tourism; investment schemes) • Narrow occupation niche • Bio-indicator for riparian habitat
Attributes of interest	• Number, group size and structure • Distribution
Threats	• Degradation and destruction of riparian forests • Poaching
Conservation objectives	• Eradicate poaching (if any) • Restore riparian habitat • Maintain gene flow
Field methodologies	• River surveys
Expected outputs	• Relative and absolute abundance estimates • Distribution of groups, preferred sleeping sites, presence of food sources • Quality and productivity of riparian forests • Semi-quantitative indexes of abundance • Presence of bachelor males in a dispersal phase

Sumatran rhinoceros, *Dicerorhinus sumatrensis* - Perissodactyla, Rhinocerotidae	
Conservation Status	IUCN Red List Endangered – CITES Appendix 1
Justification	• Very high intrinsic appeal (e.g., tourism; investment schemes)
Attributes of interest	• Individuals • Footprints
Threats	• Poaching • Health issues • Isolated animals (prevents breeding)
Conservation objectives	• Contribute to the "Sabah Rhino Strategy"
Field methodologies	• Opportunistic sightings • Camera trapping • Interviews
Expected outputs	• Presence and identification of individuals • Presence of young (breeding pair) • Presence of key features (e.g., active wallows; salt licks)

Bornean elephant, *Elephas maximus* - Proboscidae, Elephantidae	
Conservation Status	IUCN Red List Endangered – CITES Appendix 1
Justification	• Subspecies endemic to Borneo • Sabah is home to 90% of the wild populations • Very high intrinsic appeal (tourism; investment schemes) • Possible source of human-wildlife conflicts
Attributes of interest	• General population size and structure • Distribution and seasonal ranging pattern • Conflicts • Cases of poaching • Footprints and dungs
Threats	• Poaching (due to conflicts or ivory trade) • Human disturbance • Habitat fragmentation and creation of bottlenecks (fences, trenches)
Conservation objectives	• Secure the flow and dispersal of elephant herds • Minimize conflicts • Secure information about population dynamics • Assess how human activities impact population dynamics
Field methodologies	• Line transects • Car surveys • Opportunistic sightings • Interviews
Expected outputs	• Precise distribution • Relative/absolute abundance and seasonal fluctuations • General population structure (viability of the population) • Type and location of preferred/critical habitats • Occurrence of conflicts and poaching • Alleviation of bottlenecks

Tembadau, *Bos javanicus* - Artiodactyla, Bovidae	
Conservation Status	IUCN Red List Endangered – CITES Appendix 1
Justification	• Most viable populations in Borneo are found in Sabah
Attributes of interest	• Footprints • Dung • Direct sightings and individual identification
Threats	• Poaching • Human disturbance • Logging • Isolated individuals and small groups preventing proper gene flow
Conservation objectives	• Provide a safe environment to remaining herds • Stop poaching activities • Increase the size of the herds
Field methodologies	• Opportunistic sightings • Camera trapping • Interviews
Expected outputs	• Group size and composition (breeding success) • Use of key features (salt licks) • Seasonal fluctuations in ranging pattern • Evaluation of hunting pressure

Sun bear, *Helarctos malayanus* - Carnivora, Ursidae	
Conservation Status	IUCN Red List Endangered – CITES Appendix 1
Justification	• High intrinsic and appeal value (tourism) • Elusive species
Attributes of interest	• Presence/Absence • Poaching (direct or snaring)
Threats	• Poaching • Decline in food resources due to habitat degradation • Conflicts with human activities • General lack of awareness • Logging
Conservation objectives	• Stop incidental death because of snaring and poaching • Identification of key areas and of food availability
Field methodologies	• Opportunistic sightings • Camera trapping
Expected outputs	• Assessment of food availability • Presence of conflicts and cases of poaching (direct or snaring) • Better awareness

Clouded leopard, *Neofelis diardi* - Carnivora, Felidae	
Conservation Status	IUCN Red List Vulnerable – CITES Appendix 1
Justification	• Endemic to Borneo and Sumatra • Top predator and potential regulator of the food chain • High intrinsic and appeal value (e.g., tourism) • Elusive species
Attributes of interest	• Presence/Absence • Poaching (direct or snaring) • Individual identification
Threats	• Poaching • Human disturbance • Destruction of prey base • Logging
Conservation objectives	• Stop incidental death because of snaring and poaching
Field methodologies	• Opportunistic sightings • Camera trapping
Expected outputs	• Distribution • Individual identification • Existence of poaching

2.3.2. Protected species in Sabah (Schedule 2).

A total of 206 species belong to this Schedule (Part 1, Schedule 2). All protected species are the property of the government and no one may hunt, own or trade these species without appropriate permits issued by the Director of the Sabah Wildlife Department.

Sabah has adopted a precautionary principle and hunting of the species listed in Schedule 2 is not allowed unless a "Non Detrimental Finding" study has been carried out. No hunting license of animals listed in the Schedule 2 had ever been issued by the Sabah Wildlife Department to date. Therefore, all hunting of Schedule 2 listed species is illegal. The penalty for hunting a species listed in Schedule 2 without a license is a fine of RM 50,000 or 5 years imprisonment, or both.

Species belonging to Schedule 2 that can be considered for inclusion into a wildlife strategy include:

Bornean gibbon, *Hylobates muelleri* - Primates, Hylobatidae	
Conservation Status	IUCN Red List Endangered – CITES Appendix 1
Justification	• Endemic to Borneo • Seed disperser • Very high intrinsic appeal (e.g., tourism)
Attributes of interest	• Group structure (presence of breeding families) • Size and location of good quality habitat • Distribution of calls • Hunting • Presence of bottlenecks
Threats	• Poaching • Lower food resources due to forest degradation • Population fragmentation • Habitat compaction and social stress • Logging

... continue on next page

... continued from previous page (Bornean gibbon, *Hylobates muelleri* - Primates, Hylobatidae)•

Conservation objectives	• Identification of bottlenecks • Identification of key areas and food availability • Stop poaching
Field methodologies	• Call surveys • Opportunistic sightings
Expected outputs	• General structure of the population (presence of breeding pairs) • Semi-quantitative indexes of abundance • Alleviation of bottlenecks • Identification of isolated units and translocation

Monkeys (5 species) **Primates, Cercopithecidae**	**1. Red langur,** *Presbytis rubicunda*; **2. Hose langur**, *P. hosei*; **3. Silver langur**, *P. cristata*; **4. Pig tailed macaque**, *Macaca nemestrina*; **5. Long tailed macaque**, *M. fascicularis.*
Conservation Status	IUCN Red List Least Concern to Vulnerable
Justification	• Some species are endemic to Borneo • Seed dispersers • Prey resources for top predators • High intrinsic and appeal value (e.g., tourism) • Potential for human-wildlife conflict with some species • Risks of disease transmission with humans
Attributes of interest	• Presence/Absence through Species ID • Group structure and group size • Reproductive success • Distribution • Conflict (e.g., property damage)
Threats	• Habitat destruction and fragmentation • Decrease in food resource due to habitat degradation • Poaching • Social stress • Road kill
Conservation objectives	• Maintain a well-balanced primate community • Minimize human-wildlife conflicts • Reduce risks of pathogen transmission
Field methodologies	• Opportunistic sightings • Recce walks • River surveys • Line transects • Interviews • Camera trapping
Expected outputs	• Group size and distribution • Presence of conflicts • Differential habitat and seasonal use

Small carnivores	Mustelidae (7 species of marten, weasel, ferret badger, badger, otters); Viverridae (8 species of civets); Herpestidae (2 species of mongooses); Prionodontidae (1 species of linsang); Felidae (5 species of cats).
Conservation Status	IUCN Red List Least Concern to Endangered
Justification	• Several endemic species to Borneo • Seed disperser • Control of rodent populations • High intrinsic and appeal value (e.g., tourism)
Attributes of interest	• Presence/Absence
Threats	• Poaching • Road kill • Disappearance of prey base
Conservation objectives	• Maintain a healthy carnivore assemblage
Field methodologies	• Opportunistic sightings • Night surveys • Camera trapping
Expected outputs	• Distribution • Semi-quantitative indexes of abundance

2.3.3. Protected species in Sabah for which hunting license is required (Schedule 3).

These species may be hunted under a license issued by the Director of the SWD. The nine species in Schedule 3 are the large flying foxes (2 species), the common porcupine, the bearded pig, the lesser and the greater mouse deer, the common and the yellow barking deer (or muntjac) and the sambar deer. The penalty for hunting a species listed in Schedule 3 without a license is a fine of RM 50,000 or 5 years imprisonment, or both.

Cervids & Tragulids (5 species) Artiodactyla	Lesser mouse deer, *Tragulus javanicus*; Greater mouse deer, *Tragulus napu*; Red muntjac, *Muntiacus muntjac*; Yellow muntjac, *Muntiacus atherodes*; Sambar deer, *Cervus unicolor*.
Conservation Status	IUCN Red List Least Concern - Vulnerable (sambar)
Justification	• Important game resource • Important seed dispersers • Prey resource for top predators
Attributes of interest	• Distribution of sightings • Possible conflicts with reforestation exercises or agriculture • Preferred areas and important environmental features (saltlicks) • Hunting pressure
Threats	• Poaching and over hunting • Road kill • Destruction of salt licks
Conservation objectives	• Maintain healthy populations in protected areas that can repopulate surrounding areas • Design hunting plans in areas where hunting is allowed

... continue on next page

... continued from previous page (Cervids & Tragulids (5 species) Artiodactyla)

Field methodologies	• Opportunistic sightings • Road surveys • Camera trapping • Interviews and market surveys
Expected outputs	• Distribution and habitat use • Relative indexes of abundance • Economic valuation of the resource

Bearded pig, *Sus barbatus* - Artiodactyla, Suidae	
Conservation Status	IUCN Red List Vulnerable
Justification	• Important game resource • Prey resource for top predators
Attributes of interest	• Distribution of sightings • Possible conflicts • Preferred areas and important environmental features (wallows) • Hunting pressure
Threats	• Poaching and over hunting • Destruction of food resources
Conservation objectives	• Maintain healthy populations in protected areas that can repopulate surrounding areas • Design hunting plans in areas where hunting is allowed
Field methodologies	• Opportunistic sightings • Road surveys • Camera trapping • Interviews and market surveys
Expected outputs	• Distribution and habitat use • Relative indexes of abundance • Economic valuation of the resource

Common porcupine, *Hystrix brachyura* - Rodentia, Hystricidae	
Conservation Status	IUCN Red List Least Concern
Justification	• Game resource • Possible conficts
Attributes of interest	• Distribution of sightings
Threats	• Poaching and over hunting • Habitat destruction • Road kill
Conservation objectives	• Maintain healthy populations
Field methodologies	• Opportunistic sightings • Road surveys • Camera trapping
Expected outputs	• Distribution and habitat use

2.3.4. Additional features to be included in a wildlife strategy.

Wildlife abundance and distribution are affected by a number of variables. Some variables are based on physical attributes of the forest itself (saltlicks, wallows, habitat type and state of degradation/regeneration), while others are the results of human activities (hunting, road kills, etc.). Incorporating some of these features in a wildlife strategy is therefore needed to better understand wildlife population dynamics and to design adequate management measures.

Saltlicks: Providing essential minerals, saltlicks are incredibly important to wildlife. They are an essential component for explaining the ranging patterns* of many species, especially large mammals. It is therefore essential to identify if such features are present in the area and if they are, it is necessary to protect them. It is also worth assessing the value of creating artificial saltlicks to attract some large ranging species, such as tembadau.

Wallows: Wallows influence wildlife abundance and ranging patterns. Animals use them for mud-baths, resting and possibly as source of minerals. Identifying and monitoring wallows will inform on wildlife community assemblages and dynamics.

Poaching: Hunting is one of the major driving threats for wildlife extinction in multiple-use landscapes. In addition, poaching activities prevent FSC certification or tourism activities, and project a negative international image. Three major types of illegal poaching are commonly reported: poaching with firearms on foot with dogs or from vehicles at night (commercial bush meat trade, recreational hunting); snaring (mostly local consumption); and retaliation killing from human-wildlife conflict.

Road kill: Animals are regularly found killed along the roads in Sabah (especially nocturnal species that are caught in the light beams of vehicles). The road kill monitoring strategy aims to establish if this issue has a major impact on wildlife populations and if enforcement activities are efficient in addressing this issue.

<table>
<tr><th></th><th>Saltlicks</th><th>Wallows</th><th>Poaching</th><th>Road Kill</th></tr>
<tr><td>Justification</td><td>• Source of minerals for many mammal species
• Attractive to large mammals and game species</td><td>• Source of water for bathing (wild boars, elephants, rhinoceros)
• Attractive to some species</td><td>• Major threat for wildlife populations
• Highly regulated in Sabah and the law must be enforced</td><td>• Can significantly reduce population size of some species (mostly nocturnal)</td></tr>
<tr><td>Attributes of interest</td><td colspan="2">• Distribution
• Size
• Frequency (what species, etc.)</td><td>• Species
• Number of hunting cases (legal or illegal)</td><td>• Species killed
• Location</td></tr>
<tr><td>Threats</td><td colspan="2">• Destruction
• Degradation</td><td>• Increased pressure in significant populations</td><td>• Increased road kill on improved roads</td></tr>
<tr><td>Conservation objectives</td><td colspan="2">• Distribution and location
• Site protection</td><td>• Maintain viable populations of game species
• Zero killing of protected species; zero hunting in protected areas
• Hunting plans for Schedule 3 species</td><td>• Zero-road kill target
• Healthy populations of nocturnal species
• Rules and regulations to minimize wildlife disturbance</td></tr>
<tr><td>Field methodologies</td><td colspan="2">• Opportunistic sightings
• Camera trapping</td><td>• Interviews
• Night patrols
• Camera trapping</td><td>• Opportunistic sightings;
• Systematic sampling
• Road surveys</td></tr>
<tr><td rowspan="2">Expected outputs</td><td colspan="2">• Distribution map
• Seasonal and differential use by wildlife</td><td rowspan="2">• Evaluate efficiency enforcement and awareness campaigns
• Number and species killed
• Type and identity of poachers</td><td rowspan="2">• Assess impact of road kill on species assemblage
• Identify high risk areas</td></tr>
<tr><td>• Assess the need for establishing artificial salt licks</td><td></td></tr>
</table>

Chapter 3: DATA COLLECTION, REPORTING AND STORAGE

Data collection is the most important part in all wildlife studies. To better understand the dynamics of wildlife populations, we need good quality data. However, making precise observations and recording reliable information is more difficult than it seems. It requires adequate training and significant effort; the observer needs to record what was sighted in the field, not what thought to be sighted! The reporting of wrong data is a major impediment for properly understanding wildlife populations.

A very important concept in wildlife management is that **NO DATA IS DATA**: the absence of animal signs is important to record. In other words, the absence of wildlife signs in a given area or during a given season must be reported. Indeed, this kind of information can give interesting hints about the dynamics and the ecology of the species being monitored.

The way data are collected in the field need to be standardized between teams at the same site and ideally between field sites to ease field work, minimize the inter-observer biases, and achieve meaningful comparisons of wildlife species between sites and over time.

3.1. Data collection.

Data need to be recorded as soon as observations are made and not back at the office. Relying on memory to report data after the end of field activities is a bad habit. Indeed, delaying data recording means significant loss of information and accuracy either due to inaccuracy or because the final recording is not done! **It is therefore imperative for field rangers to always carry a logbook and/or specific data sheet every time they go to the forest to report any observation they may make while in the field.**

3.1.1. Logbooks or field books.

Field books are the primary and essential tool for collecting wildlife data. Field books are typically bound, of small size (pocket size) and waterproof. They are used to describe observations that are not reported in specific data sheet, and describe daily activities and findings. Logbooks are also used to make sketches of what is seen in the field. Sketches are important, even if the recorder is not an artist! Sketches add value to written information especially when observations are difficult to put into words. They should emphasize key characteristics (e.g. size or colour, etc.) as observed in the field and should always show the scale.

3.1.2. Data sheet.

Data sheets are created to assist in data collection and data analysis. Data sheets are a compromise between efficiency and user-friendliness. They are standardized forms, and their content depends on the type of activities documented and the Key Environmental Features monitored. Data sheets are designed to record information relevant to specific questions: a common mistake is to record too many details at once - or too few! It is thus more appropriate to design several data sheet focusing on specific monitoring activities rather than a general one for several types of activities; a data sheet for gibbon calls should not be used to record the size of a rhino footprint. Recording orang-utan nests along permanent transects require a different data sheet than recording nests during road monitoring. Data sheets need to be discussed and developed by the team **BEFORE** field activities are initiated. Then they are tested in the field and can be amended when necessary until everyone in the team feels comfortable with the format.

There are three major types of data sheets:
- *Single event sheet*: completed on one occasion;
- *Continuous data sheet*: each new observation is added to the data sheet (similar to a logbook);
- *Updated data sheet*: based around a site or an individual: much of the data is recorded once but new data is added with future visits or encounters.

A data sheet is separated in two parts (see examples in Part II of the Manual and Text box A.5); the first part (top of the sheet) is to record general information about field activities and type of data collected. This includes:

- Date and time of the activities (including the ending time of the survey);
- Team members;
- Location (name and description of the general area along with precise GPS location);
- Data sheet number;
- Weather during the data collection;
- Type of wildlife survey conducted while filling up the form.

The second part is generally a table or a succession of rows and columns where data can be recorded easily and systematically.

Text Box A.5: Tips to create a good data sheet.

- Make it as user-friendly as possible to minimize inter-observer biases;
- Use boxes to highlight places where crucial information needs to be recorded;
- Use a codification system or acronyms to optimize space; make sure that this system is explained and easily understandable to people who are using the data sheet;
- Not too little nor too much data is collected on one sheet;
- Ideally, the format of the data sheet reflects how data are going to be computerized.

3.1.3. Pictures and videos.

Digital pictures are easy to take and store, and show immediate results. Whenever possible, the team should bring simple digital cameras in the field and document sighting by taking pictures. For small and immobile subjects such as footprints, feeding signs, scale should be indicated using a ruler or an object of known size (use a lighter for example). It is imperative to record the number of the picture as well as the subject in a specific data sheet or logbook. Pictures need to be organized and stored in a proper filing system.

3.2. Recording wildlife data.

Wildlife data can originate from both direct observation of the animals and indirect observation of their signs. Signs can be visual (marks, nests, dens, food remains, footprints), acoustic (calls, noises of movements), or olfactory (odor). For both direct and indirect signs, the type of information to be collected is similar. It will generally include details about the sighting (age of the sign; size), time, location, species, group size, sex and age, and the behavior and spatial position. Precise methodology about data collection is explained in Part II of the Manual.

3.2.1. Direct observations of wildlife.

It is important for field observers to report what they really see and not what they think they have seen. When animals are encountered in the field, observers must focus first on their number (group size), their behavior and special characteristics that will be needed for species identification. A GPS location of the sighting or landmark that will allow for mapping the sighting must be recorded (see part B of the Manual). These direct observations will inform wildlife manager not only about species presence, but also about fluctuations of abundance according to season and habitat type, population dynamics, and wildlife interactions. These data can also be used for modeling and monitoring wildlife populations.

3.2.2. Indirect observations of wildlife.

Because they are small, elusive or scarce, many mammal species are difficult to detect and monitor in the forest. However, they may leave some trace of their activities and movements. Tracks provide vital information about animal's presence and behavior, and can also be used to indicate fluctuations of relative abundance through space and time.

One of the most common signs left by mammals in the forest is feces. Fecal samples are a great non-invasive source of information that does not require capture. Non-invasive genetic analysis using new molecular tools allow for addressing complex questions at the individual and the population levels over broad spatial scale. Search of fecal samples in the field can be greatly improved with the use of scat detection dogs (Vynn *et al.*, 2010). Depending on the desired information, samples are processed and analyzed in different ways (Table A.1).

Table A.1: Type of information that can be derived from fecal samples.

Type of investigation	Required facility	Type of information	Cost*	Practicality*
Macroscopic investigation (in the field)	None – (performed in the field)	• Species ID • Basic information about age; sex	$	Easy, but requires experience
		• Density estimates for some species	$	Easy, but may be inaccurate
Microscopic investigation (at the field station / laboratory)	Field station / laboratory	• Parasite infestation	$	Easy
		• Diet: content analysis (hair, bones, seeds and other fragments)	$$	Difficult, requires experience
Genetic investigation	Genetic laboratory	• Individual identification; relatedness; paternity analysis	$$$	Easy to collect - Difficult to process
		• Health screening	$$$	Easy to collect - Difficult to process

... continue on next page

... continued from previous page (Table A.1)

Type of investigation	Required facility	Type of information	Cost*	Practicality*
Hormonal investigation	Specialized laboratory	• Stress	$$$	Difficult
		• Reproductive status	$$$	Difficult

Legend: Cost: $: relatively cheap; $$$: most expensive; Practicality: easy means easy to undertake even for non-professional wildlife managers; difficult requires specialized facilities and human skills.

Proper sample preservation in the field is necessary to ensure the required information can be extracted from the sample in the laboratory. The same fecal sample can be divided in several fractions and therefore undertake different types of analyzes.

- **For genetic analysis**, a fraction of the sample is placed in a tube filled with 70% ethanol; or with a solution of DMSO-EDTA-Tri salts; or with a RNA later solution. The sample can also be dehydrated in a tube containing silica gel;
- **For parasitological analysis**, a fraction of the dung is placed in a tube filled up with 90% ethanol or 50% formalin solution. A fraction of the sample could also be dried under the sun for analyzing its contents and food remains (hair, bones, seeds, etc.). Dried samples can be stored in a freezer (–70°C) for extended periods of time.

The quantity of storage solution used to preserve a fecal sample should always exceed the quantity of fecal material by a ratio of 5:1 to 10:1. It is important to ensure that each sample is labeled with a pencil (ethanol can remove labeling ink) on a small sticker that is then placed within the tube. After the tube is capped, it needs to be sealed with parafilm to prevent leakage. Stored samples need to be checked periodically for leakage and evaporation.

Many animals leave characteristic feeding remains in the forest. Recording feeding trails can provide additional clues for species identification and can also contribute to the knowledge of feeding behavior of certain species. Examples of visible feeding trails include:

- Bark spat out by orang-utans;
- Twigs twisted by Sumatran rhinoceros or cut off by wild boars;
- Seedlings eaten by cervids;
- Plants pulled down by elephants;
- Bite or tooth marks on fallen fruits and seeds by rodents;
- Exposed ant/termit nests by pangolins or sun bears;
- Dead birds and other prey hunted by predators (note that birds of prey usually pluck out the feathers of their kill, while small carnivores chew the quill).

It is always useful to collect samples of plants and other food types consumed by the animals to build a reference collection that is kept at the field station.

Other physical signs that are used to indicate the presence of animals are nests, for species like orang-utans, sun bears, and giant squirrels. Information that is recorded includes tree species where the nest is built, height of the nest, and location in the tree. Wild boars build large terrestrial nests for giving birth.

Last but not least, bodies of dead animals are sometimes found in the forest or along the road. They can provide information about species distribution, but they can also be used to build up a reference collection, for awareness activities, for further research, or for forensic analysis.

Bodies of small animals can be kept as wet specimens and immersed in a container filled with alcohol (70%) or formalin (10%). Carcasses can also be frozen before being processed. Skulls and bones can be buried in the ground for a few weeks to be cleaned by ants and insects. After retrieval, the bones are immersed in a chlorine solution and bleached under the sun. Information about each specimen should be written down in a special catalogue and each specimen should be labeled precisely (number of the specimens, date, taxon, sex, age, location).

3.3. Recording ancillary data.

Recording information about abiotic factors and habitats, or ancillary data, is necessary to better understand the general landscape and the ecological context where animals live. Ancillary data are complementary variables that give clues and hints to better understand wildlife data collected in the field. These data are often needed to interpret population trends. Below is a list of ancillary variables that are regularly recorded during wildlife monitoring activities.

3.3.1. Weather.

Weather condition directly impacts forest productivity, influencing wildlife abundance, movements and behavior. Meteorological data can be obtained from the nearest meteorological station (Meteorological or Agricultural Departments, District Office). They can also be recorded with a meteorological box or with a data logger; temperature and rainfall must be included in all studies. Air temperature is recorded daily with a mercury or alcohol-filled thermometer. A min/max thermometer is the most appropriate tool to record minimum and maximum daily values. The thermometers should be kept in a meteorological box with wooden slats. Rainfall is recorded with a rain gauge located in an open area; the rain gauge must be checked every day. Today, data loggers (comprising electronic thermometers) replace the traditional thermometers and can store data easily. Other variables such as humidity, wind and water flow, and sunlight intensity can also be recorded depending on the scope of the wildlife plan. Water temperature should be recorded every time a river survey is done. Meteorological data are summarized and averaged every month and presented in histograms to show yearly fluctuations and patterns.

3.3.2. General description of the habitat.

Habitat characteristics have a strong influence on wildlife observations and must be described to complement wildlife data. Ancillary data recorded to describe habitat include the dominant landform (valleys, plains, cliffs); elevation (easily determined with a GPS or from topographical maps); steepness and slopes (measured with a clinometer or estimated directly by trained observers); soil texture (clay, sand, mud); soil color and type of top soil; etc. Features of special importance to wildlife such as saltlicks or wallows need to be identified on a map and precisely described (location, size; activity/inactivity; micro-habitat surrounding the site). Lastly, data about water availability are also recorded, for example presence of waterways and waterholes, distance to the sampling area, and number of streams.

3.3.3. Refined habitat structure and composition.

The structure and the composition of the forest determine what food resources are available, directly impacting wildlife abundance and composition. Therefore, this information is important to collect. This can be carried out in both a qualitative and quantitative manner.

A qualitative description of the habitat should be kept simple and needs to be standardized for consistency. Such descriptions will include information, such as:

- **Dominant habitat types**: classified in broad categories, such as swamp forest, semi-inundated forest, dry lowland dipterocarp forest, riparian forest. For ease of interpretation, follow the broad categories as recognized and used by the Sabah Forestry Department;
- **Dominant/most common tree species**: Belian forest, Oak forest;
- **Signs and types of human disturbance**: logging, agriculture, mining, presence of logging roads (old or active), stumping areas, stumps and felled trees, presence of colonizing pioneer trees such as Macaranga sp. indicative of past disturbance;
- **Presence of keystone species**: large Ficus trees;
- **Average canopy height**;
- **Canopy density**: open/closed.

The quantitative assessment of the forest incorporates a numerical description of the forest structure (height, diameters of trees, stock volume) and composition (which species of plants are common or rare; what habitat types are found; what is the tree density and food availability). These assessments are conducted in sampling plots. These botanical plots can be of any size or shape, balancing three different factors:

- Ability to determine plot boundaries accurately and with minimum effort (e.g., efficiency);
- Reducing edge effects;
- Expected scale of pattern in the vegetation.

A practical way to conduct these assessments is, for example, to set up rectangular plots (e.g., size of 10 m x 100 m) at regular intervals (e.g., one plot every 500 m) along line-transects that are used for wildlife monitoring.

3.3.4. Forest monitoring.

Forest dynamic is assessed with permanent botanical plots. These plots need to be marked in the forest and mapped precisely. The same plots should be revisited yearly by the same team of observers who re-measures the trees present in the plots. This monitoring provides information about tree mortality and recruitment, tree growth, carbon production, forest regeneration, to mention a few. Phenological monitoring allows for regular assessments of fruit and food production by plants. This is achieved through monthly observation of a set of trees and plants that have been identified and marked in the forest. These botanical plots are selected based on the questions to be addressed (e.g., trees randomly selected in the forest, or located along trails or transects or within plots). Information about the production of fruits, young leaves and flowers should be recorded monthly, either qualitatively or semi-quantitatively.

3.3.5. Anthropogenic data.

Human activities are also an essential element for explaining wildlife abundance and distribution. Major factors to be considered include (this list is not exhaustive):

- Human settlements - presence/absence in the survey are, distance;
- Size of the human population;
- Roads - where and importance;
- Human presence - where, when, why, how many?
- Hunting activities - record all signs of hunting/poaching encountered during field activities;
- Logging activities - all signs of logging and human disturbance must be recorded, including old stumps, logging camps, dumping areas, skid marks and tractor trails.

3.4. Reporting data.

Data collection is not an end in itself! Unless field data are properly analyzed, processed and reported, they are worthless! No research is complete until the results are analyzed, made available and understandable to people who are going to use them. Results of field activities need to be transcribed in a format that will allow for their translation in management decisions.

3.4.1. Data processing.

To ensure that data are collected, and analyzed efficiently and effectively, a data processing supervisor must be chosen from the team conducting wildlife-monitoring activities. This supervisor will be in charge of:

- *Centralizing all data sheet and wildlife information recorded by the field teams*: every time the teams are back from the field, observations/data sheets must be collected by the supervisor;
- *Checking data quality*: e.g., is the data correctly entered and readable? Is there any basic information missing?
- *Organizing and filing* the data before they are computerized;
- *Supervising/undertaking the computerization and digitization processes*: it is very easy to be overwhelmed by the amount of data that can originate from field activities such as camera trapping, satellite telemetry, etc. Data-processing should be done regularly;
- *Supervising and/or performing data analysis.*

3.4.2. GIS and map production.

All wildlife data must be geo-referenced and all observation made in the field should come with precise locations or GPS coordinates. Data are then digitized and organized in specific GIS data layers. GIS softwares allow for easy storage, visualization and exploration of field information. The GIS layers can be used to illustrate a wide range of information spatially. For example: species distribution and fluctuation over time; ecological indicators and forest status (canopy gap, tree composition); management maps. Advanced analysis of GIS data requires the support of professional expertise, available from the SFD Headquarters or other agencies.

In order for this system to be effective, a proper and regular flow of information between the field team and the GIS operator/unit is essential. The data that is processed in a GIS needs to be sent to the GIS operator/unit every month and processed maps need to be returned to the field teams on a regular basis.

Maps are a crucial tool to communicate, present and share the results of monitoring activities with all partners. Therefore, any team in charge of wildlife monitoring activities needs adequate GIS training.

3.4.3. Different reports for different audiences.

Depending on the target audience, several formats are available to present the results of field activities:

- **Technical reports**: used by people who are in charge of managing the area. These reports focus on results and should recommend possible follow-up activities;
- **Scientific reports**: they present the full details of the research process, focusing on the methodologies and the significance of the results, less on possible recommendations;
- **Brochures**: they contain enough information to explain the significance of the area, species, current threats, and/or of the management activities being conducted;
- **Fact sheets**: a short description (1 or 2 pages) of a specific topic (e.g., a species, an area, an issue), presented in a simple language, without too much detail and including illustrations (pictures, drawings);
- **Species list**: it is useful to keep a species list up-to-date that can be shared with visitors, tourists, and scientists alike;
- **Exhibitions**: organized to reach the general audience. Posters should incorporate simple language and be well illustrated with nice pictures. The inclusion of artifacts from the forest, parts of plants or animals (skulls, seeds, fruits, etc.), research equipment used in the forest and data sheet can make the exhibition more successful;
- **Powerpoint presentations**: they need to be of high visual quality, and without too many words. Font sizes should be large enough to be easily read, and in a simple color scheme (not too many colors). Results should be summarized (no one intends to memorize the statistical tests from the study!). The use of pictures is critical as they will be what the public will remember.

Most of the time, results of field activities are described in written reports that are easy to circulate, store and archive. A report (scientific or technical) will typically include several sections (Text Box A.6):

- **Title**: must be chosen carefully and reflect the content of the document. The reader should be able to grasp the content of the report by reading the title only. It is always a good idea to put a picture on the front page to attract the attention of the reader. The title page should also include the author's name, the date of report's completion, and logos of major partners involved in the study;
- **Executive Summary**: this part is crucial since this is the first (and sometimes only) section the reader will read. Make sure that this summary is well written and appealing, and that the major findings of the work are highlighted. A bullet point format can be used to list the points of major importance;
- **Table of Contents**: gives the reader a rapid overview of the contents of the report;
- **Acknowledgement**: lists people who have been involved in field activities, people who have provided some guidance during data analysis and report writing as well as financial supporters of the project;
- **Introduction**: states the reasons and objectives of the study, and the questions addressed in the report;
- **Background information**: explains why this study is needed. This section is not necessarily developed on its own and can also be included in the *Introduction or Materials and Methods* instead. Other sections such as *Study Area and Study Animal* can also be included in this section;
- **Study Area**: describes the location, administrative status, environmental and climatic variables of the study area, and includes maps. This part also describes past and current human activities, their impact on the habitats, and other environmental variables;
- **Study Animal**: presents background information about the species selected for the study or as key feature (e.g., status, ecology);
- **Material and Methods**: presents the methods used in the study, and allows the reader to assess whether the methods are appropriate to answer the questions under investigation. This section should provide enough detail to allow the reader to repeat the study using the same methods. Information presented in this section includes date and time for surveys, team composition, location of survey units, number and size of sample units, etc.;
- **Results**: presents a summary of the data collected in the field. Data are presented with a basic description and interpretation of their meaning;
- **Discussion**: gives an interpretation of the results of the surveys and compares them with results from other studies. The discussion should give answers to the questions presented in the introduction. The most important findings of the study need to be highlighted and explained to the reader;
- **Recommendations**: provides guidance for the course of action that needs to be undertaken, based on the findings of the study. The information presented here is important and can also be included in the *Discussion* or *Conclusion* section;
- **Conclusion**: lists the main findings from the study (often similar to the Executive Summary);

- **References/Bibliography**: list of articles and reports that appear in the report (*References*), or list for further readings and more detailed information (*Bibliography*). The format used should be consistent;
- **Annexes**: can include raw data, a list and GPS location of all wildlife sightings, further information about the methodologies used in the forest, or any other information of interest to readers.

The reporting frequency fluctuates according to the type of information presented and the purpose of the reporting:

- **Monthly report**: presents the results of field activities and the daily time table, produced for evaluation purposes. This type of report is shared with authorities in charge of the area (DFO). Monthly reports are concise and straightforward, and a bullet point format can be used. It is a good idea to provide annexes describing all wildlife sightings with their GPS locations, as well as pictures of findings and field activities;
- **Three-month report**: includes information such as major findings and challenges encountered during the period, budget spent, and expectations for the next period;
- **Yearly report**: generally presents findings to a larger audience, and includes not only the Department in charge of the area but other government agencies, as well as all partners who have a direct or indirect interest in the area (managers, investors, sponsors, users). This report typically describes the status of key natural features being monitored, provides recommendations for future management activities and provides budget information, among other things.

Text Box A.6: Do's and Dont's for presenting your findings in written format.

A few tips are important to keep in mind when writing a report:
- Results must always be given with an appropriate unit;
- Mean and average of data should be given with some statistical information about their range and precision: standard deviation (SD); standard error (SE); 95% Confidence Interval; range;
- Be consistent with the way numbers are rounded;
- Scientific names in Latin must be given the first time that a taxon is listed in the document. The name of the taxon follows the international nomenclature:
  - Bornean orang-utan: *Pongo pygmaeus morio*
    Pongo (first letter in capital) is the genus
    pygmaeus (no capital) is the species
    morio (no capital) is the sub-species
  - When the species is not known, we use sp. after the generic name. For example, orang-utan (genus including two species: Bornean and Sumatran) would be *Pongo* sp.
- Figures and Tables must be properly numbered and must have a title;
- Graphs are used to illustrate the meaning of the data and Tables are used more to show numbers and results of calculations;
- It is always a good idea to insert a few pictures in a report, which will make the reading more enjoyable. In this case make sure that the original scale of the pictures is maintained (crop the picture rather than changing the proportion to make it fit your report). Make sure that picture resolution is low enough to not produce super large files!

3.5. Storing data.

If information is not accessible, it is considered lost, and all efforts made in the field to collect and to record information are pointless! Methods of data storage are twofold: physical storage and electronic storage. Physical storage includes data sheets, log books, field document as well as artifacts collected in the field. Electronic storage includes all computerized data and information.

A good storage system allows for easy retrieval of existing information, and easy addition of new information. **Labeling is the key for storage**. Every field book, data sheet, report and written document should contain at least the date and location where information was collected, and the name of the observers and the type of observations that were made in the field. It is a good idea to write this information on the cover of a logbook or on the top of every data sheet. Files or boxes used to store printed documents also need to be clearly labeled. Small labels indicating this information should also be attached to all artifacts brought back from the field (animal or plant parts). A similar approach should be taken for filing electronic data: every single picture or data file must be clearly identified before being stored in clearly labeled folders. As a rule of thumb, we should never store anything in an unmarked box or file!

Filing should be systematic and follow some rule. Data can be stored chronologically (by time) and then alphabetically (by subject), or vice versa. This system needs to be clearly explained. Every year, the Master List of all the major categories available in the filing system should be updated in order to facilitate the organization of the data.

Data can be stolen or easily destroyed (fire, computer crash) and therefore need to be protected: when lost, original data are gone forever! Backing up data is essential!

- **Physical/Hard data**: all original data should be photocopied and the copies stored at a separate site.
- **Electronic data:** a master copy of all data should be made and kept in a separate hard drive. Every time new data from the field are processed and computerized, they should be uploaded in this master copy. The hard drive containing the master copy and the computers used for data processing must be stored in separate locations (in case of thieves or fire).

Long-tailed macaque (*Macaca fascicularis*). These monkeys are often found along river banks or close to human settlements. They live in “multi-males multi-females groups of several dozens of individuals).

Chapter 4: ASSESSING THE SIZE OF A WILDLIFE POPULATION

Wildlife managers are frequently asked "how many animals are living in this area?" Unfortunately, answering this question is not straightforward and requires significant investment of time, resources and skills that are often not available. In addition, assessing a population trend doesn't necessarily require absolute density estimates; qualitative and descriptive data are often sufficient for conducting basic wildlife monitoring.

4.1. Basics about population and animal abundance.

4.1.1. Defining a population.

By definition, a **biological population*** is a group of organisms of the same species present at one place at one time and the **target population*** is *the population we want to study*. Ideally, all individuals that are part of the target population, irrespective of their age and sex, are counted or studied. In practice, sometimes only a part of a population can be monitored. For example, orang-utan nest surveys only consider animals that build sleeping platforms (e.g., adults) and do not include the young that still sleep with their mothers.

The **population range*** is *the area occupied and used by animals belonging to a given population*. Sometimes, the boundaries are well demarcated and the range of a population is of fixed size. But most of the time, the range occupied and used by a population fluctuates because of availability of food resources, dispersion, and migration processes, to mention a few. In such cases, it can be difficult to determine the range precisely. With large roaming species (elephants, wild boars) the population range most probably extends beyond the boundaries of the area where the study or the monitoring is being conducted (also called target area). Therefore, only the variables that impact the target population within the target area are assessed, and not the variables that are outside.

The size of an animal population is dynamic and fluctuates with time and through space. The knowledge of **population dynamics*** is essential for understanding the ecological status of a given population and for determining management strategies. This dynamic is a combination between addition and loss of individuals to the population:

- **Addition of animals**: breeding or influx (arrival of animals from other areas);
- **Loss of animals**: death (natural or man-related) or emigration (e.g., departure of animals to other areas).

The vast majority of methods used to determine population size assumes that the population is **closed**, or that the studied population does not experience any gain or loss during the duration of the study. **Population closure is a major assumption that must be verified to determine the size of a population.** If closed population models are applied to open populations, the resulting abundance estimates are biased. Such biases arise when these models are used for migratory species, species that roam over a large range or over an imprecisely known range, and species that have a fast biological cycle (high breeding and mortality rates).

4.1.2. Total count versus sample count.

- **Total count or census**: a total count aims at recording all individuals present in the whole study area (or survey area) at a given time.

The basic assumption is that all animals are detected and counted once throughout the entire survey area (detection probability for all individuals is 1). Because of various factors (low visibility in the forest, elusive nature of most animals), this method is rarely possible and total counts usually provide smaller estimates than the true population size. Total counts are possible with stationary or slow moving objects (in this section and following, object refers to both animate and inanimate objects – living or dead – depending on the survey target) in habitat offering good visibility. It is important that surveys are not carried out when environmental conditions (weather, time of the day, etc.) may reduce detectability, or when human resources are not fully available.

- **Sample count**: when censuses cannot be carried out throughout the whole study area, a **sample count** is carried out, where animals present in a small area that is representative of the entire population are counted.

The area from where all the samples originate from is called the **sampling area** (Figure A.2). The small areas in which the variables or objects are actually counted are called the **sampling units**. In theory, all objects of interest found within the sampling units need to be counted (total count within the sampling units). Sampling units are generally plots or transects. Plots are of known size and their shape is predetermined (circular, square or rectangular). Transects (or strips) are trails or lines of known length, but often their width is unknown. Strips can be parallel, to avoid overlap. The size of the sampling units will depend on factors such as the amount of time spent making counts, the number of points to be recorded, and terrain conditions. If sample units are too small, the number of objects will be affected by the edge effect. If they are too big, a total count will become difficult to be carried out. If possible, it is best to select units of even size in order to maximize the precision obtained for a given effort. In order to extrapolate the results of the sampling counts to the entire population, we must ensure that data sampling and data collected are representative of the entire population, including threats, habitat types, and topography.

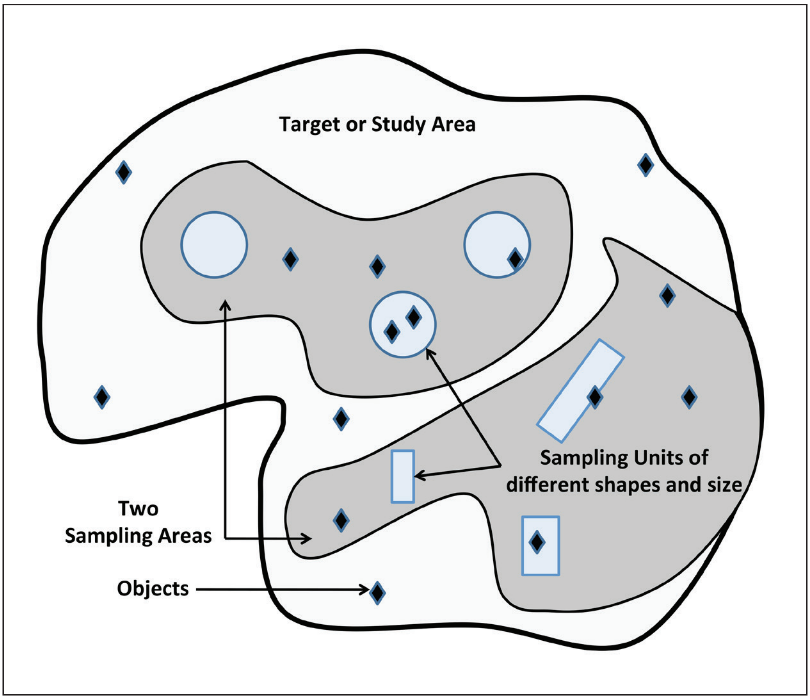


Figure A.2: Drawing of a study areas and sampling units.

- **Accuracy and precision of the samples:**

First, we must determine if the estimate obtained from our sampling count is reliable. Reliability depends on both accuracy and precision:

Accuracy is how close the estimate is to its true value. Better accuracy is obtained by minimizing all possible biases. Accuracy is needed to estimate variables such as population size. Accuracy improves by ensuring that field practices are (i) well suited to the species; (ii) well understood by the surveyors; (iii) carried out correctly.

Precision is related to how similar repeated estimates will be to each other. Precision is necessary to detect trends in a population and therefore this is a crucial indicator for wildlife monitoring. Precision is improved by (i) increasing the sample size (see below) and; (ii) ensuring that sampling units are independent. Precision of results is usually expressed by the 95% Confidence Limits or by the Percentage Relative Precision (see Textbox A.7). For a monitoring program, the target precision level can be decided beforehand; it is expressed by the target Coefficient of Variation (CV). For example, with a target CV of 10%, the monitoring program will detect a change in the population only when the number of animals increases or decreases by 10%. A target CV is needed to determine the appropriate survey effort, based on the results of pilot studies (see Textbox A.8).

Text Box A.7: Confidence Limits of an estimate

$\hat{N}$ is the Population Estimate

CL_1 and CL_2 are the 95% Lower and Upper Confidence Intervals of $\hat{N}$, meaning that the chance that the true population size lies between CL_1 and CL_2 is 95%

PRP or Percentage Relative Precision is the difference between the estimated population size and its 95% confidence limits, expressed as a percentage of the estimate:

$$PRP = \frac{50\,x\,(CL_2 - CL_1)}{\hat{N}}$$

Text Box A.8: Using Pilot studies to determine the length of transects to achieve a target Coefficient of Variation

Monitoring programs are designed to detect trends over spatio-temporal cycles. The ability to detect a trend depends upon the precision of survey estimates. The detection frequency of animals and their signs can be estimated during a pilot study. Pilot studies aim at conducting preliminary field activities (transects, recce walks) in different vegetation types and gradients of human disturbances to determine the frequency of occurrence of animals and their signs. The total number of kilometres covered during the pilot study and the number of objects recorded are put into a simple equation for estimating the number of kilometres required to achieve a target coefficient of variation of the general surveys:

$$L = \left[\frac{b}{\left(CV_t(\hat{D})\right)^2}\right]\left[\frac{L_0}{n_0}\right]$$

With: L = number of kilometres to be walked in the final transect design; CV_t = target coefficient of variation (expressed between 0 for 0% and 1 for 100%); D = estimator of density; L_0 = initial length of transects run during the pilot study; n_0 = number of objects detected during the pilot study; b = 3 in most cases.

- **Are the sampling units representative of the population: randomization and replication.**

Because samples must be representative of the whole population, a correct sampling procedure needs to consider **randomness** and **replication**.

The theory of randomness, **random sampling**, implies that if a sufficient number of sampling units are selected by chance (or at random) within the sampling area, they will be representative of the entire area. If each potential sample unit has an equal chance of being sampled, it is unlikely that any systematic bias will affect the final sample. A practical way to ensure that sampling is random is to allocate a number to all possible sampling units, and to use randomly generated numbers (with *a table of Random Numbers* or the Excel function "RANDBETWEEN" for example) to select the units that will be sampled.

Another sampling method that can be applied is **systematic sampling**. This approach is based on the fact that regular patterns rarely occur in nature. Therefore, it becomes possible to distribute sampling units somehow evenly throughout the survey area and to still produce fairly representative estimates. Other types of sampling strategies exist and are discussed further in more technical literature (see bibliography):

- **Cluster sampling**: a determined set of samples are taken at each random position (clustering can be spatial or temporal). *Advantage*: The relative precision of a cluster is greater than the precision of a single unit;
- **Multi-level sampling**: only certain randomly selected variables are recorded within each cluster;
- **Randomly stratified sampling**: the distance between two successive survey units is kept constant but the location of the first unit is random. *Advantage*: Transects easy to follow and plan (e.g., aerial surveys); cost-effective.

Text Box A.9: The problem of Convenience Sampling.

In practice, data are often collected along roads, trails or close to villages and easily accessible areas. This sampling procedure, called convenience or subjective sampling, causes the data collected to be non-representative of the general population. Convenience data are often used because they are easy to collect: it is easier to walk along a pre-existing trail than cutting a proper line-transect in the forest. It is also easier to locate sampling areas close to the base camp and not at some distance away. **Although these field practices are convenient, they should be rejected at any cost to minimize all source of bias. Sampling should be randomized as much as possible**.

Ideally, all different habitat types present in the general landscape are investigated during a survey. However, some parts of the study area can be difficult or even impossible to access, and therefore must be excluded from the survey area. In this case, it must be understood that the final estimates can only be extrapolated to those strata that have been surveyed, and not to the entire study area. The best approach for reducing biases due to incomplete coverage is to use habitat-based models. These models use ancillary data to extrapolate the results achieved in the survey units to non-surveyed areas.

It is highly unlikely that a single small sampling unit will be representative of the entire population studied. For example, a single sampling unit is unlikely to encompass all types of habitats existing in the study area. The more sampling units are surveyed, the more precise the final estimate: **the more the better**! This process is called **replication**. By replicating the sampling units, the amount of variation that exists between individual sampling units is taken into account and "normalized" (this variation can describe a normal law). As a result, the precision of the final estimate can be measured after it has been extrapolated to the whole study area. The number of units that need to be surveyed is given by the coefficient of variation (or variance) of the estimate. Ideally, this coefficient is kept below 10%. As a rule of thumb, a minimum of 10 to 20 line transects need to be conducted for proper replication.

Finally, a balance needs to be found between what can be recorded in the field, the resources available (no need to design an intensive sampling frame if only a part of it is completed), and what can be analyzed and exploited (no need to collect loads of data if they are left unprocessed in sleeping datasheets).

- **Stratification of the sampling units.**

Abundance and distribution of most animal species is influenced by environmental or human-made variables and they are not randomly distributed across the landscapes. **Stratification** is a method used to separate something complex into distinct categories called *strata*. Stratification is the process by which we identify and separate different strata and we design the sampling strategy in such a way that each stratum is sampled sufficiently well. For example, if the density of species A is assumed to differ between habitat types, it is important to determine density values that are specific to each habitat type, and then to compare them before extrapolating the results to the entire population range. In this case, the variable habitat type is stratified into X different types, and specific densities of species A are estimated for each type. Ideally, variables are stratified before the wildlife studies are undertaken: habitat types (altitude, forest composition, geological features); types of natural events (past fire events, floods); or human disturbances (hunting, logging, proximity to settlements or roads).

Stratification is usually based on knowledge gained during preliminary surveys and literature review. Between 3 and 6 different strata are usually considered for wildlife surveys. If variables impacting wildlife abundance or distribution are identified during the surveys although they were not considered beforehand, the results can be stratified after all surveys are completed (*post-stratification*).

To stratify the data (pre-or post-), data are pooled and distributed according to the different strata considered. Estimates are produced for each stratum. If the results are significantly different between different strata, the data need to be kept separated. If there is no difference between strata, all data can be pooled together.

4.1.3. Accounting for imperfect detectability in the forest.

Traditionally, population density is estimated with sample counts. The major assumption with sample counts is that all objects present in the sampling units are detected and counted once. In other words, the detection rate (number of individuals detected during the survey / true number of individuals present during the survey) is perfect and is equal to 1. However this is very rarely the case in the forest. If some individuals are missed during the survey, the final abundance estimates will be underestimated. The detection rate fluctuates with many different variables:

- **Habitat type**: detecting animals is easier in open habitat (sea, grass land) than in closed forest. For quadrats (squares or circles of known size), the detection width is predetermined and objects detected beyond this width are not considered. For transects, it is necessary to determine the ***Effective Strip Width*** (or area within which all objects are detected);
- **Climatic condition and time of the day**: weather impacts animal behaviour and our ability to detect objects (e.g., some animals are more elusive when the temperature is low, or during season of low-food productivity; it is more difficult to see and hear wildlife when it is raining). A way to minimize these biases, is to repeat surveys at same time of the day and season;
- **Species ecology**: different species will offer different opportunities to be detected. It is essential to know the basic ecology of the species under study;
- **Observer's ability to see animals**: experienced observers will detect more objects than inexperienced or unmotivated people.

In order to correct for imperfect detection of the animals in the forest, correction factors need to be introduced. There are several methods to estimate correction factors, including the double sampling approach, the double observer approach, the determination of the Effective Strip Width (ESW), and the detection probability estimated with occupancy models (see also section 4.5.).

- **<u>The double sampling approach.</u>**

Double-sampling provides an approach that reduces some of the biases inherent in wildlife surveys. First, a rapid assessment is conducted over a large area. Then a subsample of this large area is re-sampled, but with an intensive and more precise survey method. The results from the rapid assessment in this sub-sample are compared with the results of the intensive study to determine adequate **correction factors**. These correction factors are then extrapolated to the results of the rapid surveys of the larger area. Double sampling yields unbiased estimates if the rapid and intensive survey units are selected randomly and if the density estimates obtained from intensive surveys are unbiased.

- **<u>The double-observer approach.</u>**

This approach specifically corrects for observer bias and involves duplicating effort in a portion of the survey to obtain the correction factor. This can be done during the preliminary or the main survey. For example using a total wildlife count, the objects are counted by two different observers. The individual scores are compared to determine how many animals each surveyor failed to detect. This correction factor can then be applied to the larger results of the survey. Double-observer surveys yield more precise and accurate results than surveys conducted by a single observer. The limit of this approach is that it only estimates animals that are detectable. In many cases, there are always a number of individuals in the population that cannot be detected.

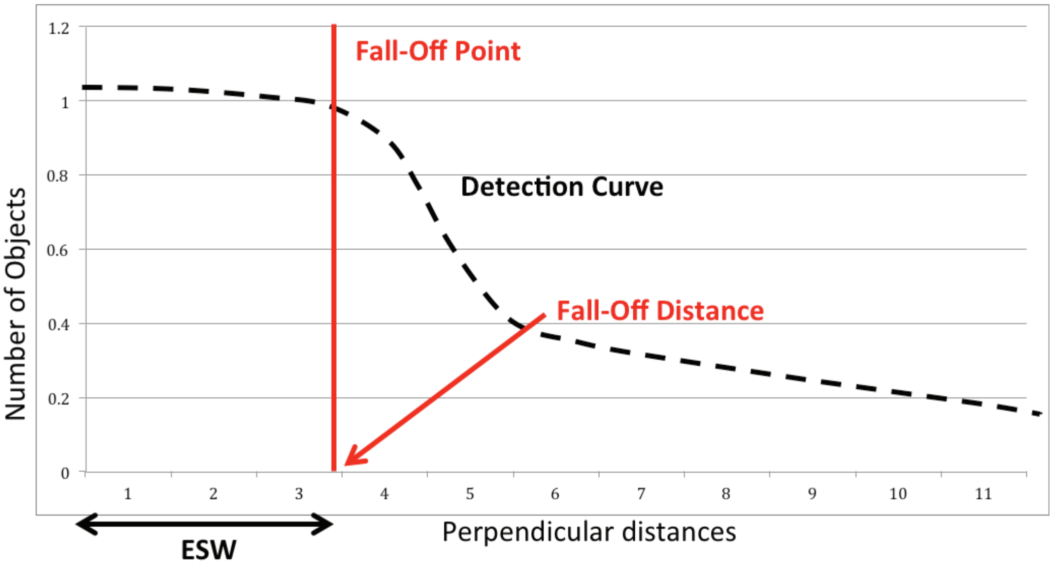
- **<u>The Effective Strip Width (ESW)*.</u>**

In general, the probability of detecting an object decreases as distance from the observer increases. However, detectability varies greatly with forest structure and composition. As a result, the distance that is efficiently surveyed from a transect in the forest fluctuates depending on habitat condition. This uneven detection rate hampers efforts to determine the precise width that is effectively surveyed along a transect and consequently prevents from precise calculation of the sampling unit area.

The **Effective Strip Width** of a line transect is by definition, the width within which the detection probability of the objects is 1 (e.g., all objects present are detected with certainty).

With the standard strip transect analysis (**fixed-width transect**), the ESW is predetermined, and the entire area within this width is searched. In this case, the transect appears as a long thin plot in which all objects that are present are counted. If the width is too wide, some objects will go undetected and the final estimates will be too low; if too narrow, the sample size may be too small for a given survey effort, resulting in a less precise estimate. With this approach, objects that are detected outside of the transect width are not used in the analysis, and many data that are recorded in the field are therefore not used for data analysis.

The **Kelker strip analysis** is a variation of strip transect sampling for which the width is determined after the surveys are completed. When a subject is spotted, its shortest distance to the transect (e.g., perpendicular distance) is measured and recorded as precisely as possible. These distances are then placed into intervals and plotted in a histogram. From



the histogram, a **fall-off-point** or the distance beyond which the number of objects that were detected per distance category declines significantly, is determined visually. This point gives the **fall-off distance** of the sample. This distance is half the value of the ESW since objects plotted in the histogram were detected both sides of the transects.

The Kelker strip transect methodology is straight forward and data analysis does not require sophisticated software, but a simple calculator (see section 4.3.5.). The Kelker analysis is a good proxy for relative and absolute densities, and it is more easily understood and applied compared to more sophisticated analytical methods like Distance sampling (see section 4.3.5.).

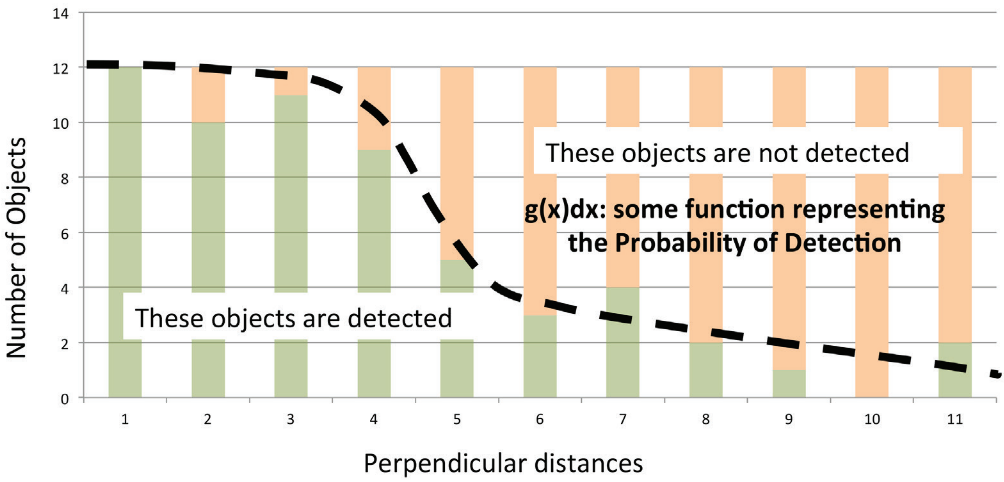
However, determining the fall-off point is subjective and can fluctuate between different analysts, resulting in major discrepancies between analyses. Alternative approaches include the **50% approach** (the cut-off point is the median of the sample size, or the distance at which the number of objects missed within that distance is equal to the number of objects detected beyond this point), or the **modified Kelker approach** (the average distance of a given data set is the fall-off point): see section 4.3.5. for mathematical application.

Regardless of how the fall-off point is determined, all objects that are detected beyond the fall-off distance are discarded from the final analysis; they are beyond the distance for which detection is certain. For small sample sizes, this method tends to give biased abundance estimates because of the associated sampling variation and the difficulty to choose a precise cut-off point.

A major hypothesis with the two previous techniques (strip transect and Kelker analysis) is that a total count is conducted within the sampling unit. Since they are providing absolute results and not estimates, total counts cannot assess the precision and the variance of the data samples. However, inter-transect variability can be estimated by increasing the number of transects. In this way, it becomes possible to infer a variance from the data sets. It should be noted that these variance estimates ignore the uncertainty in estimating the objects-transect distance and often result in low density estimates. In addition, increasing the number of transects requires more field effort.

The **Distance approach** corrects for the imperfect detection of objects in the forest. Indeed, the basic concept of Distance is to estimate the **probability of detection** of the objects based on their distance from the transect; this allows for some objects within the ESW to go undetected. When n objects are detected within ESW, Distance estimates how many objects haven't been detected. Distance sampling commonly uses perpendicular distances to estimate the probability of detection by drawing the **detection function, *g(x)*** that fits the data set the best. The ESW is called ***w***, so that the number of objects detected outside *w* is exactly the same as the number of objects missed inside *w*. The final width of the sampling unit is given by 2 *w* since data were recorded both sides of the transect. In the graph below, the objects that were missed during the surveys are located above the function *g(x)* (orange intervals). Although the true detection of the objects is not known, the detection function *g(x)* estimates a probability of detection $\hat{P}_a$ for an object as the integral of this function divided by w:

$$\hat{P}_a = \frac{\int_o^w \hat{g}(x)dx}{w}$$



To determine the curve g(x) that fits the data set best, Distance analysis uses different models that combine different key functions and series expansions. Using criteria such as robustness, efficiency and shape, the software "Distance" determines the best predictive model for the data set using likelihood and Akaike Information Criteria (AIC).

This software is freely downloadable at http://www.ruwpa.st-and.ac.uk/distance/.

To reduce bias in distance sampling estimates, several assumptions need to be met:

- Objects on the transect are detected with certainty and their probability of detection is 1: $\hat{P}_0 = 1$;
- Objects are detected at their initial location, before they start moving as a response to the presence of human observers. Movements that are independent of observer's presence are not a problem (e.g., foraging behaviour), but the same objects cannot be counted several times on the same line. It is thus extremely important to detect the animals before they sense the presence of the surveyors. Movements away from or towards the line due to observer's presence will result in a bias;
- Surveys are seen as snapshot in time (e.g., the animal movement speed needs to be small compared to the observer's speed and observers need to walk faster than moving animals). Indeed, if new individuals enter into the area being searched during the survey, this leads in density overestimation;
- Perpendicular distances are measured precisely. Grouping the distances in classes can reduce bias (further discussed in Part 2 of the Manual);
- The detection of objects is independent and objects are spatially distributed according to some random process. The lack of independence (for example if objects are clumped in clusters depending on food sources or water holes; etc.) will result in an underestimate of the variance estimate of the density;
- Lines or points that are sampled are randomly located in the survey area or determined using random selection;
- A minimum number of 60 independent distances are necessary to achieve adequate precision of the density estimates.

Distance analysis is more precise and more accurate than the common strip-transect analysis. However, it requires a more intimate knowledge of statistical science (see section 4.3.5.). Table A.2 is a brief presentation of Pros and Cons for the Strip-transect and Distance analysis.

Table A.2: Pros and Cons associated with Strip-transect and Distance analysis.

Strip-transect Analysis (Kelker method)		Distance analysis	
PROS	**CONS**	**PROS**	**CONS**
Easy to use			Requires deeper understanding of statistics
Requires a minimum number of sightings			Requires a minimum of 60 sightings
	Need to conduct a total count	Some objects can go undetected	
	No associated variance	Associated variance	

- **Detection probability estimated with occupancy models.**

Although it is possible to ascertain species presence (also known as occupancy) in an area, it is almost impossible to confirm a species absence using most sampling techniques. Indeed, the lack of detection does not mean that the species is not present. To solve this problem, occupancy modelling enables estimation of distribution, and evaluation of environmental or extraneous influences upon distribution. Occupancy models are based upon detection probabilities rather than absolute information on the presence/absence of a species. Occupancy models consist of two main parameters: detection probability and likelihood/probability of occupancy.

Detection probability is the frequency of detection. More specifically, it is the probability of a species occurring at a site, combined with the probability of actually detecting it when it is present using a given sampling technique (e.g. trapping, observation). Detection probabilities are estimated by taking multiple samples of the occurrence (i.e. detection or non-detection) of a species across a range of sites.

Likelihood of occupancy is the probability of a species occurring at a site, (irrespective of whether or not it is detected). Species occurrence varies depending on environmental factors, (habitat, climatic conditions). These factors affect population density and the amount of time individuals may spend at a site and therefore the likelihood that the species is present at a site during the sampling period. The likelihood of occupancy of a site by a species is therefore a function of the species **detection probability** and any of these extraneous factors. It may also vary over time. By taking repeated and standardized samples of occurrence (i.e. detection or non-detection) at a range of sites, and recording environmental variables at each site (habitat, landscape attributes, climatic conditions, presence of other species), the relative influence of specific environmental factors upon likelihood of occupancy and abundance can be estimated.

4.2. Size of a population: density and abundance.

The most sophisticated measure for wildlife monitoring is the abundance of a given species in a given location. Absolute abundance is expressed by **Population Density and Total Population Size.**

Population density is the number of individuals of a given species per unit area. Density is usually expressed per km^2 or per ha:

$$DENSITY = \frac{(Number\ of\ Objects)}{(Unit\ Area)}$$

$D=\frac{N}{A}$ or $N=D\times A$; with N the total number of animals and A the area size

Sample counts assume that the sample units are representative of the general population. In other words, that the density estimated in the samples is similar to the density of the general population throughout its entire range. In this case, we can write:

$$D=d; \text{ or } \frac{N}{A}=\frac{n}{a} \text{ or } N=\frac{n\,x\,A}{a}$$

With the following unknown entities: N, the total number of animals
D, the density of the general population
And the following known entities: A, the size of the population range
a, the size of the sampling unit
d, the density calculated in the sample unit

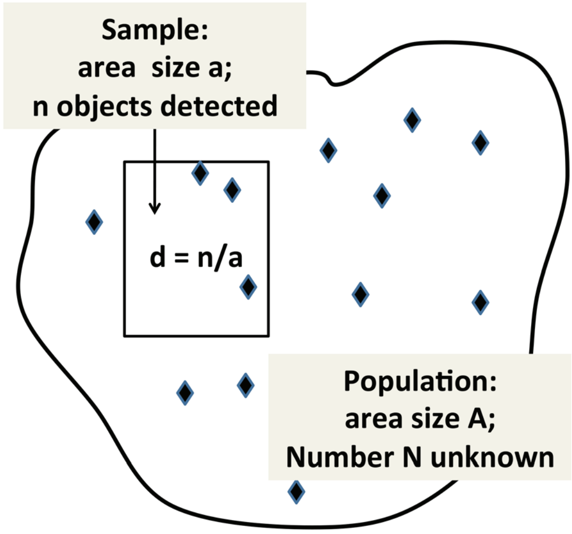


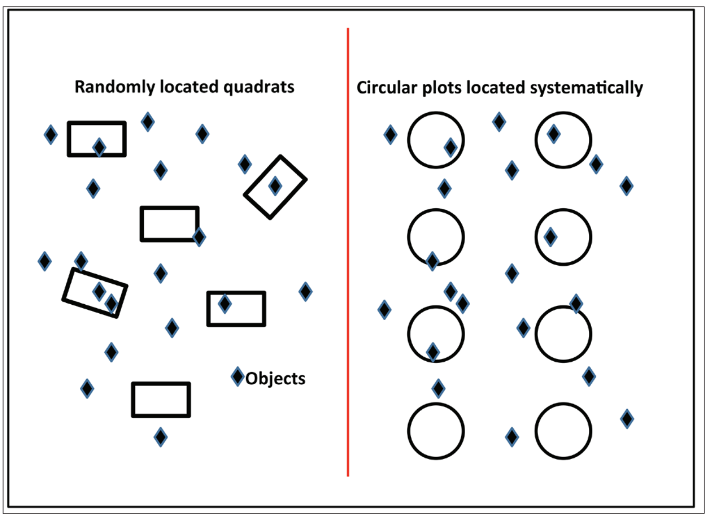
Figure A.3: Population size and density

4.3. Estimating density with different types of sampling units.

Different ways to organize sampling efforts are available to estimate animal abundance. A brief description of the most frequently used sampling methods relevant to Sabah's forests is presented below.

4.3.1. Quadrats and fixed points.

Quadrats (rectangles or squares of known length and width) and **fixed points** (circles of known radius) are small sample areas within which objects detection is assumed to be perfect (all animals present are detected and counted). They are thus assimilated to censuses (total counts) conducted in small sample areas of predetermined and known size. The plots can be randomly located or systematically stratified (see diagram). A sufficient number of these plots can provide population abundance estimates.



These methods are generally used for estimating abundance of non-moving objects such as trees and plants, orang-utan nests, and subjects with small home range that are easy to count within the plots. Although they require significant manpower, these techniques can also be used to count animals with the risk that they flee at the start of the survey.

Long-term monitoring for a few key animal species can be achieved at fixed sites by using repeated counts within quadrats and fixed points. To maximize encounter rates, quadrats can be established in areas where animals can be easily observed like saltlicks for tembadaus, valleys for gibbons, resting and roosting sites for birds (waterfowl). The boundaries of the plots are measured and marked precisely in the forest and on the maps used for monitoring.

Source of bias:

Some objects go undetected;

The surface area of the sampling units is not precisely measured.

Data analysis:

For quadrats, density in the survey units, D, is obtained with:

$$D = \frac{\sum_{i=1}^{n}(a_1 + a_2 + \ldots + a_i)}{\sum_{i=1}^{n}[(w_1 \times l_1) + (w_2 \times l_2) + \ldots + (w_i \times l_i)]}$$

a being the number of objects in each sampling unit, w and l the respective width and length of each sampling unit. For fixed points, we use the same formula but the survey area for each sampling unit is obtained with: $a_i = \pi r_i^2$

4.3.2. Sweep censuses and their variants.

These techniques aim at detecting the animals found in a survey area of known size irrespective of their location. These techniques involve the participation of several teams surveying at the same time in order to maximize the chance of detecting fleeing animals.

- **Sweep census**: in a sweep census, a line of observers moves in the same direction to record all objects during their progression. Observers follow pre-established lines that are closely interspaced to minimize the probability that objects will remain undetected: Figure A.4. The different teams move at the same speed to ensure uniform progress of the line.
- **Block counts**: a variation of the sweep survey, block counts do not require observers to follow a line. The study area is divided into several smaller units **(blocks)**. The location and size of all the units are determined based on the topography and the detectability of the animals (from 10 ha in close habitat to 100 ha for open landscape). Each team must have knowledge of the precise location of the block they are assigned to. The different teams start surveying their respective block at the same time. They record the precise time and location of every sighting to reduce the probability of double or multiple counts of animals moving through several blocks.
- **Drive census**: in a drive census, the observers position themselves in line at a location where they have a good view of the area: they create an **observation line** (at the top of a cliff, along a road). Each observer has to be in sight of his adjacent team member not to miss animals passing across the observation line. When the line of observers is in place,

beaters enter the area from the opposite direction and drive wildlife present towards the line of observers.

<u>Source of bias</u>:

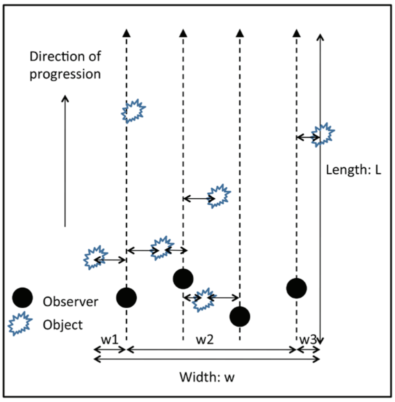
Poor detection of animals or double-counted animals - make sure that all information such as number of animals, time of sighting, direction of the animals are recorded to discard any overlapping sighting that would be recorded by two different teams;
Weather conditions affecting detectability - if it begins to rain, interrupt the survey until the end of the shower. If the rain lasts more than 30 minutes, stop the data collection and postpone the survey.

<u>Data analysis</u>:

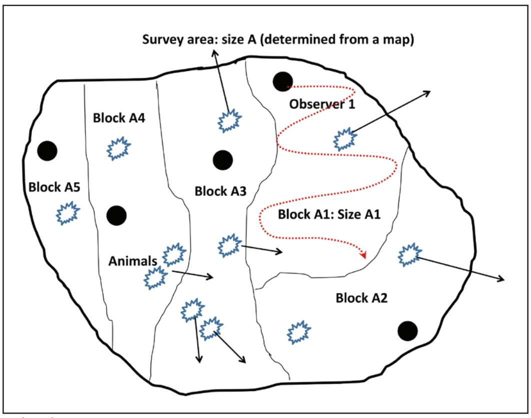
In all approaches, the final density estimate is obtained with:

$$D_{Objects} = \frac{Number_{Objects}}{A}$$

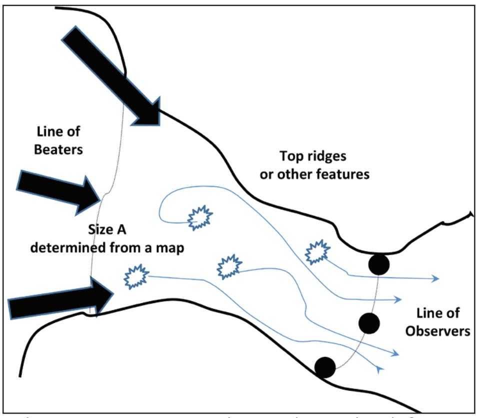
$Number_{Objects}$ is the total number of objects recorded by the different teams of observers (be careful to take into consideration double and triple counts!) and A, the size of the surveyed area: see Figure A.4.



Sweep survey: $A= L\,w$, *with* $w=w1+w2+w3$



Block Count: A=A1+A2+A3+A4+A5



Drive census: survey size A determined from a topographical map

Figure A.4: Diagrams showing sweep survey, block count and drive census techniques.

4.3.3. River surveys to determine the abundance of proboscis monkeys.

Riparian forests offer shelter and food resources to wildlife, and attract many mammals, birds and other animals. Rivers navigable by boats provide an easy way to assess and to monitor wildlife presence in an area. Although river surveys generally provide indexes for most wildlife species (see chapter 5), they can be used to approximate absolute densities of proboscis monkeys.

Several studies have shown that proboscis monkeys spend most of their nights in trees above rivers and small tributaries, and that they rarely travel more than 500 m inland from the edge of the river where they sleep at night. Because of large fluctuations of the distribution of the groups along the river according to seasons, river surveys to monitor proboscis monkeys should be undertaken regularly (e.g., every one or two months) for a minimum of 3 successive days each time.

Source of biases:

Some groups go undetected;
Average number of individuals per groups is not known precisely;
The animals move more than 500 m within the forest.

Data analysis:

The density of Proboscis monkeys or $\hat{D}_{proboscis\_groups}$ can be approximated by using the formula:

$$\hat{D}_{proboscis\_groups} = \frac{N_{proboscis\_groups}}{2 \times d \times L}$$

With *d* the average distance travelled by a group from the river (in this case d=500 m), L the total length of the stretch of river being monitored, and N the number of groups identified during the survey. The denominator is multiplied by 2 because there is a detection zone on each side of the river. The final density of proboscis monkeys can be determined if the average group size is known for the sampling area. Inter-month and inter-year indexes (or densities) are compared to assess population trends through time. If the average group size of proboscis monkeys found in a given area is known, this group density can be extrapolated to a density of individuals.

4.3.4. Rapid surveys of gibbons using territorial calls.

Call surveys are generally used for territorial songbird species, and large bird species such as great argus pheasant and hornbills. But they can also be used for rapid assessments (presence/absence) and for estimating relative or absolute density estimates of gibbon populations.

Depending on human resources available, two or three **listening posts** are located on a map, and then identified in the field the day before the survey starts. The location of these permanent listening posts depends on site accessibility and topographical features (in general, higher locations such as hill tops provide better results). These posts should be separated by about 150 m and their precise location marked with a stick. Gibbon surveys are conducted in the morning, between 06:00 h and 08:00 h. For each call heard from the listening posts, the team records the compass bearing of the call, estimates the distance to the calling group (one of four classes: close, medium, far, or very far), and notes the time at which each long call begins and ends. Ancillary information includes altitude, weather condition, habitat type and signs of habitat exploitation. A minimum of three morning surveys are needed at each site to yield some precision.

<u>**Source of biases:**</u>

Lack of observer experience leading to species misidentification (calls of gibbons are sometimes confused with calls from great argus or hornbills);

Varying detectability of calls due to maximum audible distance which depends on topography, type of forest and weather conditions;

Misidentification of direction of calls due to echos;

Inter and intra population differences in calling behavior which may change based on weather conditions (rain and fog tend to lower call frequency), human disturbances (presence of hunting also tend to lower call frequency), habitat types, days and seasons.

<u>**Data analysis**</u>**:**

For each survey, the teams plot the different groups that have been heard calling on a map. Gibbons sometimes move short distances while calling, so it is assumed that calls plotted to be less than 500 m apart originated from a single group. An index of groups heard per day can be obtained, and averaged over the successive survey sessions (with *G* the number of groups heard every day and n the number of days surveys are conducted):

$$Index_{Groups\ Calling\ per\ Day} = \frac{\sum_{i=1}^{n} G_{Day\ i}}{n_{Days}}$$

It is possible to derive group density of gibbons if the survey area is assumed to be a circle centered on the middle point between the two or three listening posts. In Kinabatangan, the maximum average distance for hearing a gibbon call on flat terrain is approximately 800 m. A proxy value of r = 800 m can thus be used for a rapid gibbon density assessment in case it is not possible to determine the size of the survey area more precisely. In this case, the size of the survey area A is: $A=\pi r^2$. Group density is obtained with:

$$\hat{D}_{group\_calling} = \frac{Number_{groups}}{A \times p}$$

For this type of analysis, the number of groups represents only the number of calls that were heard and identified from a minimum of 2 posts; p is the proportion of groups calling every morning. This proportion fluctuates every day depending on weather conditions and other variables. We recommend to use a p proxy value of 0.8, which is the average value determined for the Bornean gibbon in Kalimantan.

4.3.5. Line Transects: data analysis.

Because line transects are one of the most common techniques used for wildlife studies, they deserve a special attention in this Manual. **It is important to stress out that although line-transects remain an important and efficient way to survey wildlife in tropical forests, they are time-consuming and require significant human and financial resources**.

Line transects are straight lines cut in the forest that follow a pre-determined compass bearing. Line transects are used to count direct sightings of animals or the signs of their presence (nests, dung, footprints). Transects should be perpendicular to roads and other major topographical features (large rivers, hills, roads), lying parallel to the hypothetical distribution of most wildlife species. Such a pattern will reduce between-transect variation. The length should ideally be a minimum of 2 km to account for the uneven distribution of food resources in the forest and resulting clumped spatial distribution of wildlife.

Line transects can be used for a one-time assessment (this technique is also called **standing crop method**). Transects can also be marked permanently in the forest for repeated counts and monitoring. The data collection method is very similar in both cases, the major difference being the frequency at which the transects are run.

For each object detected from the transect, the shortest (or perpendicular) distance between the object and the transect is carefully measured with a tape-measure or a range finder. Perpendicular distances are preferred, as recent studies have found the results produced by the use of radial distances between observers and objects (**Animal Observer Distance**, also called **King method**) imprecise.

<u>Source of biases</u>*:*

Location of the transects in the forest is not randomized and the transects are not representative of the entire survey area (due to convenience sampling or else);
Transects are too short or too few;
Transects are not straight;
Perpendicular distances are not recorded precisely;
Species or objects are not identified precisely;
Some objects located above the transects are not detected;
Animals flee before they are detected (due to noisy observers or else).

<u>Data analysis</u>*:*

Strip-transect or Kelker analysis (see section 4.1.3.)

i. Called the **exploratory phase**, an initial set of data containing perpendicular distances is examined to identify the possible presence of **outliers** (e.g., distances that are further away from the transect than the majority of data points). Differences of detectability in the forest (by example presence of logging roads and open areas) cause some objects to be visible to the observers at distances that are usually not investigated. Outliers are identified in this exploratory phase, by building boxplots of perpendicular distances (statistically, they are values more than 1.5 box-lengths from the 75th percentile). These outliers are then discarded from the data set by setting up a proper truncation level (e.g., perpendicular distance above which an objects is considered as outlier). Up to ten percent of the data can be discarded and removed from the data set as outliers.

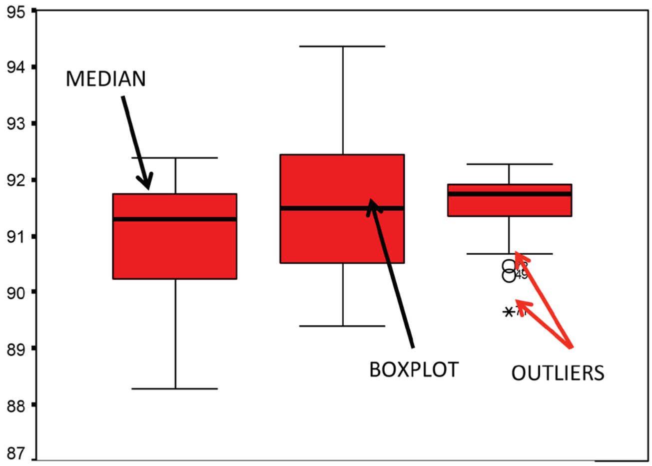


Figure A.5: Statistical boxplot.

ii. The remaining distances (objects to transect) are averaged to obtain the *Effective Strip Width* (ESW or w). ESW is half of the width of the band of forest surveyed since objects are recorded on both sides of the transect. The size of the sample area (A) is then obtained using the following equation:

$$A = 2\ L\ w$$

with ***L*** being the horizontal length of the transect (from the measure of distance walked) and w being the ESW.

iii. All objects for which the perpendicular distance is larger than ESW are discarded from the data set and the final number of nests ($N_{Objects<ESW}$) with a perpendicular distance less than or equal to ESW is counted. The final object density is obtained with:

$$D_{Objects} = \frac{N_{Objects<ESW}}{2 \times L \times w}$$

with ($N_{Objects<ESW}$) the number of object for which the perpendicular distance is inferior or equal to w, *w* the ESW, *L* the length of the transect(s).

Distance analysis (see section 4.1.3.)

With this approach, data are analysed following line-transect analysis theory outlined by Buckland.

i. In the exploratory phase, outliers are identified and discarded as above.
ii. A histogram of perpendicular distances is then built and the presence of **heaping** (e.g., over representation of some distance classes) is examined. Data are grouped in various distance classes as seen appropriate.

iii. The probability of detection is established with the software "Distance". This software uses seven models that combine probability density functions (uniform, half-normal and hazard-rate) with adjustments (cosines, simple and hermite polynomials). The model with the lowest Akaike's Information Criterion (AIC) is selected, therefore ensuring a balance between model complexity and ability to describe the data. The adequacy of the selected model to the perpendicular distance is assessed by means of a chi-square goodness-of-fit test on grouped data. The final Density estimate is obtained with:

$$\hat{D} = \frac{\hat{n}}{(2wL) \text{ x } \hat{P}_a}$$

With $\hat{n}$ the estimated number of objects within the survey area, *w* the ESW, *L* the length of the transect(s) and $\hat{P}_a$ the detection probability in the sampling unit area.

iv. Finally, an estimate on the variance of objects density using non-parametric bootstrap is done in order to handle the model selection uncertainty and other sources of variation. It is beyond the scope of this Manual to detail the entire Distance analysis process: the methodology to be used is explained thoroughly in several other articles (see references) and at http://www.ruwpa.st-and.ac.uk/distance/.

4.3.6. Line transects: major applications.

Despite its limitations, line transects remain one of the most commonly used techniques in tropical wildlife studies. In Sabah, they are regularly used for orang-utan nest counts, dung counts, and mammal community surveys.

- **Orang-utan nests.**

Because they are elusive and occur at relatively low density, encounters with wild orang-utans in the forest remain rare events. Therefore, it is extremely difficult to use direct animal sightings to estimate population abundance for this species.

However, orang-utans build nests in which they sleep at night or sometimes rest during the day. Nests can remain visible for several weeks or months after they are built and therefore are encountered at much higher rates than individuals themselves. Orang-utan nest counts produce a large number of data points during surveys and correspondingly better precision, assuming that the variables used to calculate density (nest production rate, decay rate) are also estimated with reasonable precision. Furthermore, nests are immobile, making the determination of perpendicular distances much easier compared to detection of the apes themselves. Special attention needs to be made not to confuse nests built by other species for ape nests such as giant squirrels, sun bears or some bird species (adjutant storks, raptors).

Orang-utan nest counts can be done only once for assessments (**standing crop nest count**) or at regular intervals from permanent transects for monitoring a population (**marked nest count**). The premise of the marked nest method is that all existing nests along transects are marked and subsequent surveys repeated at short enough intervals so as to record all nests constructed since the last passage. An important assumption of this method is that ape nests constructed after one transect is run do not fully decompose before the next survey. This would result in an underestimation of ape density. An interval of six to eight weeks is used to survey orang-utan nests in Sabah.

Both methods require conversion factors to convert nest counts to ape abundance. The **standing crop method** requires an estimate of the proportion of nest builders, nest construction rate and nest decay rate. The orang-utan density $\hat{D}_{ou}$ is estimated by using the following equation:

$$\hat{D}_{ou} = \frac{\hat{D}_{all\_nest}}{\hat{p} \times \hat{r} \times \hat{t}}$$

with $\hat{D}_{all\_nest}$ the nest density estimated in the considered area, $\hat{p}$ the proportion of nest-builders, $\hat{t}$ the nest decay rate and $\hat{r}$ the daily-rate of nest production.

The proportion of nest builders $\hat{p}$ has been estimated as 0.9 for orang-utans in Borneo and seems to show only minor variation between populations.

The daily rate of nest production $\hat{r}$ is currently available for only two Bornean orang-utan populations: 1.005 in Kinabatangan and 1.163 in Gunung Palung (Kalimantan). To account for inter-population variability in orang-utan nesting behavior and to obtain more conservative estimates of orang-utan densities, it is suggested that an average value of 1.084 is used, with an associated coefficient of variation (CV) of 0.063 and standard error (SE) of 0.079.

The nest decay rate $\hat{t}$ varies with forest type, altitude, nesting tree species and several other biological parameters. Because of large variations associated with this parameter, nest decay rate is responsible for the major part of imprecision related to ape density estimates. The most reliable estimates for nest decay rate are obtained via direct monitoring of the survival of a sufficient number of nests. This estimate requires spotting a sufficient number of new nests and checking on them from the day they are created until they are no longer visible. Recent work carried out in Sabah showed that within a similar habitat type, the tree species used for nest construction was the major significant habitat-related parameter for nest decay rate. Since tree specific composition changes with study area, mean decay rates that are estimated at a given location cannot simply be extrapolated to other sites.

A weighted general $\hat{t}$ value could then be calculated for each site using $\hat{t} = q\hat{f}$ with the $\hat{f}$ estimated time of nest visibility for different groups of trees and *q* the proportion of nesting trees from each group recorded during the field. The following taxa-specific nest decay rates are available from studies in Lower Kinabatangan:

Dimocarpus:	385 days	SD=193 days
Dipterocarpaceae:	205 days	SD=119 days
Eusideroxylon:	476 days	SD=140 days
Myrtaceae:	128 days	SD=99 days
Rubiaceae:	143 days	SD=60 days
Sterculiaceae:	135 days	SD=44 days
Other taxa:	151 days	SD=101 days

In contrast to variables required by the standing crop method, the **marked nest count** merely requires an estimate of proportion of nest builders and nest construction rate. Indeed, during a marked nest count survey, transects are walked repeatedly and only nests constructed between two transect visits are counted. Since the time elapsed between two successive transect visits is known precisely, nest density can be translated into ape density without any nest decay rate, as long as the interval is sufficiently short to assume that no nests have disappeared (completely decomposed) during the interval. However, recently built nests will be encountered at a very low rate unless ape density in the area is high. Therefore much more effort is required to yield a nest encounter rate and precision comparable to standing crop nest counts.

During repeated counts along permanent line transects, only nests that have been created between two successive counts are considered. In this case, $\hat{D}_{ou}$ is obtained using the following equation:

$$\hat{D}_{ou} = \frac{\hat{D}_{recent\_nest}}{\hat{p} \times \hat{r} \times \hat{d}}$$

$\hat{D}_{recent\_nest}$ the estimated density of nests created between two successive counts, $\hat{r}$ the estimated daily rate of nest production per day per individual, $\hat{p}$ the proportion of nests builders, and $\hat{d}$ the inter-visit interval (time between surveys).

<u>Source of bias</u>:

Poor placement of the lines: results in inaccurate and imprecise final results;

Inexperienced observers: inexperienced surveyors miss up to 40% of nests that would be detected by skilled surveyors. A double-observer count allows for calibrating this bias;

Inconsistency of nest detection: depends on the age-class of the nests (fresh green nests and very old nests with no leaves are difficult to spot in the forest), the distance to the transect, height in the canopy, weather and light conditions, among others; Poor nest detection results in inaccurate density estimates;

Inexact measurements of the perpendicular distances results in imprecise density estimates and heaping.

- **Dung count.**

Dung count is the standard method to estimate elephant population size in tropical forests. Well-marked and narrow permanent transects are ideal for this type of survey. The final animal density can be obtained from dung density by using the following formula:

$$\hat{D}_{Animals} = \frac{\hat{D}_{Dungs}}{\hat{t} \times \hat{r}}$$

with $\hat{t}$ the dung decay rate and $\hat{r}$ the daily creation rate of dung (or the number of defecation events per 24 hours).

Source of bias:

Poor placement of lines;
Poor detection of dung;
Inexact measurements of perpendicular distances.

- **Mammal community surveys.**

Although looking for animals is often more difficult than looking for their signs of presence, line transects can be used for detecting animals as well. With enough sightings, it becomes possible to estimate abundance of taxa such as primates, deers, squirrels, several bird species, butterflies and other invertebrates. For rare or cryptic species, the number of observations is generally too low to estimate abundance. In this case, a semi-quantitative index of abundance can be derived from the linear encounter rate, or the number of groups detected per km of walk (e.g., total number of observations divided by the total number of kilometers walked during the transects).

For solitary species, data entries are individual sightings of animals.

Social species occur in **groups**, or aggregations of individuals at a given moment in time. If groups are counted during surveys, group density is converted into individual density, weighted by mean group size. Where possible, the group size should be obtained during the survey itself. Group size can also be estimated in an intensive study area or from the literature, but this may introduce additional biases since group size fluctuates according to various factors such as habitat type, time of the day, season, and behavior.

$$\hat{D}_{individuals} = \frac{\hat{D}_{Groups}}{\hat{N}_{individuals/group}}$$

For traditional line transect sampling, the point of measurement of the group is the group center, but this requires good visibility and tight group, or species occurring in small-size groups. When it is not possible to detect all individuals in the group, the distance of the closest and the furthest individuals from the transect are recorded to determine an average group center. When the entire group cannot be observed, data for the sub-group that is visible can be utilized. Another alternative is to record the distance to the first or to the nearest individual that is detected, and then to add the average spread of the group to this distance in order to obtain the center of the group. However, this approach is known to produce inflated density estimates. It is important to assess the average group spread independently of the surveys, assuming that the spread of the group is approximately circular and constant (which is often not the case). Ideally, the spread should be measured before human disturbance, which is almost impossible with non-habituated groups. If group size and location cannot be determined with accuracy, recording and measuring the distance of each detected animal as independent observation can also produce good density estimates.

Source of bias:

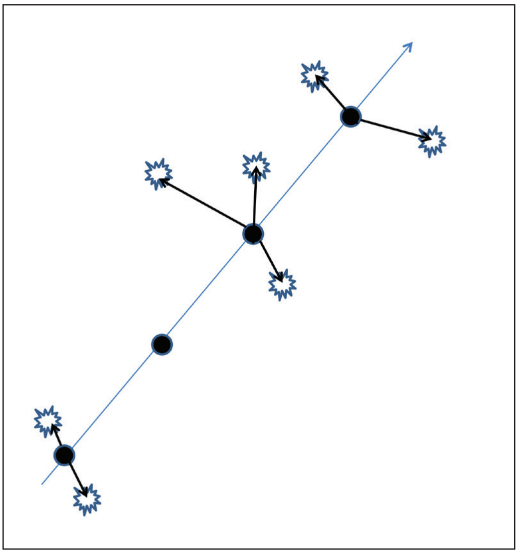
Poor placement of lines;
Poor detection of animals or detection after the animals start moving;
Inexact measurements of perpendicular distances (especially for social species living in groups);

Unfavourable weather conditions: rain affects animal behaviour and the probability of detecting animals because of the noise of dripping water. If rain starts falling, interrupt the survey until the end of the shower. When rain is lasting more than 30 minutes, stop the data collection and postpone the survey;

Species misidentification.

4.3.7. Point counts or point-transects.

This method, also called **cue counting**, is a modified type of line-transect in which the length of the transect is zero. Observations are made from points located along and at the center line of the transect. Data collection and data analysis are the same as conducted in line transects. This method is mostly used for estimating presence/absence and abundance of song birds or frogs. But this method can also be used to survey social species such as primates.



The grid of points doesn't need necessarily to be located randomly in the forest. The team spends a pre-determined and fixed amount of time at each listening/observation post and records the number of calls or sightings during this time, as well as the approximate distance.

Source of bias:

Imprecise estimates of call/sighting distance and species;

Imprecise estimates of the cue rate (see analysis below);

Disturbance created by the observers before reaching the sampling points.

Data analysis:

The cue rate (number of calls per animal per unit of time) is estimated during the survey to derive final animal density estimates from call density estimates.

$$\hat{D} = \frac{\sum_{i=1}^{n} (PD_{Recorded\ Objects})_i}{\hat{c}\ \sum (Number\ of\ Points)}$$

$PD_{Recorded\ Objects}$ being the perpendicular distance of all objects detected during the survey; $\hat{c}$ the estimated cue rate and the Number of Points being the total number of stations surveyed.

4.3.8. Aerial surveys for orang-utan nests.

Aerial surveys provide a fast and efficient way to assess orang-utan population distribution and abundance in Sabah. They are currently used to monitor trends of several key populations in the state such as Lower Kinabatangan, Malua Forest Reserve and Deramakot Forest Reserve.

A precise grid of parallel transects is selected on a 1:50.000 map or using Google map of the target area. Transects are interspaced with a constant interval ranging from 3 to 20 km, depending on the size of the survey area and on financial resources. Transects generally run perpendicular to major rivers and hills found in the area. The location of the first transect is randomly selected. The same transects are run every year or every few years for monitoring purposes.

In Sabah, aerial surveys are carried out with a small helicopter type Bell 206 Jet Ranger. The helicopter speed and height are kept constant at respectively about 70 km/hour and 60-80 meters above the forest canopy. The team consists of four people in addition to the pilot. The co-pilot is seated in front of the aircraft and collects information about habitat types, signs of wildlife presence and human activities. The co-pilot also checks the flight pattern by recording the precise location of the aircraft using a GPS handheld unit (use of the Tracklog function in continuous and *Waypoint* function every 30 seconds). All visible nests from either side of the helicopter are recorded by two rear observers. The two observers indicate all sightings to a nest recorder seated between them. The nest recorder notes the number of nests detected by the observers per each 30-second interval. All crew members are in constant radio-contact during the flights.

Source of bias:

Differences in observer detection skills: to decrease this important source of bias, it is ideal that the same team of properly trained and skilled observers conduct repeated surveys (the co-pilot and the nest recorder are replaceable);

Fluctuation in nests detectability due to habitat type: nests detectability fluctuates according to the degree of canopy openness/closure. It is easier to detect nests when the forest canopy is not contiguous (highly degraded forest; swamp forests) and more difficult when the canopy is closed (primary or selectively logged forest). The extent of these biases is assessed following ground-truthing surveys. The following parameters are considered by the co-pilot during aerial surveys (Table A.3):

Table A.3: Variables used to categorize habitat during aerial surveys of orang-utan nests

	Logging signs	Canopy	Trees	Emergents	Nest visibility
Highly degraded forest	+++	Open (ground is visible)	Very Few	None	+++
Degraded forest	++	Semi-open (ground is visible most of the time)	Few	Few	++
Selectively logged or primary forest	0 to + (old)	Semi-closed to closed (ground barely visible)	Many	Many	+
Macaranga infested forest	+ to ++	Semi-closed	Many	None	++
Active logging	+++	Open	Very few	None	+++

Unfavorable weather conditions: when rain, fog or clouds make nest detection difficult, the survey must be stopped;
Piloting skills - the pilot must follow the pre-established pattern of transects and attempt to maintain constant helicopter speed and height.

Data analysis:
The ratio between the numbers of nests detected by each observer per period of 30 seconds gives the *linear aerial indexes* (AI_O) of orang-utan nests (number of nests/km) for both sides of the aircraft.

These left AI_{left} and right AI_{right} aerial indexes are compared to test for possible observer differences. If there is no difference, all the data can be pooled together. In this case, the general aerial index AI_O is:

$$AI_0 = \frac{AL_{\ left} + AI_{right}}{2}$$

If there is a statistically significant difference between the two observers, the two data sets are processed and analyzed separately.

The post-survey stratification is done by calculating the ratio between the length of aerial transects and the length flown over each stratum identified on the map or during the flight (e.g., habitat types, forest condition, altitude). At this stage, it is important to discard from the data set the segments of flight that were flown over unsuitable orang-utan habitats (e.g., rivers, large open areas, plantations). For each variable or stratum, data are pooled together and specific AI_O are calculated and compared. Finally, data can be pooled together for those variables that fail to show any statistical significant difference.

Following the post stratification analysis, we then estimate an orang-utan nest density from the Aerial Indexes by using the formula:

$$\hat{D}_0 = \exp[4.7297 + 0.9796 \log(AI_0)]$$

$\hat{D}_0$ being the estimated orang-utan nest density and AI_O the general aerial index. We can determine a final confidence interval for the predicted orang-utan nest densities as:

$$\frac{\hat{D}_0}{C};\hat{D}_0 \text{x}\, C$$

Where $C = \exp(0.6067 \text{ x} \sqrt{1 + v^*})$
and $v^* = 0.1908 – 0.2628 \text{x} \log(AI_0) + 0.1132[\log(AI_0)]^2$

The final orang-utan density is obtained by using the formula:

$$\hat{D}_{ou} = \frac{\hat{D}_0}{\hat{p} x \hat{r} x \hat{t}}$$

With: $\hat{D}_0$ nest density estimated in the considered area, $\hat{p}$ the proportion of nest-builders, $\hat{t}$ the nest decay rate, and $\hat{r}$ the daily-rate of nest production.

As discussed in subsection 4.3.6, the proportion of nest builders has been estimated as 0.9. An average rate of daily next production of 1.084 is used with an associated coefficient of variation of 0.063 and SE of 0.079. It is impossible to record nesting tree species during aerial surveys. As a result, a proxy value of $\hat{t}$ = 286.3 days (Coefficient of Variation = 0.373) can be used. This value was previously determined by the KOCP in 2003 for aerial surveys undertaken throughout Sabah. As long as specific decay rates are not available for the surveyed areas, this value is recommended for standardization and future comparisons of the results.

A 95% Confident Interval for the orang-utan density is estimated using the delta method with:

$$\frac{\hat{D}_0}{K}; \hat{D}_0 x K$$

$$K = \exp(2.0796[0.086(1 + v^*) + 0.143]^{1/2}$$

$$v^* = 0.1908 - 0.2628 x \log(AI_0) + 0.1132[\log(AI_0)]^2$$

4.4. Estimating density by using capture-recapture methods.

The ideal scenario for wildlife monitoring would be to detect all animals and recognize all individuals that are counted, so as not to count the same individual several times. For species with unique features such as spots or stripes, or if animals are marked artificially, abundance can be assessed with capture-recapture models.

Under the capture-recapture approach, a sub-sample of a population is caught, marked, and released (n_1 individuals). Another round of capture is conducted at a future date, where n_2 individuals are caught. The general assumption is that the proportion of animals already possessing marks at the second capture (e.g., recaptured animals from the first sampling event) represents the proportion of marked animals in the entire population:

$$\frac{m_2}{n_2} = \frac{n_1}{N} \text{ or } N = \frac{n_1 x n_2}{m_2}$$

With *N*, the total number of animals in the population; n_1 the number of animals first marked and released; n_2 the number of animals caught during the second capture; m_2 the number of animals marked in the second sample.

Capture-recapture methods assume that all animals have the same probability to be trapped. They also assume that marked animals possess an equal probability to be captured during successive captures. In other words, mortality and behaviour of marked individual are not affected by the capture event.

Text Box A.10: the two-sample method, or Lincoln – Petersen Index.

The most basic method involves only one recapture session. It was used in the 18th century by Laplace to estimate the human population size in France. This method is a quick way to obtain a rough estimate, but this applies only to closed populations.

With: n_1, number of animals marked and released on the first capture
n_2, total number caught during the second capture
m_2, number of marked animals caught during the second capture

$$\hat{N} = \left[\frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)}\right] - 1$$

The Standard Error of the sample is given with:

$$SE = \sqrt{\frac{n_1^2(n_2 + 1)(n_2 - m_2)}{(m_2 + 1)^2(m_2 + 2)}}$$

More sophisticated methods and softwares have been developed for capture-recapture analysis, including MARK and CAPTURE. Although these methods appear strong and reliable, they can still produce imprecise estimates with rare and wide-ranging species (large carnivores, elephants, rhinoceros) even with a high (and therefore costly) sampling effort.

If the population is open, marked animals can emigrate or die, preventing resampling in successive captures. In this case, a minimum of three capture events are needed to estimate the population size using more complex statistical models such as the Jolly-Seber method.

4.4.1. Invasive capture techniques.

Various traps can be used to physically capture animals:

- **Pitfall traps** (buckets, boxes): amphibians, reptiles, insectivores, rodents;
- **Sherman and cage traps**: rodents, small carnivores;
- **Mole traps**: insectivores;
- **Mist nests and harp traps**: bats, birds.

Following capture, animals are physically restrained and often anesthetized before being measured, weighted and marked using methods such as toe clippings, tagging, hair cutting, and collaring. However handling and anesthetizing small vertebrates is always a stressful procedure for the animal and should be done with caution by experienced and trained handlers.

4.4.2. Non-invasive capture techniques.

Hair and faeces can be collected in the field during repeated events. Individual identification of each sample via DNA analysis makes the data set suitable for capture-recapture analysis.

Other non-invasive methods include camera-trapping. When the presence of stripes or marks makes possible individual identification, the capture-recapture analysis can be used for abundance estimates. Extensive information about camera-trapping in Sabah can be found in the Manual recently produced by Sabah Parks and BBEC II, and available free of charge (Ancrenaz *et al*., 2012).

Animals can move beyond the area that is actually sampled either naturally or as a response to the presence of observers. These movements are a major issue to estimate wildlife abundance; this bias can be addressed by using spatial capture-recapture models. These models incorporate spatial information of captures to estimate animal movement both within and beyond the sampling area.

4.5. Estimating abundance and distribution using occupancy models (*section written by Dr. Jedediah Brodie*).

4.5.1. Introduction to occupancy models.

The various distance sampling methods outlined above, such as line transects, point counts, and aerial surveys, may be very effective for certain wildlife species, particularly those that are (a) arboreal (i.e., living in trees), and (b) have a high enough density of individuals or indirect signs (orangutan nests) that detection rates can be reasonably high. As such, most distance sampling applications in Sabah have been geared towards diurnal arboreal primates. Much useful information could also be gathered from line transect surveys at night with spotlights to assess nocturnal, arboreal carnivores and primates.

However, line transects are not very effective for studying most terrestrial mammals in rainforest habitats for several reasons:

- These species often occur at low density, which means that detection rates, and thus statistical power, will be very low;
- It can be very difficult, even for experienced field staff, to move quietly enough in the forest so that the animals do not hear the researchers approaching and move away from the transect. Such movement in response to the researchers creates a huge bias in the density analysis by changing the distance from initial detection to the transect line;
- Straight transect lines that are cut through the forest for sampling may also be used or avoided more by terrestrial animals themselves. This creates another large source of bias by artificially inflating/deflating detection rates along the transect.

An alternative survey strategy that circumvents the issues above is the use of occupancy modeling. The premise of occupancy models, as with the distance sampling methods discussed above, is that we cannot be sure, if we do not detect an animal in a given area, whether the animal actually does not occur there or whether it is in fact there but we simply could not detect it. The basic idea of these models is that replicated surveys are used within sampling units to estimate the probability of detecting the species (also known as "**detectability**"). Then the probability that the species occurs at a given site (or other parameters, as discussed below) can be estimated while accounting for imperfect detectability.

These models were originally designed to ask simple questions about wildlife distribution like, "how much of Area A is occupied by species X within a given sampling period?". Such information on animal distribution may be very useful to managers. Indeed **distribution** (measured as the proportion of the total habitat that is occupied) could be a useful variable with which to monitor wildlife populations over time, or to compare the impact of different management actions on wildlife.

The latest occupancy models address additional questions. For example, the free software program "PRESENCE version 4.1" contains models that can assess occupancy under different circumstances and scenario:

- Despite potential mis-identifications of the species ("false-positive detection" models);
- Across several "states" of the animal, for example adults versus young ("multi-state models");
- For two species in order to determine, for example, whether the occupancy of a carnivore is related to the occupancy of its prey ("two species" models);
- When sampling at different sites began at different times ("staggered entry" models);
- Across several seasons or years ("multi-season" models);
- Using various combinations of the above, for example "multi-season multi-state" models.

4.5.2. Abundance-based occupancy models.

Different types of occupancy models can also extract information on abundance from the underlying occupancy data. **This is based on a simple assumption, that abundance is positively related to detectability.** This seems biologically plausible because the more animals that occupy a given site, the higher the probability that at least one of them will be detected during a survey. Of course, detectability will vary due to many different factors, not just abundance (see above). So abundance-based occupancy models estimate two parameters, *abundance and detectability*, where detectability can be modeled as a function of whatever covariates are appropriate.

PRESENCE has two types of abundance-based models: the "single-season-heterogeneity (Royle/Nichols)" models and the "repeated count data (Royle Biometrics)" models: Text Box A.11.

Text Box A.11: Data entry with Royle/Nichols vs Royle Biometrics Occupancy Models

The main difference between these two classes of models is that the Royle/Nichols model, like standard occupancy models, has the data in the form of 0s and 1s, whereas the Royle Biometrics procedure uses what are called N-mixture models to allow additional detection data within a sampling occasion to be used.

For example, if a site is surveyed for three consecutive days, and 15 bearded pigs are detected on day 2 but none on days 1 or 3, the data for a Royle/Nichols analysis would be 0 1 0, whereas for a Royle Biometrics analysis it would be 0 15 0. In other words, by not collapsing everything to a 0 or 1, the Royle Biometrics model "keeps" much more of the observed structure in the data.

The ability to estimate abundance from occupancy data, along with the recent availability of high-quality and relatively low-cost camera traps, could prove to be a very important development for wildlife assessments in tropical rainforests. Most wildlife species in Borneo are not individually identifiable in photographs and are thus not amenable to mark-recapture analysis from camera trap data. But abundance-based occupancy models offer a possibility of assessing abundance for these species. However, there are several caveats to the use of these methods. What the models are estimating is the number of individuals of a given species that occupy a given sampling unit; in the case of a camera trapping study, this would mean something like, "how many individual banded civets use the area in front of each camera?". It is not necessarily straightforward to translate such estimates of *local* abundance into an estimate of how many individuals occur across the entire study area. This is especially true for wide-ranging species where a single individual could be detected at several sampling locations. All these issues are thoroughly discussed in Mc Kenzie *et al.*, 2006; in the "Handbook for wildlife monitoring in Sabah using camera-traps"; etc.

4.5.3. Considerations for designing an occupancy study (Text Box A.12).

Occupancy models involve replicated sampling within a number of sampling units in the study area. For example, managers may wish to assess the proportion of a forest reserve (*study area*) occupied by sambar deer by randomly choosing several plots (*sampling units*) within the reserve, and repeatedly visiting (*replicated sampling*) the plots to look for sambar sign. The number of sampling units should be as high as possible, subject to logistical and financial constraints. The placement of sampling units could be random or systematic (e.g., along a grid or transect lines), which would allow inference to be made to the entire study area.

In many cases, researchers opt to survey animal- or human-made trails, because detectability is much higher on trails that at random locations in the forest. For example, many carnivores occur at very low density and the only way to obtain enough detections to be able to conduct statistical analysis is to survey trails or other movement pathways where the animals are likely to be found. But in such cases, inference can only be made, for example, about "what proportion of trail sections across the study area is occupied?". It is also common for sampling units to be arranged so as to straddle gradients in factors that may be of interest for analysis. For example, if managers are interested in how occupancy or abundance changes with forest condition, it would make sense to place cameras along transects from pristine forest to areas of increasingly intense logging.

Replication of samplings can be achieved in several ways.

- **Temporarily:** Commonly, sampling units are visited at different times, with each visit marking a separate sampling occasion. Motion-triggered camera traps make such sampling very efficient because they remain in the forest for weeks or months at a time, and each consecutive day that they are deployed can be considered a sampling occasion. The use of camera traps is discussed much more fully in the "Handbook for wildlife monitoring using camera traps" (Ancrenaz *et al.*, 2012), which discusses study design, deployment of cameras, and data analysis.

- **Spatially:** For example, rather than going to each sampling unit a number of times, researchers could go to each unit once and measure detections in several sub-plots within each unit. This method may be advantageous where camera traps are unavailable or where logistical considerations make it unfeasible to visit remote or inaccessible sampling units more than once.

- **Use of multiple survey methods at each sampling unit in order to estimate detection probability**: The basic idea is that instead of repeat surveys at different times, each site is surveyed using several different methods in order to estimate the detection probability. For example, managers could use a combination of camera traps, direct observation, and track or scat detection at each sampling unit. These are known as "multi-method" models (and are also available in PRESENCE).

Text Box A.12: General advice for designing occupancy studies (from MacKenzie and Royle, 2005)

As a general concept, occupancy is the fraction of sampling units in a landscape where a target species is present. Reliable inferences about the studied population using occupancy methods can only result from quality data and by considering the following issues:

1. **Study objectives**. As for any wildlife study (see section A.2.2), they must be clear and answer the following questions:
   - Why collect the data: formulation of a clear objective;
   - What data to collect: three levels can be considered in demographic studies: individuals – species – community (multiple species);
   - How data are collected: this stage is formulated (see below) only when the "why" and "what" questions are formulated clearly.
2. **Sampling units**. The sites from which data are collected generally represent only a fraction of the greater collection of sites presumably occupied by the studied population. These sites should be selected at random or following a stratified random sampling approach. When sites are chosen arbitrarily (convenience sampling), extrapolating the results to the greater population is not possible. A practical way to design the sampling strategy is to place a grid system (series of squares of similar area) over the map of the study area. The size of each square depends on the species to be studied (they are smaller for small species and larger for wide-ranging species). Within each square, we select a precise location for the sample site (this can be the central part of the square by example). This site is then sampled with line transects, traps, recces, etc.
3. **Time of repeated surveys**. Repeated surveys are often conducted as multiple discrete visits (e.g., at different times). Other options include conducting multiple surveys within a single visits and/or using multiple observers to conduct independent surveys.
4. **Number of repeated surveys/survey effort**. Attempting to survey as many sites as possible may not be the most efficient approach but surveying fewer sites more often may result in a more precise estimate of occupancy. Sampling units should be surveyed a minimum of 3 times when detection probability is high (>0.5 survey-1) unless a removal design is used. For rare species it is more efficient to survey more sampling units less intensively while for a common species fewer sampling units should be surveyed more intensively.
5. **Removal design**. A removal design is used when surveying of a site stops once the species is detected or when X surveys have been conducted. This approach is generally more efficient if detection probability is constant, but less robust to assumption violations than a standard design.

4.5.4. Considerations for occupancy data analysis.

After completing a field survey collecting replicated sampling data from multiple sampling units within one or several study areas, addressing simple questions about habitat occupancy is fairly straightforward. The free software program PRESENCE, or the R package Unmarked (also free), can be used to answer questions such as "how much of the study area is occupied by species X, given the fact that we cannot perfectly detect the species even when it is there?".

More interesting and potentially more useful analyses can address the relationship between different factors and either the occupancy or the local abundance of any wildlife species for which sufficient data have been collected. It is important to note that, as with all the methods described in this manual, the occupancy analyses discussed here assess relationships among variables, rather than actual causality. In other words, we might be able to say, for example, that the local abundance of binturong is *related* to logging intensity, but we could not actually say that logging *caused* the variation in binturong abundance without additional data. Nevertheless, very important insights can be gleaned from analyzing relationships between wildlife occupancy or abundance, and natural or human-related variables.

In such analyses, the first step is often to choose which dependent variable to analyze: occupancy or local abundance. This will depend on the study question. As noted above, it can be difficult to interpret abundance-based occupancy models for wide-ranging species, insofar as it is difficult to extrapolate from abundance at particular camera locations to abundance across the overall study area. However, there is no reason that managers necessarily *need* to estimate abundance across the overall study area. Some of the most interesting questions for managers may be things like, "how does the intensity of logging (or hunting, or tourism, or road density, etc.) affect endangered species X?". These questions can be well addressed by using *local* abundance (i.e., the number of individuals present at each camera site) as the dependent variable. Such analysis can generate precise response curves, showing the effects of different variables on a particular species of interest. When comparing across multiple study areas, "area" should often be included as a categorical group effect in the analysis, to account for within-site correlation in environmental factors that may not have been measured during the study.

As with any quantitative analysis, measures of precision (e.g., standard error or confidence intervals) must be presented along with the average estimates. Occupancy analysis in both PRESENCE and Unmarked uses an information-theoretic model-selection approach. Results are often best presented by showing model-averaged estimates (ideally in graphical form) along with a table of model selection results.

Simple occupancy analyses can and should be undertaken, at least initially, by local managers in the agencies that conducted the studies. Performing the analyses may not only generate useful results, but, by helping managers learn about the models, will help them design further studies. However, for more complicated analysis it likely makes sense for managers to collaborate with trained biologists who are familiar with quantitative analysis. Indeed, the details of many of the analytical procedures mentioned in this chapter are beyond the scope of the manual. This is particularly true for analyses in Unmarked. While less user-friendly than PRESENCE, this package is much more useful for complex occupancy analyses, especially those involving model-averaging or the production of graphs based on model results.

4.6. Estimating whether wildlife populations are increasing or declining (*section written by Dr. Jedediah Brodie*).

Monitoring and surveillance of wildlife populations are key tasks for forest managers. Indeed, it could be argued that the whole point of using any of the methods discussed in this manual is to try to determine whether particular populations are increasing, remaining stable, or decreasing in response to different management activities. But unfortunately, figuring this out is not completely straightforward.

It might seem that managers could just use line transects or occupancy models every year for a few years and then just report whether density or occupancy in the final year was higher or lower than in the first year. The problem is that, while such an approach would provide essentially an average estimate, it would not provide the equally-important measure of variance. **It is just as critical to know and to report the confidence in the trend estimate as it is to report the average trend estimate itself.**

Statistical approaches such as regression are designed to provide both average estimates and measures of confidence in a temporal trend. However, it is not appropriate to use regression on yearly population density estimates. Regression (in fact, nearly all statistical hypothesis tests) assumes independence among data points, and population size one year will certainly not be independent from population size in previous years. Thus, alternative techniques are needed to determine if a population is increasing or decreasing.

For occupancy-based approaches, the issue is addressed relatively simply. There are "multi-season" models in both PRESENCE and Unmarked, where a "season" can be defined in a variety of ways. Managers can easily call each year a "season", and use multi-season models to estimate habitat occupancy within each year as well as changes in occupancy between years. Moreover, more dynamic occupancy models are continuing to be developed. In Unmarked, analysts can use dynamic occupancy models to estimate not only yearly habitat occupancy, but also the probability of immigration and local extinction within and among sites.

For other types of surveys, the way to estimate the average and variance in population trend is explained below.

If surveys were done every year, then one calculates the natural logarithm of the ratio of population size in year *t* to year *t*-1. The average and variance of these annual log ratios are the average and variance in population trend, also known as **population growth rate, *r*.** As an example, look at the series of **population estimates *(N_t)*** for a series of years in Table A.4. From 1978 to 1979, the population increased

Table A.4: Yearly population size of a given population and its increment.

Year	N_t	*r*
1978	34	0.11
1979	38	-0.05
1980	36	0.03
1981	37	0.10
1982	41	-0.05
1983	39	0.27
1984	51	-0.08
1985	47	0.19
1986	57	-0.17
1987	48	0.22
1988	60	0.08
1989	65	0.13
1990	74	-0.07
1991	69	-0.06
1992	65	-0.13
1993	57	0.21
1994	70	0.15
1995	81	0.20
1996	99	0.0
1997	99	

from 34 to 38 animals. For that time interval, r = ln(38/34) = 0.11. Averaged across all time intervals (note that there will be one less time interval than there are study years), $\bar{r}$ = 0.06 and variance in r = 0.02. Since $\bar{r} > 0$, we know that the population has increased over the study period.

However, data are often missing for a variety of logistical or financial reasons, and it is very common to end up with a time series where data from a few years are missing. At this point the analysis becomes slightly more complex, but is still doable. The method of Dennis *et al.* (1991) is probably the best way to estimate population trends for wildlife based on survey data where some estimates are missing.

Analysis from incomplete data

As an example of this approach, start with the same time series of annual population estimates as above, but this time say that data were not collected in three of the years (see Table A.5). Here the approach is to regress *population growth increments corrected by the time intervals over which they occurred* (Y variable), against *transformed time intervals* (X variable). So if the *time interval between successive samples* is ***i*** (measured in years, in this case), then the X variable for year t is $x_t = \sqrt{i}$. The Y variables is calculated as:

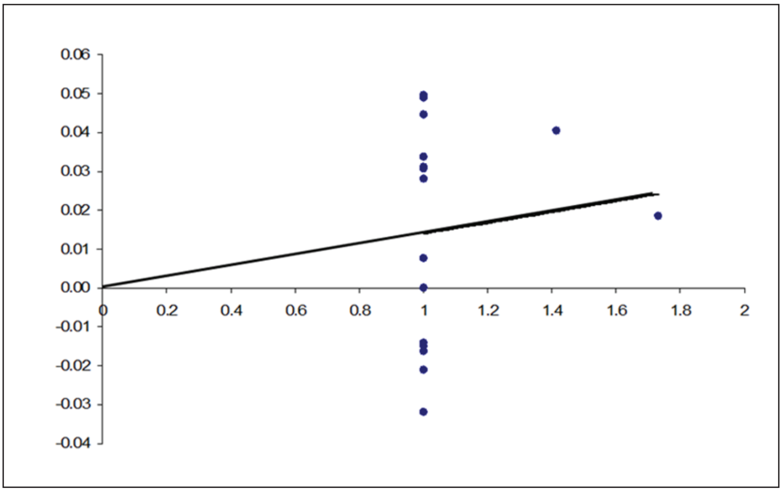
$$\mathrm{y_t} = \frac{\ln\left(N_{t+i} / N_t \right)}{x_t}$$

Note that for most years the time interval to the next sample is 1 year, so $x_t = \sqrt{1} = 1$. But in 1982 the time interval to the next sample was two years, so xt $= \sqrt{2} = 1.41$. In 1986 the time interval to the next sample was three years.

At this point, the Y variables are regressed against the X variables, with the regression intercept forced through zero (because, if no time passes, then the population size cannot change). The *slope of the regression line* is **r**, and the *variance in the slope* is the **variance in** *r*. Analysts can also calculate the 95% confidence intervals for the slope coefficient; if this confidence interval does not overlap zero, that provides good evidence for a "**statistically significant**" change in population size over the study period.

Table A.5: Yearly population size with incomplete dataset.

Year	Nt	xt	yt
1978	34	1	0.03
1979	38	1	-0.01
1980	36	1	0.01
1981	37	1	0.03
1982	41	1.41	0.04
1983			
1984	51	1	-0.02
1985	47	1	0.05
1986	57	1.73	0.02
1987			
1988			
1989	65	1	0.03
1990	74	1	-0.02
1991	69	1	-0.01
1992	65	1	-0.03
1993	57	1	0.05
1994	70	1	0.03
1995	81	1	0.04
1996	99	1	0.00
1997	99		



An important note here is that **this approach relies solely on the first and last observation in the time series in order to calculate *r***. This means that if population size in the last year is greater than in the first year, the population is said to have increased, regardless of what happened to it during the intervening years. Given that, why is it necessary to measure population size in all years rather than just the first and last year? It is necessary because **data from all of the intervening years are used to calculate variance (and confidence intervals) in *r***; as mentioned earlier, such estimates are just as important as the r value itself.

The fact that the average trend estimate relies solely on the first and last years of observation has an important implication for wildlife monitoring: **it may be better to actually skip sampling in certain years, if that means that the funding can be applied to get better and more precise estimates in the remaining years**. As a general rule, up to ½ of the sampling years can be skipped in order to get more precise estimates in the years in which sampling does take place.

A critical issue that was not discussed here is that of **sampling variance** (also called **sampling error**). As an example, variation in abundance estimates from one year to the next will partly result from *real changes in population size* (**process variance**), and partly from the *unavoidable vagaries, discrepancies, and biases inherent in field work* (**sampling variance**). Methods exist to separate sampling variance from process variance, thereby allowing the calculation of much more accurate and precise estimates of population trend. However these methods require state-space models or other highly complicated statistical procedures, and are beyond the scope of this manual.

To conclude, it is important to stress that managers should ideally undertake the analyses discussed here, both to generate results and also because understanding the models will greatly help with study design. However, there are many complex analyses that should best be conducted in collaboration with quantitative ecologists, wildlife biometricians, or suitably skilled scientists available from local universities or wildlife agencies and research institutions. Wildlife monitoring is a collaborative process to be approached as a "team work" involving various partners and demanding many different types of skills.

The flat-headed (*Felis planiceps*) cat is one of the five species of wild cats found in Sabah. This nocturnal animal is very secretive and is rarely seen. Its survival depends on healthy river banks, and the populations are declining throughout its range.

Chapter 5: USING INDEXES FOR WILDLIFE ASSESSMENT AND MONITORING

5.1. What is an index?

An **index** is a measurement related to the actual number of animals within a population. Indexes (or indices) are not an estimate of the total population size but can reflect **relative abundance**.

Because they are easy to record, indexes are commonly used for wildlife surveys. Indexes can be derived from direct and indirect signs left by animals: number of individuals of species A observed per unit of time or per unit of distance; average number of females with an infant; number of calls heard per unit of time; number of scats, footprints or nests encountered per unit of distance (encounter rates); number of road kills per unit of time; number of animals caught per night of trapping; and number of pictures per camera trap day, to name a few. When indexes are replicable, they allow for some inter- and intra-population comparisons.

In principle, the Index (I) is the product of the population (N) and a detection or encounter probability (k), as reflected in the following equation:

$$k = I/N$$

In theory, k, which is also the ratio of the index and population, is relatively constant. When a fixed amount of searching effort locates a fixed proportion of the population, indices can allow for semi-quantitative comparisons between different wildlife populations or a given population over time. For example, if the population is reduced by half, the index is expected to be halved as well.

However, in practice, the ratio between indices and population size is rarely constant because index detectability can fluctuate significantly. There are three major classes of variables that affect the probability of detection:

- Inconsistencies in observer effectiveness relating to skill level, interest and training (e.g., eyesight, hearing, knowledge, tiredness);
- Fluctuating environmental variables: temperature, rainfall, wind speed, time of the day/night, season, type of soil, and food resources;
- Differences in species ecology including breeding habits (e.g., having a distinct mating season or location) and other species specific behavior.

These differences make direct comparison of indexes obtained at various places or at different times difficult and sometimes misleading. For example, the number of footprints of species A per 100 m of trail is not only influenced by the number of animals present in the population, but also their behavior, weather conditions, sampling location, and type of substrate. The number of calls heard per unit of time will also fluctuate depending on the season, the time of the day or the night, and the location of the listening post. Many of these variables impacting index detectability also show their own temporal and seasonal trends, further confounding the interpretation of the indices.

In order to minimize these possible sources of bias, the collection of indices must be standardized. Standardization in data collection may include:

- **Standardizing environmental variables:**
  - ⇨ Collect repeated indexes under similar weather conditions;
  - ⇨ Collect indexes at the same time of the day and during the same season;
  - ⇨ Collect information about ancillary variables (e.g., soil substrate) for result calibration;
- **Standardizing animal variables:**
  - ⇨ Analyze possible behavioral differences between populations (populations that are heavily hunted are more elusive);
  - ⇨ Determine if the surveys are conducted during the mating season since reproduction will impact animals' activities;
- **Standardizing human variables:**
  - ⇨ Ensure that the protocol is completely understood by the team performing the survey;
  - ⇨ Use the exact same protocol for each survey;
  - ⇨ Use the same team for repeated surveys (or alternate teams at different sites);
  - ⇨ Use the same equipment for successive surveys;
  - ⇨ Standardize the area searched or the length of the route (use the exact same routes or express results per units of distance);
  - ⇨ Standardize the amount of time spent collecting data (express the results per unit of time).

If multiple and random observations are obtained in sufficient quantities, some of the possible sources of biases (weather conditions; time of the year) can actually be included in the final analysis. This in turn increases the precision of means and differences between different data sets.

When specific and potential sources of variation are well understood, it becomes possible to introduce correction factors to account for fluctuations in detectability. Greater precision is achieved when several data sets are available to conduct regression analysis. For example, a correction factor of 2 will be introduced if it has been established with certainty that the probability of detecting orang-utan nests (irrespective of their distance to the transect) in the closed canopy of primary forest is half that in open canopy of over-degraded forests. However, in general the varying detectability between habitats is not known precisely; in this case indices of abundance cannot be compared directly between habitat types. In certain circumstances, a **double sample approach** can be used to determine the level of precision for the different indexes that are estimated from the data. In double-sampling, a small subset of data used for rapid assessment and index determination is surveyed intensively to estimate the absolute abundance of the subjects. By comparing the indexes and the results of the intensive assessments it becomes possible to determine specific correction factors and finally to calibrate the rapid assessments using indices.

Because of all these limitations, index values should be seen more as explanatory or predictor variables of wildlife populations rather than quantitative variables. However, indices remain useful to rapidly assess population trends as long as factors influencing the detection rates are independent and randomly distributed. Index methods are often a cost-effective tool for wildlife monitoring, especially if double-sampling or other methods that aim at reducing biases are conducted regularly.

Variables that will generate indexes can be recorded during most field activities. Depending on how raw data are pooled together during the analysis stage, a wide range of indexes can be determined: for example per species; per unit of time (hourly, daily, monthly); and per unit of space (per km, per area).

When possible, indices are calibrated with the survey effort undertaken during the data collection stage, weighing results with number of people, duration of survey or travelled distance (Figure A.6; Text Box A.13).

5.1.1. Recce walks.

The basic principle of recce walks is to follow a line of least resistance through the forest by following easy paths such as old trails, ridge-tops, water bodies, and areas with clear understorey. Dense vegetation, steep or waterlogged areas are avoided. The general idea is to cover longer distances in shorter time compared to strict line-transects. Recce walks are especially important during rapid assessments to become familiarized with a new area. They provide general information about wildlife species (presence/absence), habitat types and human activities simultaneously. Although absolute density estimates cannot be derived from recce walks, this method can be used to monitor population trends in remote areas. Two types of recces can be applied. **Guided recces** follow a general bearing although observers should not deviate more than 40° from it. **Travel recces** are followed without predetermined direction. Guided recces provide more precise indexes than travel recces.

Source of bias:

The sample is not representative of the study area as a whole since certain vegetation types are systematically avoided;

Missed animal signs: observers should pause and take detailed notes every kilometer of the walk;

Varying animal detectability may occur due to changing habitat types, different seasons, or different teams.

Data analysis:

i. Species Presence/Absence is plotted on a map showing the precise path followed during the recces;
ii. The data set appears as a list of objects sighted during the recces, including time and the horizontal distance along the recce. For each variable of interest, it is thus possible to sum up the total number of sightings for the entire recce or for some parts of it;
iii. The length of the trail is precisely estimated from 1:50,000 scale topographical maps or/and with a GPS (Track Log function);

iv. A specific linear kilometric index of wildlife sightings is obtained by dividing the total number of sightings for a given species (or group of species) by the total length of the recce (encounter rate). Post-stratification allows the derivation of localized encounter rates for different legs of the recces (stratified per habitat type; per elevation classes; per class of type and extent of disturbances; per compartment or any other geographical unit).

Linear indexes are expressed as number of sightings/km walked. Linear indexes can also be stratified temporally. In this case indexes are worked out per hour of search; or period of the day; month; season; or any other temporal unit we are interested in. Temporal indexes are expressed as number of sightings per hour; per day; per month. Linear or temporal indexes can be plotted in histograms to allow visual comparisons of temporal and seasonal fluctuations;

v. To gain in accuracy and precision, raw data must be weighted with the survey effort or time spent in the forest (Text Box A.13). In this way, standardized indexes can be determined for every type of activity undertaken. However, care must be taken when comparing encounter rates collected from different areas or at different times because of the different biases these indexes are subject to;

vi. Short line-transects can be combined with recce walks to determine the correlation between absolute abundance estimates derived from line transects with the linear indexes derived from recces. This is more time-consuming but this double-sampling approach allows for the calibration of indices from recce walks. Calibrated recce data are more precise for monitoring population trends through time, at a same location, or between locations.

Text Box A.13: The importance of weighing raw data during opportunistic collection.

A team of rangers records the number of deer sightings during their journeys by car and by foot for two consecutive months in an area A:

	Recce by car	Recce walk
October	250	10
November	120	35

From the raw data, it can be inferred that overall, more sightings were made from the car recces; more sightings were made by car in October, and; more by foot in November. In the absence of survey effort indication, no general trend can be deducted from this data set.

However, by weighing these data with the true survey effort (i.e. by summing the total distance travelled by the teams to obtain linear indexes), a trend can be detected:

	Recce by car			Recce walk		
	Sightings	Km	Encounter Rate	Sightings	Km	Encounter Rate
October	250	500	0.5 ind./km	10	5	2 ind./km
November	120	30	4 ind./km	35	7	5 ind./km

Although the absolute number of sightings is higher from a car, the weighted index indicates that sightings occur more often during recce walks. In addition, a temporal trend can now be confirmed with more sightings in November than October.

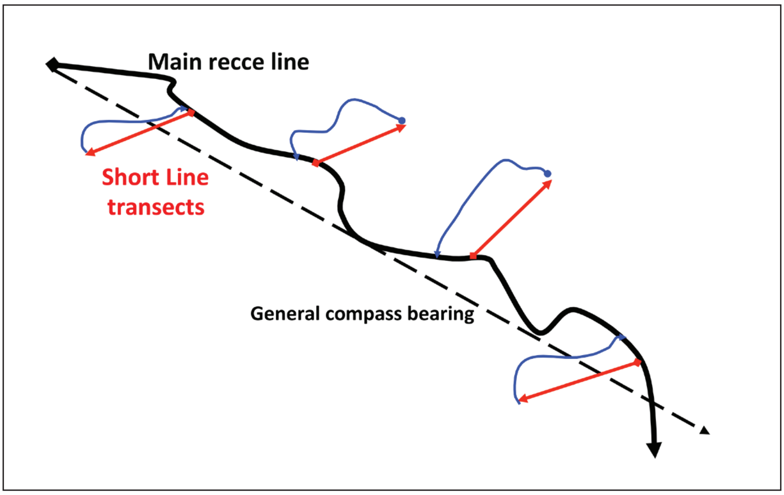


Figure A.6: Recce walk and line transects.

5.1.2. Road surveys.

The presence of roads provides an easy way to assess and/or monitor wildlife presence in an area. It is important to monitor the impact of hunting/poaching and vehicle traffic on wildlife populations. Abandoned roads also offer interesting opportunities to conduct rapid wildlife assessments or regular monitoring on foot. If properly standardized, road surveys can potentially produce large amount of low-cost data. Each time a car is used for field activities, the team has the opportunity to conduct basic road survey and to record data about wildlife species that occur in the area. Ideally, a set of roads that are regularly travelled by the team for their field activities is selected and mapped precisely for road surveys. Every time the team uses these roads, data should be collected systematically. Road-based observations can thus be used for rapid assessment, monitoring population changes over time, examining the response of various species to disturbances, including accessory activities such as tourism.

Most animal species are affected by the presence of roads: traffic and resulting disturbances, hunting pressure (for game species), and road kill (for smaller species). The shoulder of the road attracts some species because of increased food opportunities due to edge effects (carnivores, browsers) or increased permeability in the forest (large species, primates). On the contrary however, other species will avoid such open areas. All these biases need to be considered when designing road surveys and analyzing data recorded from roads.

The following techniques were previously developed in Kalimantan by *The Nature Conservancy* to conduct rapid assessments and monitoring activities along roads. They can easily be adapted and used for monitoring wildlife in Sabah.

- **Assessing wildlife along roads (*Rapid Assessments*)**

These rapid assessments are conducted along a section of road and all wildlife indices that are encountered and identified are recorded in a specific data sheet. The length of road segment surveyed should ideally be about 5 km for assessment by foot, and at least 10-20 km for assessment from a vehicle.

Source of bias:

Misidentification of sightings;
Incorrect recording of distances.

Data analysis:

Assessment by foot

For assessment by foot, the following indexes are calculated for every segment of 1000 m:

- **Abundance of all signs** -Total number of all animal signs recorded over a 1000 m stretch;
- **Number of different species** - Minimum number of species identified over 1000 m stretch (e.g., two civet-like tracks separated by some distance and of different size would count for two species).

These counts are repeated for each segment of 1000m, then the counts are summed and averaged for each transect. If for example, the transect is 5 km long:

$$\text{Mean Number}_{\text{(species for transect A per km)}} = \frac{\sum(\text{Nb Sp}_{0-1000\text{m}}. + \text{Nb Sp}_{1000-2000\text{m}}. + \cdots + \text{Nb Sp}_{4000-5000\text{m}}.)}{5}$$

The same method is replicated for the most common species in order to estimate the mean number of different species for each transect (Diversity).

Assessment by vehicle

For assessment from a car, the number of species seen for the entire road survey is derived from the dataset. A **linear kilometric index** is obtained by dividing this number by the total length of the journey. Specific linear kilometric indexes are also obtained for the commonest species.

- **Monitoring wildlife along roads**

Stretches of road that have been used for rapid assessment can also be used repeatedly at regular time intervals for longer-term monitoring purposes. However, roads that are compacted, very rocky or covered with creepers and plants are unsuitable for easy track detection and should be avoided for monitoring purposes. To ease data collection and to allow an easy location of sightings, permanent posts can be placed along the road to indicate the horizontal distance (every 100 m for foot monitoring; every 500 m for car monitoring). Road surveys by car can be a cost-effective way to characterize differential species use of habitat; monitor daily and monthly patterns of occupation; collect basic data about population composition and structure, among other things.

Source of bias:

Misidentification of sightings;
Incorrect recording of distances;

Inconsistency of track detection due to durability of substrate and other factors.

<u>Data analysis</u>:

i. For each survey, the number of different species observed along the entire stretch is summed up;
ii. For each segment of 1000 m, the number of wildlife sightings is summed and averaged:

$$Average = \frac{\sum(Number\ of\ sightings\ per\ segment)}{Number\ of\ segments}$$

iii. Patterns of wildlife presence/absence and their fluctuation are inferred using graphs showing the average of animal seen for each segment of 500 m;
iv. Hourly distribution is obtained by pooling the data observed every hour throughout the month(s) and year(s);
v. Differential habitat use is obtained by pooling the data per habitat type as determined during the survey design period;
vi. For car monitoring, data and indexes can also be stratified per habitat type.

5.1.3. River surveys.

Riparian forests offer shelter and food, therefore attracting many mammals, birds and other animals. Rivers that are navigable by boats also provide an easy way to assess and to monitor wildlife presence in an area. At night, boat surveys provide information about the nocturnal guild, especially crocodiles and carnivores. Under certain circumstances, these indexes can be compared between sites to identify areas of specific importance for wildlife and between seasons to document possible temporal variations of abundance. The methodology is similar than for road surveys (see above).

<u>Source of bias</u>:

Misidentification of sightings;
Difficulty to detect the entire group;
Incorrect recording of distances cruised on the river.

<u>Data Analysis</u>:

Linear kilometric indexes or encounter rates are obtained for each species by summing the number of groups or individuals detected and dividing it by the total travelled distance.

For a social species, the individual encounter rate is obtained by multiplying the group encounter rate by the average group size.

5.1.4. Forest monitoring.

It is important to monitor forest production to better understand wildlife dynamics. Monthly monitoring of a pre-determined set of trees can inform about the phenological status of the forest. Trees selected for phenology have to be marked and identified to the species level if possible. This subset of trees can be part of already established botanical plots, located along permanent line transects or randomly selected in the forest.

Calculating semi-quantitative phenological indexes is a simple way to monitor fluctuations of food availability in the forest. With binoculars, the team in charge of the monitoring assigns a monthly score of abundance (e.g., absence=0; few=1; many=2; maximum=3) for each of the following plant parts: Flowers; Young Leaves; Unripe Fruits; Ripe Fruits.

<u>Source of bias</u>:

Inconsistency in data collection: changing observers responsible for data collection can result in differences in score assignment;

Difficulty in observation: unfavorable weather and poor light condition can hinder precise phonological assessments (raining, early morning, overcast weather).

<u>Data analysis</u>:

The semi-quantitative score of abundance is converted into a phenological index using:

$$Phenological\ Index = \frac{\sum(scores\ for\ a\ given\ subset\ of\ plants)}{Number\ of\ plants\ in\ the\ subset}$$

The subset of plants is stratified by habitat types, species or taxa, compartments, and others. With this approach, monthly indexes fluctuate from a minimum value of 0 (e.g., no production for the considered plant part) to a maximum value of 3 (e.g., maximal production stage). Periods of low and high food production can be identified through the use of graphs.

5.2. Interview surveys.

Although the use of interview surveys (design, data acquisition and analysis) is still debated over by many conservationists, they can provide information that complement the results of field studies. Interview surveys can be used to better comprehend the attitude of local communities toward wildlife, perceived presence and threats of certain species, and presence of conflicts and their underlying causes. They also integrate some knowledge about social and economic factors that may be critical to understanding the status of wildlife. Ancillary data such as level of hunting, presence of conflicts, use of forest products that could be key factors to sustain wildlife, and location of important key feature areas for wildlife can be recorded through interviews. Often, conducting interviews at the beginning of a wildlife study results in a better knowledge of the conditions to be expected when the teams begin their survey, as well as better acceptance by local communities of the work we need to conduct in the area. In addition, interview surveys provide a vehicle for raising awareness about biodiversity conservation.

If well designed and carefully implemented in the field, interviewed-based surveys can provide robust and cost-effective tools in the conservation of relatively easily recognizable species. However, it should be noted that assessing presence of a species from interviews is often more reliable than absence. The stated presence of a species needs to be confirmed by the interview teams by checking a concordance between the name, the identification in the picture and the description of the behavior. However, wildlife distribution, presence and abundance cannot be inferred only from interviews. Information gained during the interview sessions need to be validated and confirmed by subsequent field visits.

Interviews yield better results when they are conducted by interviewers who know the language/dialect used by interviewees and who are aware of the local names of wildlife species. Traditionally, interviews are structured (e.g., following a list of established questions) or semi-structured. The interviewers have to be careful to not ask leading questions!

Interview surveys follow similar sequences:

- Identify the aims of the interviews and the type of questions required through a sampling scheme, questionnaire design;
- Conduct a pilot study to refine the questionnaire and to assess the feasibility of the survey;
- Train teams who will conduct the interviews with necessary skills;
- Conduct interview surveys;
- Analyze data;
- Share survey results with participating communities: a critical step!

Possible shortcomings associated with interview surveys include the difficulty to test the reliability of the answers, and the difficulty to collect information on sensitive topics. To conclude, it's just as difficult to do a proper interview survey as it is to collect unbiased, useful ecological data, and the methodology and training requirements are just as intense. In order to properly design, conduct and analyse an interview survey, it is crucial to collaborate with social scientists from local universities (Unimas, UMS, etc.) who are trained in such techniques.

Pig-tailed Macaque (*Macaca nemestrina*): these monkeys are highly adaptable and are found in all kind of habitats, from primary forests to oil palm plantations. They live in groups of several tens of individuals and are often seen foraging on the ground.

Chapter 6: IMPLEMENTING AND EVALUATING THE WILDLIFE MONITORING STRATEGY

6.1 Human resources required to implement a Wildlife Monitoring Strategy.

Identifying a focal person who supervises and is responsible for the entire strategy is a crucial element for a wildlife strategy to be successful. More specifically, this focal person will be in charge of:

- Overseeing and coordinating the team work, wildlife activities and schedule;
- Centralizing and storing all wildlife data;
- Supervising data processing;
- Supervising initial data analysis and reporting;
- Liaising with relevant stakeholders and partners to adapt the results of the Wildlife Strategy to management activities when needed.

In order to minimize observer biases during repeated surveys, a permanent team assigned to wildlife monitoring activities (called the Wildlife Unit) needs to be identified and trained accordingly. Ideally the personnel that make up the wildlife unit(s) will be a consistent group that is not changed regularly, that will be engaged on a full-time basis in wildlife monitoring activities. Bearing this in mind, it will also be possible to integrate wildlife monitoring activities within the range of other daily duties such as patrols, inventories, replanting, etc. Therefore, all field teams, irrespective of their function in the project, should be briefed on basic wildlife data and how to record opportunistic wildlife data on specific data sheet and logbooks. Every field team should appoint a specific data recorder who will be responsible for reporting to the focal wildlife person, which will ease the coordination process.

A team Leader for the Wildlife Unit needs also to be appointed. He/she will be responsible for:

- Managing the data sheet and data entry;
- Schedule and activities;
- Managing the equipment.

Ideally an assistant team leader will also be identified. His/her duties will include assisting the team leader in undertaking the responsibilities listed above – including attending all additional training modules.

6.2 Financial resources required for wildlife monitoring activities.

The ultimate aim of a wildlife monitoring strategy is to establish whether or not conservation and management objectives are being met. Financial, human, and time resources are more often than not a major constraint to achieving this goal. The following approache can be taken to minimize these constraints (from Tucker *et al.*, 2005: Please note that the list below is only indicative and not exhaustive):

- Prioritize monitoring activities that are of highest conservation interest and at highest risk. It is wise to monitor more closely areas that are exploited and easily accessible by people since they are under more hunting/degradation pressure than areas that are remote and not encroached on by human activities;
- Monitor pressures rather than the state of feature. For example, it can be easier to monitor hunting pressure rather than abundance of game species;
- Set simple conservation objectives and restrict field procedures to what is required to test if these objectives are being met;
- Focus on key sites that are representative of the entire area;
- Only monitor as frequently as necessary. For example, there is no need to undertake aerial monitoring of orang-utan nests every month;
- Use the most cost-effective methods available, even if some of these methods are not necessarily the most simple. For example, monitoring changes in habitat is more effectively done through remote sensing than extensive field surveys, but remote sensing analysis requires an expertise that is not necessarily available on site. The use of occupancy models can provide precise information about species abundance and population trends. Although data can be relatively simple to collect, the use of specific softwares will require the assistance of specialists.
- Use efficient sampling strategies and integrate wildlife activities in the range of duties carried out by field teams;
- Revisit the wildlife strategy when more funding becomes available;
- Collaborate with scientific institutions to conduct specific research projects that will inform detailed aspects of the general wildlife strategy.

A wildlife strategy should not be seen as a stand-alone exercise. In the contrary, it should be embedded in the general management strategy of a given area (given that such a plan exists). Ensuring that the results of wildlife activities are integrated in a more regional analysis (satellite image analysis, remote sensing, habitat analysis, etc.) maximizes the value of the data collected locally (recce-walks, transects, sightings, etc.) since they are placed in a general context. This also reduces the overall cost of the wildlife strategy since regional-scale analysis developed for the general management of the area is available for the wildlife strategy. The key is to ensure that a regular and efficient flow of information exists between the people in charge of wildlife activities and the other units that are part of the general management of the project.

A preliminary budget should be determined when the wildlife strategy is being developed. Items to be considered include the costs of acquiring the necessary external data such as: satellite images, aerial photographs, etc.; specific equipment (binoculars, walking distance measurer, GPS, field ID books, log-books, digital cameras, vehicles, etc.); staff time and a per diem for local field research assistants and guides; training and professional input; stationery and data analysis (software, computers, etc.); and money for meetings, transportation costs and other operational costs associated with implementing the wildlife strategy.

6.3 Evaluating and measuring success of the wildlife monitoring activities.

Results of wildlife monitoring activities must reach the decision-making level and be incorporated in management decisions. Therefore, it is important to clearly interpret how the data collected in the field reflects the status of the key features, and it is expected that the management authorities will adhere to wildlife management recommendations that arise from the data analysis in respect to general operations. If current operations negatively affect any key features found within and adjacent to the area, management will need to revise and restructure their standard operating procedures in order to preserve and enhance key values (protection and/or dependency) related to the particular species in question.

Wildlife is a highly fluctuating entity. Therefore, any wildlife strategy MUST be adaptable and readily changeable. As a result, planning and monitoring have to be seen as a continuous, iterative and evolving process. An adaptable management approach must allow the site manager to respond to the natural dynamic processes occurring in order to accommodate interests of other stakeholders and to adapt to the fluctuating political and socio-economical climate. However, it is easier to identify a management measure than to quantify its intensity and adequacy (for a more detailed discussion on this topic see Alexander, 2008).

The adaptable management process begins with decisions about what the strategy aims to achieve: Figure A.7. For each feature it is necessary to determine clear objectives (see section 2.2.). Different management activities are then defined to ensure that these objectives are achieved. These management activities need to consider the condition of the feature (assessment), as well as the factors that have the potential to change the feature. The length of management period can fluctuate according to the predicted rate of change of the feature and the level of confidence in the data collected about this feature. Evaluation and review are then conducted at intervals that match the management period (Text Box A.14). With this approach, evaluation is a very specific activity since it is linked directly to both the objectives for a feature and the associated management activities.

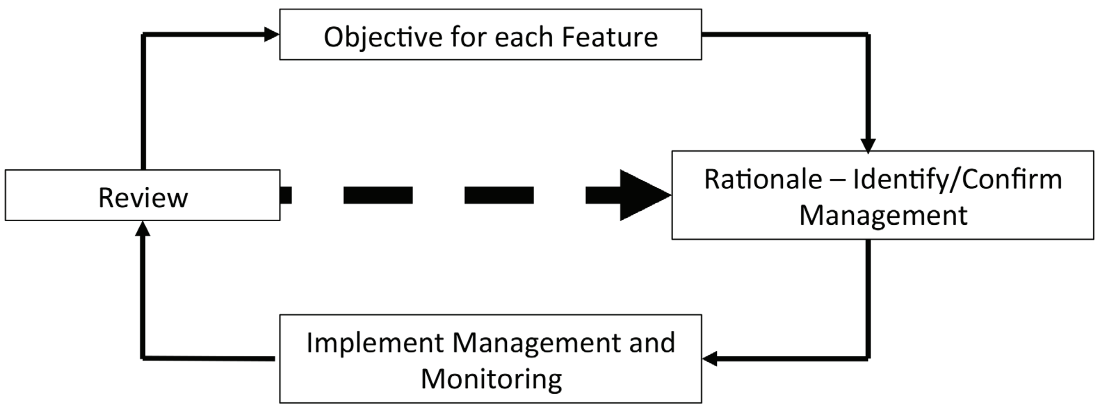


Figure A.7: Diagram showing the full adaptable planning cycle (from Alexander, 2008)

Text Box A.14: Different time frames for evaluating different features

The different biological characteristics impacting wildlife (breeding parameters; diet; abundance; range; behavior; etc.), may take time for specific positive or negative changes in population trends to become measurable. Performance indicators for each management activities need to be reviewed regularly but with different time frames. Below are a few examples that illustrate this adaptable monitoring system (taken from the Malua Wildlife Monitoring Strategy):

- Extremely short-term changes/indicators (Three months – One year):
  - Sign boards established to show the limits of riparian forest reserves, etc.;
  - Decreased rate of encroachment (illegal logging, poaching, etc.);
  - Absence of road kill;
  - Compliance with sustainable practices (RIL, EIA, etc.).

- Short-term changes/indicators (One – Five years):
  - Increased number of fast-breeding species (cervids, tambadaus);
  - Use of artificial nest boxes and wildlife bridges;
  - Recolonization by wildlife of compartments/areas that are rehabilitated (encounter rates, orang-utan nests, etc.);
  - Increased sightings of protected species close to natural or artificial saltlicks (tembadaus, carnivores, etc.);
  - Increased number of mother trees in compartments harvested under the Reduced Impact Logging (RIL) practices;
  - Increased tree growth in sylviculture treatment compartments (cutting of climbing bamboos);
  - Improved water quality (less sedimentation);

- Medium-term changes/indicators (Five – Ten years)
  - Recolonization of treatment areas (bamboo cutting and fruit-tree planting areas) that lead to an increase in encounter rates of fruit-eating animals (primates, hornbills, etc.) and of carnivores;
  - Increased numbers of elephants;
  - Increased encounter rates of game species (wild boars, cervids);
  - More breeding groups (young and juveniles) of species that respond positively to forest restoration (monkeys, etc.) or to lower poaching pressure (tembadaus).

- Long-term changes/ indicators (10-50 years)
  - Increased number of slow-breeding and/or large-ranging species (orang-utans, large carnivores, hornbills, etc.);
  - Increased bird, amphibian/reptile, mammals and invertebrate diversity at the community level (with reappearance of rare endemic and specialized species that were declining or were decimated by past logging activities);
  - Changes in forest canopy: increase in class I stratum and decrease of class IV stratum (most degraded forests);
  - Change in tree diversity composition and forest structure (increased tree density and basal area; decline of pioneer tree species; etc.) as indicated by long-term botanical plots monitoring).

A series of questions need to be addressed during the review process of monitoring activities for each feature:

1. Is there any reason to change the objective?
2. What is the current status of the feature?
3. Are the factors influencing the feature under control?

It should be noted that if the feature appears to be in good condition and all of the factors are under control, there is no reason to change the management activities that were designed in the original plan.

A framework detailing management matrices for each feature included in the wildlife strategy is a handy tool to assist in management decisions. The manager should develop these matrices for each of the features included in the area they are responsible for. For example, Text Box A.15 presents a management matrix for the feature "orang-utan" in the Malua Forest Reserve.

Text Box A.15: Example of a management matrix developed for orang-utan for the Malua Wildlife Strategy

	Results	Possible reasons	Impact on Management Strategy
Results of Aerial Survey and Permanent Transects	Increase in population size estimates	1. No food nor social stresses 2. Bias resulting from temporary food abundance (mass fruiting event) 3. Influx of refuges from nearby areas	1.2. No specific change 3. Investigate reasons for influx; 3. Assess impact of artificially inflated densities on the ecosystem
	Population size estimate stable	1. Orang-utan life history parameters prevent fast population recovery	1. No specific change
	Decrease in population size estimate	1. Food scarcity 2. Social stress	1. Intensify restoration with fruit trees 2. Identify sex/age classes the most at risk
Results of opportunistic sightings (recce walks, log books)	Majority of adult females with baby or infant	1. No food or social stresses	1. No specific change
	Presence of excess males close to oil palm plantations	1. Influx of newcomers inducing a population compression 2. Transient males stranded in isolated forest patches	1. Consider relocation 2. Identify bottleneck areas and provide "escape ways"
	1.Fewbabies/infants 2.Consumption of unusual food items	1.2. Food shortage resulting in increased mortality, lower breeding success and social stress	1.2.Intensify restoration with fruit trees 1. Consider relocation if there are excess males
Results of interviews with oil palm plantations	No conflict	1. No food shortage	1. No specific change
	Conflict but no illegal killing	1. Food shortage	Develop proper mitigation methods 1. Increase restoration along boundaries 1. Consider relocation
	Illegal killing as a means for conflict mitigation	1. Food shortage 2. Lack or failure of awareness efforts	1. Develop proper mitigation techniques 2. Increase restoration efforts 3. More awareness and enforcement needed.

Overall, the wildlife strategy, the results of wildlife monitoring activities, and the planning process itself need to be revised regularly by the supervisor in consultation with the teams involved in field work activities, with a focus on adapting to conditions and opportunities encountered on the ground. Refinement or creation of management activities and plans concerning the identified key wildlife species requires expert analysis of the data collected during the proposed wildlife monitoring surveys. This data analysis should be undertaken regularly (at least once a year) in order to gain sufficient understanding of each species within the concerned area. Finally, an annual external and/or independent review or audit is recommended at least every five years, to ensure that monitoring strategies are precise and fundamentally sound.

6.4. Need to conceive a wildlife strategy at the landscape level.

The viability of most wildlife populations depends on the environmental matrix that extends well beyond the geographic boundaries of the area that falls under the manager's jurisdiction. As a result, efficient conservation and wildlife management strategies must be taken at a regional scale and should consider the landscape encompassing multiple-use forests, agro-industrial lands and other types of land-use practices that are found outside of the managed area. It is crucial to consider activities that affect wildlife resources and to address wildlife threats that take place outside of the managed area. For example, there is no point to protect a species like tembadau if the herds are decimated as soon as they leave the managed/protected area.

Therefore, it is necessary to identify the different stakeholders and their associated land-use practices outside of the boundaries of the managed area. This identification phase is followed by a consultation process that will: (1) determine what management plans and wildlife strategies exist for these sites; (2) assess if these plans are on line with the desired outcomes for the features; (3) inform the stakeholders of what is needed in order to achieve the goals of the strategy; (4) assist in the development of management practices that will minimize the negative impacts of their activities on wildlife resources; (5) inform relevant stakeholders of status of the features that are monitored in the managed area; (6) assess the level of threats within the areas that fall within their jurisdiction; (7) share information regarding the results of the wildlife strategy.

Numerous actions need to be considered and undertaken to achieve this:

- Locate and map all pockets of natural habitat (protected forests; HCVF; riparian forest reserves; etc.) in the areas surrounding the managed site;
- Develop a Master Plan that includes a map showing where forest corridors need to be established at the regional level;
- Ensure that sign boards that show the boundaries of the managed areas and of the protected forests (HCVF, riparian forest reserves, etc.) are erected and maintained;
- Ensure that all stakeholders are aware of the protected status of wildlife: provide sign boards that explain the status of protected species and the offences faced by poachers and awareness campaigns are initiated, etc.;
- Ensure that poaching is completely controlled (too often, land users of sites adjacent

to well-managed forests perceive these areas as a source of game resources, which results in an increased poaching pressure);

- Develop an efficient communication system to share the conclusions of wildlife management activities with all stakeholders living in the region;
- Inform local, regional and national authorities about the results of the wildlife monitoring activities.

Pangolin (*Manis javanica*): pangolins are nocturnal and forage primarily on termits and ants. All populations are in sharp decline because of the illegal trade for their meat and their scales.

Annex I: GLOSSARY and LIST of ABBREVIATIONS

Glossary

Biodiversity:	Contraction for "biological diversity". It is the variation of life at all levels of biological organizations: this is encompassing the totality of genes, species and ecosystems of a region (including both biotic and abiotic factors).
Bio-indicator:	Measure of biology and other feature of the environment that reflects to some degree the state of ecosystems, habitats and components of biodiversity. A bio-indicator aims at fulfilling three major functions: • simplification: to provide a simplified measure of a complex feature; • quantification: to enable numerical assessment; • communication: to help understand the condition of a natural feature.
Biomass:	Total weight of living organisms in a given area.
Carrying capacity:	Number of individuals that can be supported in a given area without deterioration of the habitat.
Density:	Number of animals or plants per unit area.
Detection probability:	Probability of a species occurring at a site combined with the probability of actually detecting it when it is present with whatever sampling techniques are being used.
Dispersal:	Permanent abandonment of a home range in search of suitable habitat for a new home range (called emigration): dispersal of young immature/dispersal as a response of habitat disturbance.
Ecological niche:	The role of a species in a community as determined by its distribution, adaptations and behaviours.
Ecosystem:	A dynamic complex of plant, animal, fungal and microorganism communities and their associated non-biological (abiotic) environment interacting as an ecological unit. Four levels: • genetic diversity: variety of genes within a particular species; • species diversity: number and variety of species found in a given area; • ecosystem diversity: diversity of ecosystem mosaic. • landscape diversity: variety of ecosystems that occur within a larger landscape
Effective Strip Width:	Along a transect, width within which the detection probability of the objects is 1.
Feature:	A habitat, matrix, species or a species assemblage occurring at a given site.
Home range:	An area traveled by an animal or a population in its normal activity: all the requirements for sustaining the animal must be found within the home range. We can distinguish between daily and seasonal home ranges.
Index:	Measurement that is related to the actual number of animals or plants under focus.
Migration:	Two-way (or more) movement of an animal or group of animals between seasonal home ranges.
Monitoring:	A surveillance undertaken to ensure that formulated standards are being maintained.

Population:	Group of animals that occupies a certain area at a certain time (biological population). It is also defined as any collection of individuals which are the subject of investigation (studied or target population).
Population density:	Number of individuals per unit area in a given population.
Population dynamics:	Fluctuation of the size of a population through addition and losses of individuals.
Population range:	Area occupied and used by animals belonging to a given population.
Population size:	Number of animals within the given population (absolute population size).
Species:	A group of organisms capable of interbreeding freely with each other but not with members from other species (a genetic criteria includes that more than 0.3% difference in nucleotide sequence defines two independent species).
Stratification:	Act of separating something into distinct categories (or strata).
Surveillance:	Collection and analysis of repeated observations or measurements without predetermined objectives (it intends to measure key ecological attributes in a given area over an extended period of time and assess wildlife population trend through time).
Survey:	Making a single observation to measure and record something.
Territory:	Part of the home range that an animal or a group of animals defends to the exclusion of other members of its own species.

List of Abbreviations

ASL:	Above Sea Level
CV:	Coefficient of Variation
DBH:	Diameter at Breast Height
DFO:	District Forest officer
EIA:	Environmental Impact Assessment
ESW:	Effective Strip Width
FF:	Front Feet
FSC:	Forest Stewardship Council
GPS:	Global Positioning System
HCVF:	High Conservation Value Forest
HF:	Hind Feet
HoB:	Heart of Borneo
HWW:	Honorary Wildlife Wardens
KOCP:	Kinabatangan Oarng-utan Conservation Programme
LKWS:	Lower Kinabatangan Wildlife Sanctuary
m:	meter
∑ :	Sum
SD:	Standard Deviation
SFD:	Sabah Forestry Department
SWD:	Sabah Wildlife Department
WCE:	Wildlife Conservation Enactment
WWF:	World Wildlife Fund

Annex II: THE BASICS OF STATITSICS

This part gives a very brief and rapid overview of one of the most important aspect of wildlife management: data analysis and data interpretation. Data analysis is the process of summarizing the data collected in the field and summarizing in a numerical and graphic form. Data interpretation is the process of giving biological meaning to the results. Unless the data are analyzed and shared with people who are implementing field activities, our studies are of small value. An abundant literature already exists about ways to analyse data and about statistics, and only a few general ideas are discussed here.

Always remember that reliable results come from reliable data: before doing any analysis, review the methods used to collect the data and review the conditions under which the data were collected:

- Are they the results of quick guesses or the results of well-established protocols?
- Was the staff properly trained?
- Were the methods appropriate to answer the questions?
- Was the time of the year appropriate for the study?
- Was the sample size large enough?

Several types of measurements and distributions.

One can distinguish three major types of measurements:

- *Interval level measurements*: physically counting, weighing or measuring something in order to measure the difference between individuals. Interval level measurements can be continuous (infinite number of values such as fractions, weights, lengths, etc.,) or discrete (integer number of values, such as number of trees in a plot, of people in a village, animals in a population).
- *Ordinal level measurements*: measurements are ranked so we can also rank the difference ("sample A is bigger than sample B"). Data are classified into classes, such as quantity of flowers in a tree (absence – a few – a lot); canopy openness; etc. With ordinal data, the true difference between measurements cannot be assessed.
- *Categorical level measurements*: objects or answers collected during interview surveys are assigned a specific category, but these categories cannot be ranked and compared directly: nest classes; dung classes; sex; etc.

Values collected during field activities can often be visualized by plotting their frequency of distribution (histogram). The distribution shows the range of the data (how spread they are) and the pattern of the data across this range. Two major types of distribution are susceptible to describe our data with a relatively easy mathematical formula:

1. _Normal distribution_: the spread is more or less symmetrical around the average (mean) value of the sample (figure 1).
2. _Poisson distribution_: when discrete interval level data are independent of one another. They are expected to follow a Poisson distribution. Data are bunched on one side of the mean and

there is a long tail: data are not symmetrically distributed. This distribution applies to processes in which detection probability is constant across time and space. This distribution is the most commonly encountered in biological processes. To conform to a Poisson distribution, a variable must have a mean which is relatively small compared to the maximum value in the sampling unit (Figure 2).

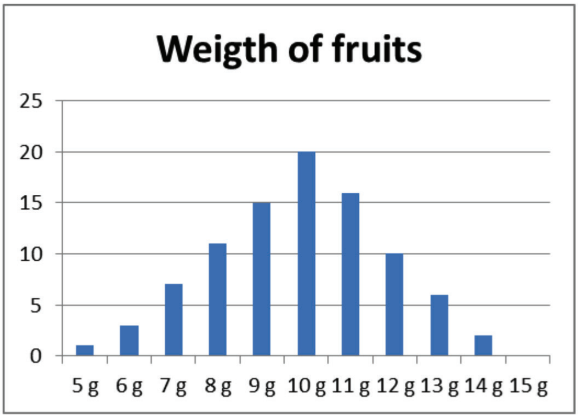


Figure 1: Normal distribution

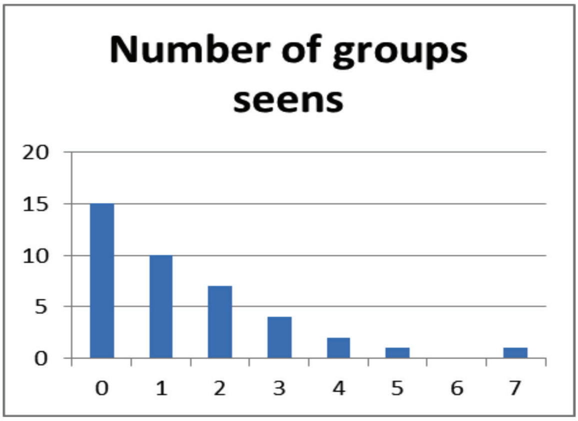


Figure 2: Poisson distribution

However, certain data sets are not following these two distributions, and more complex formula are needed to describe these data, such as bimodal or binomial distribution, etc.

When the sample size is too small, it is difficult to determine the shape of the distribution of the data, preventing the use of basic statistics methods. In two words, the more data the better. However our survey efforts should be balanced with what resources are available.

Descriptive statistics: the basics.

Statistics is a group of methods that are used to collect, analyse, present and interpret data and to make decision. Descriptive statistics are used to organize, display and describe the data: they summarize large data sets in tables, graphs and summary measures.

Inferential statistics are methods used to analyse the data and assist in decision-making or population management decisions. They mostly describe what is typical of the population (a central tendency) and the variation of the population from this center.

The range is the maximum spread of all data (smallest and largest data point recorded in our data set: the range can be calculated by subtracting the minimum value from the maximum value). Mean, median and mode are different ways of describing the "centre" of the data set.

1. *Arithmetic means or average*: sum up all the data points and divide them by the sample size.
2. *Median*: value with an equal number of data on either side of it: the median divides the frequency distribution in two halves. Median is useful to describe frequencies that are not symmetrical about the mean.
3. *Mode*: it is usually used for categorical measurements. The mode represents the most frequent value in a sample. This is visualized by the "peak" on a graph of frequency distribution. If two or more values rank the same, the distribution is bimodal or multimodal.

For data that are normally distributed, the mean, median and mode are the same!

Additional basic descriptive statistics measures include:

4. *Variance:* this is the average deviation of observations from the mean value of the sample: this measure quantifies how widely or narrowly the data are dispersed around the mean. If the values fall close to the mean, the variance is low:

$$Variance = \frac{\sum(each\ value - mean)^2}{n-1}$$

5. *Standard deviation*: is the average deviation from the mean. For a normal distribution, this is the square root of the variance:

$$SD = \sqrt{Variance}$$

6. *Coefficient of variation*: shows the standard deviation as a percentage of the mean. This allows for comparing the variability of similar variables with different units:

$$CV = \left(\frac{SD}{Mean}\right) x100$$

7. *Standard error*: is a measure of the repeatability of a survey. It combines the variability in the population with the variability due to the sampling effort. This is the average deviation of sample means from the population mean. In other words, SE gives a statistical assessment of the probable range of values for the real mean:

$$SE = \frac{SD}{\sqrt{Sample\ Size}}$$

8. Confidence limits: they give a measure of precision of the sample estimates and are a direct reflection of the variability of the data. The distance between the lower and the higher data is called the confidence interval of the sample. Confidence limits are usually set at 95%.
   For a normal distribution with more than 30 samples, the 95% Confidence Limit = z x SE, with z=1.96. In this case the 95% Confidence Interval is: Mean $\pm$ 1.96 SE.
   If there are less than 30 samples, the z value is originating from a Student's Table.
   Another way to estimate 95% CI is to use non parametric bootstrapping. In this case, we assume that the variability within the sample is a good approximation of the variability within the population from which the sample is drawn.

Inferential statistics: the basics.

Inferential statistics are a group of methods that help making decision about the population from where the sample results are originating from. It will provide a way to estimate how reliable is the conclusion derived from our data. This measure is usually in the form of a probability. Many tests are available to estimate this probability. For data originating from a "Normal Distribution", we can use "parametric test". In the contrary, when data are not normally distributed around the mean, we use "non-parametric tests".

Inferential statistics make assumptions based on the data to tell us the probability for the samples to be different and to be representative of the original population. As a rule of thumb, the threshold limit is set up at 5%. A 5% significance level means that there is 1 in 20 chance that our conclusion will be wrong due to random error in the sample. All statistic tests require a minimum of 5 data to be meaningful. These statistical steps all follow the same logical framework:

1. We set up a null hypothesis (and its alternative hypothesis). The null hypothesis is a hypothesis of "no difference" and is usually noted Ho. What we want to assess is actually the hypothesis that the sample is not different than the studied population.
2. We need to look at the measurements and to assess if the data are normally distributed or not in order to determine if parametric or non-parametric tests need to be sued.
3. The result of the tests gives the probability of obtaining results at least as extreme as the one we have if the null hypothesis was true (i.e., no difference): in other words, the tests give the probability that the differences observed with our data sets could be explained by pure chance.
4. If the probability is too small, we can reject the null hypothesis and accept the alternative hypothesis H_1, that there is a difference. In general, if the probability of getting a difference of the magnitude obtained in the study is 5% or less, the difference is considered statistically significant and we reject the null hypothesis. That is, there is a >95% probability that the difference is NOT due to chance or random events.

Tembadau or banteng (*Bos javanicus*): this species of Bovid is fully protected under the Sabah Wildlife Enactment, 1997. However poaching has resulted in local extinction and decline of all populations in Borneo. Only a few scattered populations of small size remain today in Sabah.

Annex III: THE TWENTY COMMONEST SURVEYING MISTAKES

(from Sutherland)

Not knowing your species: understanding the study species is essential for considering biases and interpreting data.

Not knowing exactly why you are surveying / Collecting data without knowing how they are going to be processed: think exactly what the question is and what data are required to answer it. How will the data be presented and analysed?

Counting in one or a few large areas rather than a large number of small areas: a single count gives no measure of the natural variation and it is then hard to see how significant any changes are.

Not giving precise information as to where sampling occurred and whom did the sampling: give the precise data and location; always use a GPS.

Only sampling sites where the species is abundant: it seems obvious to concentrate upon sites where the species is known to occur. However it is important to know where the species occurs at low density or where it is absent.

Changing the methods in monitoring: unless there is a careful comparison of the different methods, changing the methods prevents comparisons between years and sites.

Pretending that the samples taken within a site are replicates.

Not having controls in management experiments: this is the greatest problem in interpreting the consequences of management.

Not being honest about the method being used: crucial to describe precisely the methods used during the experiment for comparing with other similar studies.

Believing that the density of trapped individuals is the same as the absolute density.

Assuming that the sampling efficiency is similar in different habitats: differences in physical and vegetation structure will influence almost every surveying technique and thus confound comparisons.

Deviating from transect routes.

Not knowing the assumptions of the survey techniques: each technique has its own assumptions and it is important to consider these.

Thinking that someone else will identify all your samples for you.

Assuming that other people will collect data in exactly the same manner and with the same enthusiasm. Everyone collects data in a slightly different way, which affects the results: it is essential to standardize and test.

Being too ambitious: a common problem is to start an extensive project that is never completed.

Not knowing the difference between accuracy and precision: ideally we want the result to be both accurate and precise. A precise but biased (inaccurate) measure may be sufficient if we look for changes over time. Accuracy is important to estimate population size.

Believing the results: practically every survey has biases and inaccuracies: the secret is to evaluate how much this matters.

Not storing information where it can be retrieved in the future.

Not sharing the results of the investigations: no point of doing the work unless the results are shared with relevant partners and key audiences.

Annex IV: REFERENCES AND FURTHER READINGS

A vast literature is available about wildlife monitoring techniques. Provided here is a short and non-exhaustive list of readings that are easy to obtain from the web (articles and books that can be freely downloaded are indicated with *).

Alexander. M. 2008. *Management Planning for Nature Conservation*. Springer Science. 425 pp.

Amstrup, S. C., McDonald T.L., and Manly. B.F.J. 2005. *Handbook of Capture-Recapture Analysis*. Princeton University Press.

*Ancrenaz, M., Hearn, A.J., Ross, J., Sollman, R., and Wilting, A. 2012. *Handbook for wildife monitoring using camera-traps*. BBEC II Secretariat; c/o Natural Resources Office, Kota Kinabalu, Sabah, Malasyia. 71 pp.

*Ancrenaz, M., Gimenez, O., Ambu, L., Ancrenaz, K., Andau, P., Goossens, B., Payne, J., Tuuga, A., and Lackman-Ancrenaz, I. 2005. Aerial surveys give new estimates for orang-utans in Sabah, Malaysia. *Plos Biology*, 3 (1): 30-37.

*Bennun, L., Davies, G., Howell, K., Newing, H., and Linkie, M. 2002. *African forest biodiversity: a field survey manual for vertebrates*. G. Davies, Ed. Earthwatch Europe, UK. 172 pp.

Brockelman, W.Y., and Ali, R. 1987. Methods of surveying and sampling forest primate populations. In *Primate conservation in the Tropical Rain Forest*. C.W. Marsh and R.A. Mittermeier (eds), pp. 23-62. Alan R. Liss, New York.

Buckland, S. T., Anderson, D. R., Burnham, K. P. and Laake, J. L. Eds. 1993. *Distance sampling: estimating abundance of biological populations*. Chapman & Hall, London, UK.

Buckland, S.T., Plumptre, A.J., Thomas, L., and Rexstad, E.A. 2010. Design and analysis of line transects for primates. *International Journal of Primatology*. DOI 10.1007/s10764-010-9431-5.

Dytham, C. 2003. *Choosing and using statistics: a biologist's guide*. Blackwell Publishing, Carlton, Victoria, Australia. 258 pp.

Donovan, T. M. and Hines, J. 2007. *Exercises in occupancy modeling and estimation*. < http://www.uvm.edu/envnr/vtcfwru/spreadsheets/occupancy/occupancy.htm >

*Efford, M. G. 2011: *Spatially Explicit Capture-Recapture Models*. R package version 2.1.0. http://CRAN.R-project.org/package=secr

*Fiske, I., Chandler,R.B., and Royle, J.I. 2011. Unmarked: Models for Data from Unmarked Animals. R package version 0.9-0. http://CRAN.R-project.org/package=unmarked

Goossens, B., Setchell, J.M.,Abulani, D.M., Jalil, F., James, S.S., and Aris, S. 2003. A boat survey of primates in the Lower Kinabatangan Wildlife Sanctuary. *In Lower Kinabatangan Scientific Expedition* 2002. M. Mohamed, A. takano, B. Goossens and R. Indran (eds), pp 37-46. University Malaysia Sabah, Kota Kinabalu.

*Gustafsson, L., Nasi, R., Dennis, R., Nghia, N.H., Sheil, D., Meijaard, E., Dykstra, D., Priyadi,H. and Thu, P.Q. 2007. *Logging for the ark: improving the conservation value of production forests in South East Asia.*: Center for International Forestry Research (CIFOR), Bogor, Indonesia. 74 pp.

Hilty, J. and Merenlender, A. 2000. Faunal indicator taxa selection for monitoring ecosystem health. *Biological Conservation*, 92: 425-436.

*Hockings, M., Stolton, S., Levirington, F., Dudley, N., and Courreau, J. 2006. *Evaluating effectiveness: a framework for assessing management effectiveness of protected areas*. 2nd edition. IUCN, Gland, Switzerland. 105 pp.

*Kie, J.G. 1988. *Performances in wild ungulates: measuring population density and conditions of individual*. US Fish and Wildlife Services, Pacific Southwest. 17 pp.

*Kuhl, H., Maisels, F., Ancrenaz, M., and Williamson, L. 2008. *Best Practices Guidelines for Surveys and Monitoring of Great Ape Populations*. IUCN SSC Primate Specialist Group. Gland, Switzerland. 32 pp.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and Hines, J.E. 2006. *Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence*. Elsevier, New York.

Mackenzie, D.I., and Royle, A. 2005. Designing occupancy studies: general advice and allocating survey effort. *Journal of Applied Ecology*, 42: 1105-1114.

Marshall, A.R. Lovett, J.C., and White, P.C.L. 2008. Selection of line transect methods for estimating the density of living animals: lessons learnt from the primates. *American Journal of Primatology*, 70: 1-11.

Mathewson, P.D., Spehar, S.N., Meijaard, E., Purnomo, N., et al. 2008. Evaluating orang-utan census techniques using nest decay rates: implications for population estimates. *Ecological Applications*, 18 (1): 208-221.

*Nelleman, C., Shivus, B., Malata, P., and Kisingo, A. 2011. *Sign and the art of tracking – a guide to support law enforcement tracking and anti-poaching operations*. Interpol/UNEP. 132pp.

Nijman, V., Menken, S.B.J. 2001. Density and biomass estimates of gibbons (*Hylobates muelleri*) in Bornean rainforest: A comparison of techniques. In *Forest (and) Primates: Conservation and Ecology of the Endemic Primates of Java and Borneo* (ed. V. Nijman), PhD thesis, pp. 13-31, Tropenbos International.

Olupot, W., and Sheil, D. 2010. A preliminary assessment of large mammal and bird use of different habitats in Bwindi Impenetrable National Park. *African Journal of Ecology*; 49: 21-30.

Otis, D. L., K. P. Burnham, G. C. White, and Anderson, D.R. 1978. Statistical inference from capture data on closed animal populations. *Wildlife monographs*, 62: 1–135.

Payne, J., and Francis, C.M. 2007. *A field guide to the Mammals of Borneo*. The Sabah Society, Kota Kinabalu, Sabah, Malaysia. 332 pp.

Plumptre, A.J., and Harris, S. 1995. Estimating the biomass of large mammalian herbivores in a tropical montane forest: a method of faecal counting that avoids assuming a "steady state" system. *Journal of Applied Ecology*, 32:111-120.

*Rexstad, E., and Burnham, K.P.. 1991. *User's Guide for Interactive Program CAPTURE*. Colorado Cooperative Fish & Wildlife Research Unit, Colorado State University, Fort Collins, Colorado.

Royle, J. A., and Nichols, J. D.. 2003. Estimating abundance from repeated presence-absence data or point counts. *Ecology*, 84 (3): 777–790.

*Schnell, I.B., Thomsen, P.F., Wilkinson, N., Rasmussen, M., and Gilbert, M.T.P. 2012. Screening mammal biodiversity using DNA from leeches. *Current Biology*, 22 (8).

*Sit, V., and Taylor, B. 1998. *Statistical methods for adaptive management studies. Land Management Handbook*. Ministry of Forest, British Columbia, Canada. 148 pp.

*Sodhi, N.V. and Ehrlich, P. eds. 2010. *Conservation biology for all*. Oxford University Press, UK. 338 pp.

Solari, S., Rodriguez, J.J., Vivar, E., and Velazo, P.M. 2002. A framework for assessment and monitoring of small mammals in a lowland tropical forest. *Environmental Monitoring and Assessment*, 76: 89-104.

Sutherland, W.J. 2006. *Ecological Census Techniques a handbook. 2nd edition*. Cambridge University Press, UK. 432 pp.

*Tucker, G., Bubb, P., de Heer, M., Miles, L., Bajracharya, S., et al. 2005. *Guidelines for biodiversity assessment and monitoring for protected areas*. UNEP-WCMC. Katmandou, Nepal 132 pp.

Thompson, M.E., Schwager, S.J., Payne, K.B., and Turkalo, A.K. 2009. Acoustic estimation of wildlife abundance: methodology for vocal mammals in forested habitats. *African Journal of Ecology*. DOI: 10.1111/j.1365-2028.2009.01161.x

Vynne, C., Skalski, J.R, et al. 2010. Effectiveness of scat-detection dogs in determining species presence in a tropical savanna landscape. *Conservation Biology*. DOI: 10.1111/j.1523-1739.2010.01581.x

*White, L. and Edwards, A. eds. 2000. *Conservation research in the African rainforest: a technical handbook*. Wildlife Conservation Society, New York, USA. 444 pp.

*White, G.C. and Burnham, K.P. 1999. Program MARK: Survival estimation from populations of marked animals. *Bird Study Supplement*, 46: 120-138.

A. Way to handle anesthetized small rodents for physical examination and measurements.
B. Collecting fecal sample for further DNA analysis.
C. Observing primates during a boat survey.
D. Small mammal trapping.
E. Observing the behaviour of wild elephants.

PART 2:

FIELD ACTIVITIES

River monitoring from a slow motion boat is an efficient way to record regular information about many wildlife species that can be detected along the river edges (monkeys - proboscis monkeys in particular, and birds during the day, carnivores and crocodiles at night, etc.) as well as possible encroachments and disturbances from human origin.

TABLE OF CONTENTS

Part 2: Field activities

The second part of this Manual complements the previous part of the Manual and can be brought to the field by the teams during their field activities.

A family unit of Bornean elephants investigating a source of disturbance. When elephants are disturbed by the presence of people, they form a cohesive group around the matriarch of the unit to assess the danger.

Chapter 7: OBSERVING WILDLIFE AND COLLECTING DATA

7.1. Preparation for field activities.

Animals are mobile, shy, difficult to detect and often hard to identify with certainty. Good data result from good observation of the animals themselves, their signs and their surrounding habitat. It is important to record what is seen in the field, and not what we think we have seen. A common mistake is to record guesses as facts. If observers are not sure about what they have seen, they should write a note about this. Wrong information will lead to wrong conclusion. In the field, the team should write down as many details as possible about observations. Common mistake is not to record enough information, or have the intention to fill up the log books and data sheet after returning to camp. The more that is written during field activities the better. For example, all the questions/boxes that are on the data sheet must be filled up during the data collection and not after we are back to camp. Additional information must be recorded in a logbook. Hand writing has to be legible not only to the data reporter but also by other people who will handle the data for data processing. **Good field data are truthful, accurate and well written.**

Animals are generally afraid of people and observing them in their natural environment requires moving quietly and remaining silent. It is important to walk slowly in the forest to maximize detection of direct and indirect indices of animal's presence (footprints, dung, animals), and to be attentive to the surrounding sounds since animals are often heard before they are seen. Unless specified otherwise, a wildlife team should consist of not more than two or three people to minimize noise and disturbance. **Smoking is not an option while looking for wildlife.**

Because it is close to impossible to make accurate records for all wildlife observations, it is imperative to be familiar with, and able to recognize with certainty the species that are included in the wildlife strategy. It is also of paramount importance to know precisely the signs that need to be looked for and the data that need to be recorded within the frame of the wildlife strategy. The attributes selected for monitoring purposes must be known and understood by the people involved in the wildlife study. **Every time one of these attributes is detected in the field, it must be recorded**. It should be noted that it is worth recording additional wildlife observations even for the most common species or if they are not included in the list of *Key Wildlife Features*

Team doing line transect survey in nipah mangroves.

A team of field research assistants recording data about orangutan nest during a line transect survey.

selected for the area. When encountering an unknown species, attention needs to be focused on key characteristics that will help identifying the species, e.g., general coloration and marking patterns (skin, plumage), size, shape and length of the tail, bill and wing shape (for birds); behavior; location in the forest; and surrounding habitat.

Before going to the field, the team needs to be aware and to be familiar with the type of field activities they are going to carry out, and what information is going to be collected. Everyone needs to know how to use specific data sheets designed for wildlife monitoring.

Equipment checklists should be available for the survey techniques selected for the wildlife strategy. Before entering the forest, these checklists need to be checked to ensure that the team brings all the equipment needed to conduct the fieldwork with ease. Depending on the type of activities, these list could include: log books and data sheet, pencils, rulers, clipboard, compass and GPS, binoculars and camera, map of the area, field identification books , plastic vials for sample collection (feces, food remains), gloves, plastic bag for collecting dead animals (road kills), torchlight, and spare batteries.

(Left) Field camp established in the forest and used on a regular basis for monitoring activities and (right) car survey at night to detect nocturnal species.

7.2. Collecting data about footprints, tracks and trails.

A lot of information about wildlife originates from marks and signs left by animals in the environment (**indirect sightings**). Although these indirect sightings are relatively frequent in the forest, reading tracks and recording information properly is difficult. It requires a lot of training and significant field experience to collect consistent and accurate information. The first thing to remember when looking for tracks is to **slow down** and to pay attention to all details.

7.2.1. Footprints.

Tracks and trails are the most common signs of wildlife encountered in the field. Many animals use regular routes for moving across the environment. It is thus possible to focus search efforts on pre-established trails, dirt roads, along streams and ridge tops where chances of detecting footprints are maximized.

Track: single foot or hand print;
Track pattern: spatial arrangement of the tracks left by all four hands/feet of the animal;
Tracking: process of following a track pattern and recording data;
Trail: animal passing that sometimes indicates directionality (footprint, food remains, scats);
Substrate: surface on which a track is imprinted.

Distinguishing between species can be very difficult and requires good observation skills. Identifying footprints is learnt through practice and by consulting field identification books. *Plantigrade species* are those that walk using their whole foot (bears, porcupines, primates, humans). *Digitigrade species* walk on their toes (cats, dogs, civets). *Unguligrade species* only walk on two toes that form the two cleaves of a hoof (wild boar, deer, cattle) or only the third toe (horses): Figure B.1

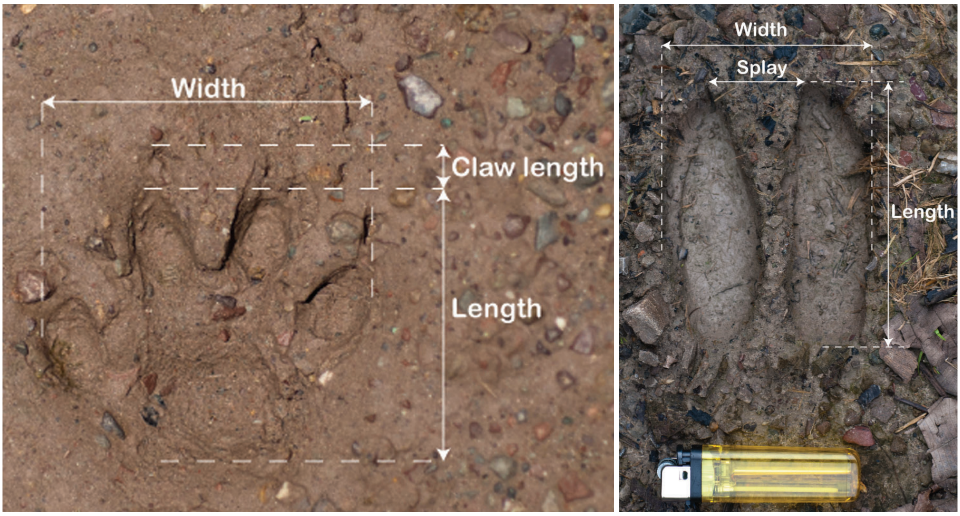


Figure B.1: Footprint of a digitigrade and unguligrade species.

For every footprint, three basic pieces of information are recorded:

Width: widest section from sides-to-side of the print;
Length: measured with and without claws (if visible);
Splay: distance between the two tips of a hoof.

Figure B.2: Measurements characterizing a footprint.

The size and the shape of the track can vary for different reasons:

Left or right feet: for plantigrade species, the smallest of the five digits is the first digit (corresponding to the human thumb); if it appears on the right side of the track, the track was made by the animal's left foot. For cats and other four-digit animals, the smallest digit of the track corresponds to the little finger/small toe; if it appears on the right side of the track, it was made by the animal's right foot. The two halves of a deer's hoof are digits 3 and 4; digit 4 is the outer one and is often slightly larger than the third toe;

Front or hind feet: Front feet (FF) of ungulates typically show a greater splay than the hind feet (HF); cats have a broader and larger FF than HF; plantigrade species have generally a longer HF than FF; elephants have a more oval-shaped FF than HF;

Soil substrate: sand and mud are good substrates for track deposit but they produce larger tracks (compared to actual foot size); hard soil provides more accurate measurements. The tropical forests floor is often covered by leaf litter, preventing good track deposit. Improving track detection here can involve sweeping away leaves and other material covering the top soil, or depositing sand over a path. Often logging roads, river banks or edges of waterholes are good sites for track surveys;

Topography: tracks deposited while walking up steep slopes will be smaller than actual, and those deposited going downhill will be larger than those found on level ground;

Age of the track: fresh tracks have well-defined vertical edges. Older tracks are more difficult to measure. With time, they start to spread and become larger, their edges fade away and are difficult to define precisely. Tracks remain visible for various time periods, depending on the species leaving the track, soil condition, topography and meteorological conditions (heavy rain will wash away all tracks, drought will render the soil so hard that tracks will be barely visible). With time, vegetation and debris will accumulate and cover the track: assessing the presence of all these factors helps in aging the track;

Gait of the animal or locomotion type: this can be divided in four major categories: walking, trotting, galloping and jumping. When an animal is walking or trotting, it shows a symmetrical track pattern. When running or jumping, the prints are unevenly spaced and tend to be more grouped: for a gallop, the HF tracks are always in front of the FF.

The track pattern is described with some additional measurements:

Step: distance from one set of tracks to the next;
Stride/Pace: a measure of two consecutive steps, giving an approximation of body length when the animal is walking;
Straddle: width of the outermost edges of opposite tracks;
Intergroup measurement: distance between the leading point of one track pattern to the next track pattern (during gallop or jump). This measurement is helpful to determine the gait of the animal.

When tracks cannot be identified, it is worth taking a permanent record with a drawing or a photograph. It is also possible to do a plaster cast of the track. In this case, it is important to clear all debris and vegetation obscuring the edges of the track before pouring the plaster. Ensure that measurements are taken (as mentioned above) and to place a ruler or an object of known dimension (such as a lighter) to give the object scale before taking photographs.

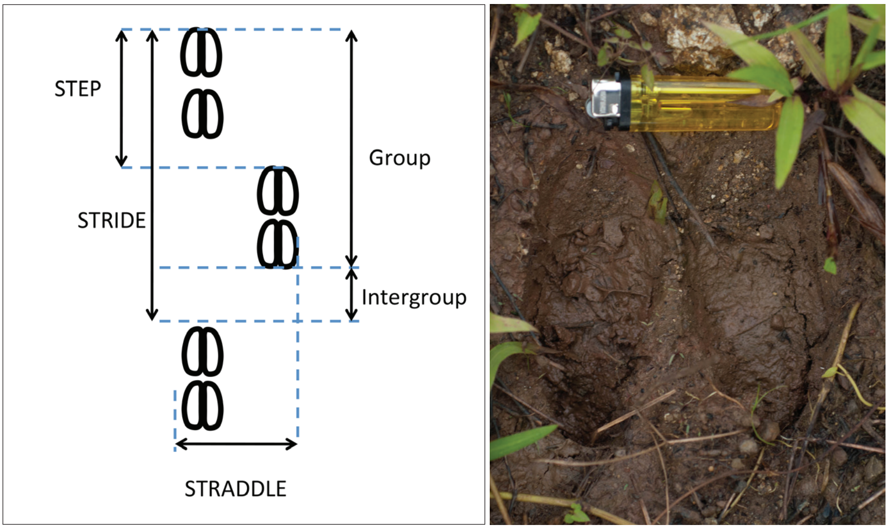


Figure B.3: Characterizing a track pattern.

Figure B.4: Different types of feces (scat of carnivores; dung of tembadau; pellets from deer).

Box B.1: Who left this footprint?

Identifying a track to genus or, even better, species level requires a bit of detective work. An identification guide (see chapter 7) with scale drawings of possible prints is a good tool to help distinguish between species. A ruler is also an essential tool, as it will be necessary to measure both the length and breadth of the tracks. The following steps help to identify the owner of the footprints in Sabah:

a. Hoofed animals: simple measurements can narrow the choice down to either one of the smaller deer species – muntjac or mouse deer – or the larger ungulates – banteng, sambar deer or bearded pig.
   - Sambar tracks and pig tracks may sometimes be confused. In general, pig tracks are broader and more rounded than sambar tracks.
   - The presence of scat near the track may also help in the ID process.

b. Padded animals: are there claws present in the track?
   i. No claws present: members of the cat family, as a rule, do not show claws in their prints. The size and shape of the central pad can provide a clue as to the specific species.
   ii. Claws present: if there are claws present, the prints could belong to any number of animals e.g., civets, otters, martens, porcupines:
   - Look at the number of toes visible, the shape of the toes and the pad, and measure the length and breadth of the whole track, comparing your findings with the drawings in this guide.

Remember that substrate can have a large effect on the size of a track, with muddy surfaces making tracks appear bigger than they really are. Also be aware that animals normally place their hind foot slightly over and forwards of where the front foot was placed when walking, so the hind pad will overlap with the fore pad.

7.2.2. Scats, pellets and feces.

Scats, pellets and feces are commonly found in the forest, and scat surveys have a lot of potential. However, the species is often difficult to determine from direct observation, except when dealing with hoofed animals (Figure B.4.). Sambar deer produces pellets that are easy to recognize with some practice: the pellets are deposited in groups of about 20 to 40 relatively large pieces. Muntjac and mouse deer pellets are very similar in shape, with the only difference being that mouse deer pellet is smaller. With pellet alone, it is impossible to distinguish between the two different species of mouse deers and likewise the two different species of muntjacs. Cat and civet (also otters, weasels, martens, mongooses) scat is very similar in shape and size. Examining the contents of the scat may provide clues as to the animal in question: presence of seeds and vegetation will indicate a member of the civet family since unlike cats, civets eat relatively large quantities of fruit or vegetation. Sun Bear scat is also fairly easy to identify. It is larger and softer than pig scat, not segmented, often very dark in colour, and either contains vast quantities of seeds (especially figs), or is filled with termite exoskeletons. In South-east Asia, many carnivore species of around the same body size live together, which makes species identification a complex task. Species identification can be improved by comparing samples from the field with a reference collection of dried and labelled animal scats. Genetic analysis will provide the ultimate identification, but this quickly increases the cost of the surveys.

Feces are easy to collect and to store. However, feces should never be handled with bare hands to avoid possible genetic contamination of the sample and to minimize the risks of disease transmission. The team should always bring gloves and small plastic bags to manipulate and to store the samples when going to the forest.

When a dung or scat is found in the forest, information such as maximum and minimum diameter, estimated age, species (if known) and any accompanying sign of animal presence need to be recorded. Ancillary information includes the GPS location, and a site description (environmental variables, presence of 'latrines' or communal defecation spot).

If fecal samples are collected for DNA analysis, it is best to scrape the surface of the feces with a sterile stick or a dried twig. As dung is processed by the intestines of the animals, epithelial cells from the intestine's walls are carried with it and are deposited at the surface of the faeces. An adequate sample should be about 2-3 cm^3, the size of a large pea. Avoid contamination by using a new collecting tool for each new sample or by sterilizing the tool between two successive collections (see section 7.5.8.).


Collecting elephant feces at Sukau.

Determining the age-class of the dung and its decay is a way to estimate when animals have been present at a site. However, seasonal differences in decay rates can be significant, and comparisons should ideally only be made for data collected at the same season. Dung decay rates depend on several fluctuating environmental parameters, such as weather conditions (dry versus wet periods); location of dung deposition (presence/absence of shade, soil types); disturbance by physical factors and animals, to name a few. The elephant dung decay rate is detailed in section 8.1.4.

For pellets the following age classes can be distinguished:

Fresh: odour possible, glossy coat (fatty acid and epithelial cells) still present;
Recent: pellets with dulled surface, but no mould;
Old: pellets start to break down; possible change of coloration (carnivores);
Very old: pellets are crumbled, dispersed and covered by leaves or vegetation.

7.2.3. Other animal signs.

Nests are a way to assess the presence of several species in the forests of Sabah, some examples being orang-utan, sun bear, giant squirrel, and birds. Size and number of twigs used for nest construction, the general shape of the nest and its location in the trees are used for identifying the species of nest builder. Wild boars build large terrestrial nests for giving birth.

Additional signs that need to be recorded during field activities will include scrapes or spray marks (cats); bark rubbed off trees (cervids); mud rubbed on tree trunks (elephants, wild boars); claw marks on trees (sunbears); feeding signs and others. More tips for species identification are described in the relevant sections of chapter 8.

7.3. Collecting data from dead animals.

Animal carcasses are another opportunity for data acquisition. Indeed, dead animals can inform about the general health of the animals, their size and body condition, their reproductive status, etc. Dead animals or their remains are found opportunistically in the forest, along the roads (road kill), or at check points (game species). In certain circumstances, specimens are also taken following capture by scientists and wildlife managers.

It is very important to always use gloves when handling dead animals, and to be careful of external parasites that can move from the carcass to the human handler.

Information to be recorded includes date, location, details about the circumstances and possible cause of death, genus (if known), sex and reproductive status. Basic measurements of a carcass include:

Total Length (TL): from the tip of the nose to the tip of the tail (TL=B+T);
Head and Body Length (B): without the Tail;
Tail Length (T): base to tip, excluding the hair that project beyond the tip;
Girth (G): circumference of the body, measured behind the front legs;
Hind Foot Length (HF): from the end of the heel bone to the end of the longest toe, excluding the claws. The HF length is one of the most important measurements to take since this length is subject to less individual variation than other measurements; it is a good indicator for identifying small mammals;
Weight: recorded with a weighing scale.

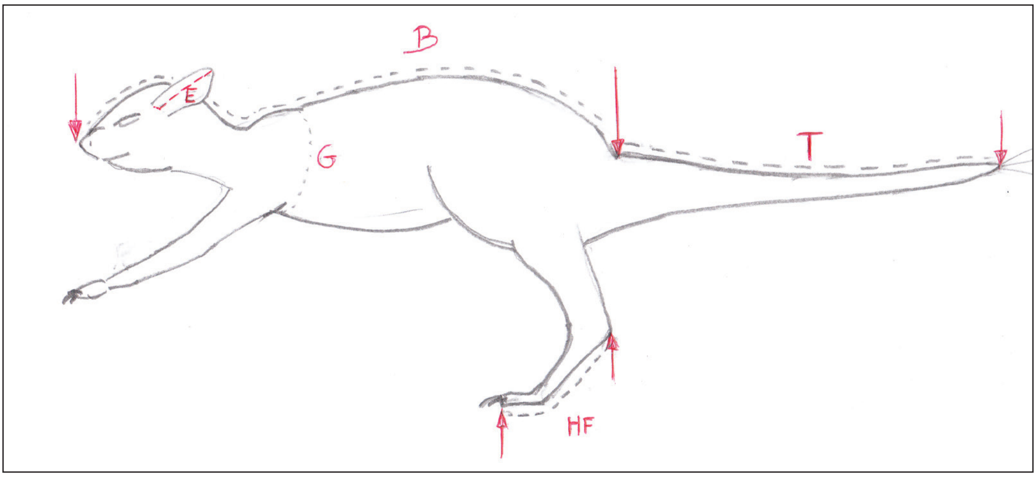


Figure B.5: Basic body measurements.

Observation of a dead animal can provide a lot of information about the individual if we know what to look for:

Sex: look for the presence of primary (testes, penis) and secondary sexual characteristics;
Breeding condition: large and swollen testes may indicate adult males in breeding conditions (small mammals); nipples can indicate pregnancy (swollen with milk) or maturity (small and pink in immature females, brown and wrinkled in adult females);
Body condition: extra fat and glossy fur will indicate sufficient food intake while skinny carcasses will indicate food deficiency or a lengthy health problem. Signs of fighting or falls should also be looked for carefully;
Age: several classes of age are distinguished with mammals:

- Infant: not yet weaned (depending on the milk produced by his mother);
- Juvenile: weaned, but not sexually mature and still depending on his mother;
- Sub-adult: independent from his mother, but not sexually mature. This stage lasts usually longer in males than females, and this stage is also characterized by dispersal;
- Adult: sexually mature; fully grown.

Age indicators include skull suture closure (with disappearance of the lines of sutures with age); changes of body coloration (primates); horns and tusks (rings of Bovid horns show the growth line of the animals). Tooth order and wear provide precise clues for aging mammals. Teeth of mammals grow in a specific order and it is possible to use them to age ungulates and elephants.

Text Box B.2: Using teeth to age elephants.

Elephants have 6 molars on both sides of the upper and lower jaws. During the examination of a skull, the number of molars in the lower jaw are determined first, and then compared with the following chart. The length and width of each molar should also be measured for aging the skull more precisely.

Molar Number	Molar appearance	Molar loss
1	Birth	2 years
2	Birth	6 years
3	1 year	13-15 years
4	6 years	25-30 years
5	18 years	40-45 years
6	30 years	>65 years

A small piece of skin should always be collected and stored in a vial filled up with ethanol for further DNA analysis. Carcasses of small animals can be preserved in a freezer or in a jar filled with ethanol (see part 1 of the Manual).

7.4. Collecting ancillary data.

Biotic and abiotic elements impacting wildlife must be considered to interpret population trends. Ancillary information worth recording includes habitat types and level of degradation, weather, and human activities. It is beyond the scope of this Manual to detail all the available ways to collect and to interpret ancillary data that are relevant to wildlife studies (see reference list for further reading). Table B.1 provides a brief summary of some of the ancillary data that need to be considered for a sound wildlife study.

Understanding and documenting habitat structure, composition, and seasonal fluctuations in forest food productivity is essential to comprehend wildlife dynamics. However these components are often overlooked in wildlife studies. The few techniques explained below provide a simple and rapid way to assess the forest and its production.

A quantitative assessment of the forest structure and composition is conducted in **botanical plots**. These plots can be square (e.g., 50 m x 50 m) or round. However, measuring and demarcating the limits of any quadrat in the forest is time consuming. To save time, the botanical plots of rectangular shape can be established along line transects. The length of these rectangles can be the entire transect or only portions of it. If the *effective strip width* (ESW) searched for data collection is five meters on both side of the transect, it is easy to visualize it directly without measuring. The distance of the trees to the transect is measured only when observers are not sure whether the tree is included within the ESW. In these plots, all trees with a diameter at breast height (dbh, or 1.30 m from the ground) greater than 10 cm are recorded, measured (dbh, height) and identified to the species or taxa level. These data inform about tree density; basal area; tree composition; height classes. Specific attention needs to be given to keystone plant species that are known to sustain wildlife communities, such as fig trees, oak trees, and large climbers. Data about canopy openness, ground vegetation, soil condition, and presence of signs of human disturbances are also recorded during these rapid botanical assessments.

The dynamic of the forest is assessed through the regular monitoring of a subset of trees and plants included in permanent botanical plots (these plots can be located along permanent transects, etc.). The boundaries of the permanent plots need to be clearly identified and marked in the forest with tags and paint. All trees that are recorded within the plots are marked with two tags to ease in relocating them for future surveys. All trees are also mapped very precisely. Ideally, these plots are reassessed every year to document the succession stages and the general health condition of the sample, including mortality and recruitment rates, and growth rates of trees and lianas.

Table B.1: List of ancillary data and ways to record them.

Ancillary data	Recording tool/technique	Frequency
Weather • Air Temperature • Rainfall • Cloud cover • Moon phase	Mercury or alcohol-filled thermometer (Min-Max value) Data logger Rain gauge Direct observation	Daily
Water temperature	Thermometer	Every survey
Habitat characteristics • Dominant landforms • Elevation • Steepness, slopes • Soil characteristics • Water availability	Direct observation Maps – GPS Clinometer - compass Direct observation - charts Direct observation	Every time a survey is done at a new site
Habitat structure and composition • Dominant habitat type • Human disturbance • Average canopy height • Canopy cover • Ground vegetation cover	Direct observation	
Logging activities • Elapsed time • Intensity	Literature search – Direct observation Direct observation- Plots	
Human activities • Presence of settlements • Distance to roads • Hunting pressure	Maps - Interviews Maps - Surveys Interviews – Direct observation	

In order to document the seasonal fluctuations of food resources in the forest, information about presence of flowers, fruits or young leaves that are regularly consumed by wildlife, needs to be collected regularly. This data collection is done systematically within **phenological plots** (see section 5.1.4.), or opportunistically along line transects. In the latter case, all trees and climbers bearing fruits or flowers and that are visible from the transect (line or recce) are recorded in a specific datasheet. A semi-quantitative assessment of the production is achieved by assigning a class of production to each item produced (e.g., fruits, young leaves, flowers). Large fruiting emergent trees that are located up to 50 meters on each side of the transect should also be monitored.

To better understand how wildlife populations adjust and recover from human disturbances, **additional ancillary data** about human activities are also recorded in specific data sheets. Every 50 m, a set of variables are estimated semi-quantitatively by **the same observer** to decrease possible biases. These variables include presence of small/medium/large trees; abundance of climbers and; canopy height. They are processed in four different classes (0 for absence, to 3 for maximum). Signs of human disturbances include number of logging roads (active/inactive); presence of old stumps; or presence of bullet cases or snares. These signs are summed up and transformed in a kilometric index or encounter rate (number of object/km travelled). A general degradation level of the survey area can be deducted by comparing and compiling all these scores.

As an example of this, the following codification is used by KOCP in the lowland forests of Eastern Sabah for rapid assessments of the general stages of degradation and regeneration of the habitats:

No disturbance: more than 300 trees/ha with a diameter dbh more than 10 cm/ha; closed canopy; no sign of human activities;

Intermediate disturbance: tree density between 100 and 300/ha; canopy disruption less than 50%; less than 5 logging roads per km of line transect;

Heavy disturbance: tree density less than 100/ha; canopy disruption > 50%; more than 5 logging roads per km of line transect.

7.5. Recording data: field methodology.

This section aims at providing a technical description of field activities for data collection. It is a simple but complementary and applied extension of the first part of the Manual where these activities were already presented in a more theoretical approach.

Generally, wildlife data can be recorded in specific data sheets or in logbooks (field books). Different data sheets are used for different field activities (see examples of data sheets in the Annex of the Manual). In addition, pocket-sized waterproof logbooks **MUST** be brought to the forest every time the teams are in the field. These field books are used to record all observations that are not recorded in a specific data sheet. For ease of reference, the name of the owner and the number of the field book must be written on the cover of each book.

7.5.1. Collecting continuous and opportunistic data in logbooks.

Remember that **NO DATA IS DATA**: the absence of sighting is always worth recording. It is also crucial to systematically record some core *information* in the logbooks to weight the data with survey effort:

- Type of field activities that are conducted during data collection;
- Date, time, start and end time of the activities conducted in the forest;
- Precise location of the field work (compartments, GPS location) and of the sighting recorded.

All animal sightings are worth recording. However, this can be overwhelming. As a rule of thumb, opportunistic data will include:

- All attributes that have been selected for monitoring the key wildlife features identified in the area (see next chapter);
- Any rare or unusual sighting.

When opportunistic data are collected systematically and precisely over time, they provide indication about seasonal fluctuations of various species, their dynamics (when is the breeding season), and ranging patterns. In turn, this data set can be used for occupancy assessments, for comparing areas and seasons, and possibly for monitoring general population trends.

7.5.2. Collecting wildlife data along recce walks.

Field methodology: Two (to three) people are enough to perform a recce walk:

⇨ *Observer 1* checks the general direction of the recce with a compass and cuts a narrow line;

⇨ *Observer 2* collects data.

The strip sampled should have a constant width to minimize the variation in detectability between different habitat types. Attributes that are detected outside of this width are recorded but it is important to write down that they are far away from the recce and outside of the predetermined strip width. In general, consider:

⇨ 1 m on each side of the transects for foot prints;

⇨ 5 m for elephant dung;

⇨ 10 m to 15 m for direct animal sightings or for orang-utan nests.

Data collection: Similar to a line transect, record number and nature of objects, distance along the line, ancillary data. However the perpendicular distance of the object to the recce line is not measured.

Ancillary data: Ancillary data include habitat description and weather condition, presence of signs of human activities, among others.

Equipment required:

- Map of the area
- Walking Distance measurer
- Compasses
- Binoculars
- Wildlife Identification Books
- Data sheet
- Tape
- Range finder
- GPS
- Tags
- Plastic bags (for samples)
- Field books

7.5.3. Collecting wildlife data along roads.

The following technique was developed in Kalimantan by *The Nature Conservancy* to conduct rapid assessments and monitoring activities along roads. This type of survey uses a section of road in a forest area and records all wildlife indices that are encountered and identified along it.

<u>Wildlife assessment along roads by foot.</u>

Field methodology: The road to be surveyed should be identified from a map or during preliminary field surveys;

- ⇨ The minimum survey length to be covered is 5 km, in multiples of 1 km if possible;
- ⇨ The best time to survey is in the early morning;
- ⇨ Avoid walking the transect if there was a heavy rain in the past 6 hours or during a prolonged dry season;
- ⇨ Walk slowly at a steady pace of 1 km/h, looking at both sides of the road for possible tracks.

Data collection: Record all visible indices of wildlife that are recognized along the road (species level if possible) on the appropriate data sheets;

- ⇨ Change data sheet every 1000 m of the road transect. A 5 km survey should produce five distinct data sheets;
- ⇨ Footprints of the same individual are counted only once within each 1000 segment. Be careful not to count the same animal path multiple times;
- ⇨ Take precise measurements or photographs of undetermined tracks.

Ancillary data: Presence of human signs along the road: vehicles; cartridges, etc.;

- ⇨ Distance to the nearest village or active camp: measured from a GIS or from maps before or after the surveys;
- ⇨ Weather the night before the survey (occurrence of heavy rain): heavy rains will wear off old tracks and soften the ground, and fresh tracks will be easier to detect; conversely during periods of drought, old tracks will remain visible for longer periods of time, and dry hard ground surface will not retain fresh tracks;
- ⇨ Durability of the substrate: type of substrate and vegetation cover will directly influence markings left by wildlife in the soil; a semi-quantitative measurement of these parameters is discussed below.

The durability of the road substrate can be determined by dropping a 1 kg weight (e.g., fishing weight) from a standard height of 1 m (hip height) at regular distances along the transect (every 50 m). After dropping the weight, two descriptive measurements are estimated and assigned to one of the five classes:

- *General condition of the substrate at the point where the weight was dropped*: one of the five following types of soil is selected.
- *Depth of impact from the weight*: from no mark on the ground (very hard substrate); gentle marks (<1 mm); slight marks (1-2 mm); medium (2-5 mm); deep (>5 mm).

Each measurement is assigned a score following this Table:

Table B.2: How to easily determine a durability index for different ground substrates.

Type of Substrate	Compact Ground	Rocky Ground	Pebbles	Sand	Mud
	0	1	2	3	4
Depth of Impact	None	Very Slight	Slight	Medium	Deep
		1	2	3	4

The two scores are summed and provide a durability index (fluctuating between 0 which is the hardest substrate to 8 which is the softest). These indexes are estimated every 50 m along the road and averaged to provide a *Mean Durability Index* for each transect or each section of 1000 m.

Equipment required:

- Field book
- Data sheet
- Binoculars
- Camera
- Ruler
- Tape measurer
- String
- Identification field books
- GPS
- Weight

<u>Wildlife assessment along roads by car.</u>

Each time a car is used for field activities, the team has the opportunity to conduct a basic road survey and record data about wildlife species that occur in the area. Ideally, a set of roads that are regularly used by the team for their field activities is selected and mapped precisely for these road surveys. Every time the team uses one of these roads, data should be collected systematically. Similar surveys can be done at night for collecting data on nocturnal species.

Field methodology: Before starting the car engine, set the car odometer to zero. Activate the function Tracklog on a GPS unit to be able to track the journey on a map (downloadable into a GIS software). Record the following information in a logbook or data sheet before beginning the survey:

⇨ Date;
⇨ Time;
⇨ Team composition;
⇨ Road name;
⇨ Compartment survey.

At the end of the journey, the length of the stretch of road **must** be recorded (total number of kilometers surveyed).

Data collection: Record all direct sightings for all wildlife as well as fresh tracks left by the species included in the wildlife strategy (dung, footprints, else). Multiple records of a group of animals (elephant dungs) are considered as one data entry.

For each observation, record in the logbook the sighting, the time of the day and the distance from the beginning of the journey (odometer reading).

Equipment required:

- Logbook
- GPS
- Camera
- Tape measurer
- ID field books
- Torch light
- Data sheet
- Binoculars
- Ruler
- String
- Spare batteries
- Spot light

Wildlife monitoring along roads by foot.

Stretches of roads that have been used once for rapid assessment can be used repeatedly at regular time intervals for monitoring purposes. However, roads where track detection is difficult should be avoided for monitoring purposes (e.g., roads that are compacted, very rocky or covered with creepers and plants).

Field methodology: Using a tape measurer or GPS, set up permanent marking for the transect every 50 m the first time the transect is established. Road durability is assessed the first time the transect is conducted (see above).

Data collection: All wildlife data are collected as they are for rapid assessments. Data are also processed as it is for rapid assessments and plotted in histograms to show seasonal and temporal variations.

Equipment required: The same equipment is required as is for rapid assessments.

Wildlife monitoring along roads by vehicle.

If well established and conducted, road surveys by vehicle are a cost-effective way to characterize differential species use for different habitats, to monitor daily and monthly patterns of occupation, and to collect basic data about population composition and structure, among other things.

Field methodology: A stretch of 10 to 20 km of passable road is identified and mapped for monitoring purposes;

⇨ Sign posts (belian or other long lasting materials) indicating the distance are placed every 500 m by the road side. They must be visible from the road by the driver;

⇨ Once the posts are established, the main habitat types present within each 500 m segment need to be identified and recorded.

Data collection: Each time the stretch of road selected for monitoring purposes is used, the following information must be recorded on a specific data sheet for each 500 m segment:

⇨ Any wildlife sightings (type of sightings, group size, etc.);

⇨ Time of the day;

⇨ Precise location of the sighting along the road.

Equipment required: The same equipment is required as is for rapid assessments.

7.5.4. Collecting wildlife data along rivers.

Field methodology: A section of river is selected on a map or directly in the field. Its precise length is measured with a GPS in order to estimate kilometric indexes of sightings (Tracklog);

- ⇨ Surveys are conducted early in the morning (06:00 to 08:00) or late in the afternoon (16:30 to 18:30);
- ⇨ The team consists of a minimum of two observers (each focusing his research efforts on one bank of the river) and one boatman;
- ⇨ The speed of the boat is kept constant at about 4 km/hour.

Data collection: Primates and other animals are located through visual searches of riverside trees, using 10 x 40 binoculars. When a group of animals is detected, the following data are recorded:

- Species;
- Group size (seen and estimated);
- Group composition;
- Behavior;
- Location and GPS waypoint.

In case it is difficult to determine the exact number of individuals in a group, especially when there is more than one group in an area, it can be assumed that all animals found within 50 m of the next nearest animal are part of the same group.

Similar surveys can be conducted at night for crocodiles, small carnivores and nocturnal species.

Equipment required:

- Data sheet
- GPS
- Watch
- Field book
- Binoculars
- Spot light (for nocturnal surveys)

7.5.5. Collecting wildlife data using territorial calls.

Field methodology: Two or three listening posts are identified in the forest for conducting gibbon surveys. These posts should be separated by about 150 m and their precise location marked with a stick for easy recognition.

- ⇨ Gibbon surveys are conducted in the morning, between 06:00 h and 08:00 h.

Data collection: For each call heard from the listening posts, the team records the following:

- Compass bearing of the call;
- Estimates of the distance to the calling group (in one of four classes: close, medium, far, or very far);
- Time at which each long call begins and ends.

Ancillary information: Includes altitude, weather condition, habitat type and signs of habitat exploitation.

Equipment required:

- GPS
- Compass
- Watch
- Binoculars
- Walkie talkies
- Data sheet and field book
- Tape recorders (used to record the voices for identification purposes)

7.5.6. Collecting wildlife data along line transects.

Field methodology: Line transects should always involve a minimum of physical disturbance (cutting paths) to minimize the negative impacts on the habitat. Cutting off climbers and small trees to establish the line can result in the destruction of some major food sources (*Spatholobus* spp., *Entaeda* spp., *Ficus* spp.) or pathways of wildlife, which in turn can influence distribution and abundance of wildlife and introduce a bias in the results. Also, because transects can be used by hunters after survey's completion, it is important to make them as discrete as possible.

⇨ If transects are used only once for rapid assessment (**Standing-Crop Counts** or **one-off transects**), there is no need to tag any tree. Permanent transects used for monitoring (**Repeated Counts**) need to be tagged every 50 m, and trees are marked with paint for easier detection off the path during subsequent counts.

⇨ *Correcting for slopes*: Perpendicular distances collected in the field are reported on a two-dimensional plan scale for analysis, and the presence of slopes in the field need to be corrected for. When the terrain between the transect and the object is not flat, the degree of the slope is estimated in the field and a linear distance is obtained with:

$$A = PD \times \cos(\alpha)$$

with A, the plan perpendicular distance (the true distance to be used in the final data analysis), P.D. the perpendicular distance measured in the field, and alpha the estimated slope encountered in the field while measuring the perpendicular distance: Figure B.6.

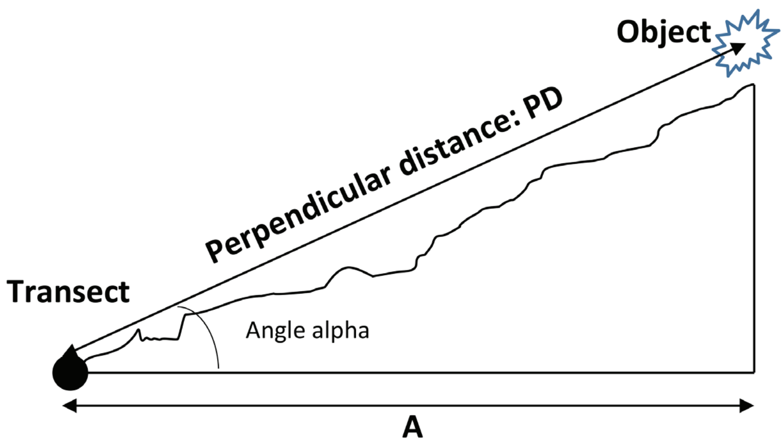


Figure B.6: How to measure perpendicular distances along slopes.

Ancillary data: Depending on the research question to be answered, data are collected differently in specific data sheet. For example:

i. Ancillary data that need to be collected along the entire length of the transect:
- Signs of human disturbances: number and status (active/not used) of logging roads, number of tree stumps (indicative of logging activities); number of snares or cartridges; etc.
- General topography (slopes, ridges, streams);
- Habitat type (forest type; open area).

ii. Ancillary data collected every 50 m:
- Forest structure - can be assessed semi-quantitatively by assigning different scores (e.g., 0 for absence and 3 for maximum) to the following variables:
  - √ presence of small/medium/large trees;
  - √ abundance of climbers;
- Canopy height (also assigned by class).

iii. Ancillary data collected in quadrats:
Tree density and forest composition - determined by counting trees with dbh more than 10cm in a series of 10x100 m botanical plots located randomly along each transect.

Equipment required:
- Data sheet
- Field book
- Map
- GPS
- Compass
- Walking distance measure
- Binoculars
- Tags
- Tape
- Range finder
- Plastic
- Wildlife identification books
- Bags (for sample collection)

In Sabah, line transects are conventionally used for 1) counting orang-utan nests, 2) dung surveys and 3) wildlife community surveys. The methodology of these three approaches is briefly presented below.

<u>i. Counting orang-utan nests along line transects</u>.
The methodology applied differs between **standing crop counts** or one-time transects, and **marked-nest counts** or repeated surveys.

Field methodology : ***Standing crop count***: this method is mostly used for general one-off surveys. It is the most suitable for rapid assessments. Trees used as nesting sites do not need to be marked or tagged.

Data collection: For each nest, the precise perpendicular distance to the transect is measured with a measuring tape. The size, dbh and species of the nesting tree is recorded. All nests encountered, irrespective of their age-class, are recorded.

Field methodology: **Marked-nest counts**: these surveys are repeated at short enough intervals of time so as to record all nests that have been built between two successive passages. This approach gives a snapshot of nest abundance between two counts and it is thus suitable for monitoring purposes. It is important that new nests are not constructed and destroyed/disintegrated between two successive surveys, which would result in an underestimation of ape density. **An interval of six to eight weeks is used to survey orang-utan nests in Sabah**. During a marked nest count survey, transects are walked repeatedly and only nests constructed between two successive visits are counted.

When a new nest is found, one tag is placed along the transect from where the nest is visible and another tag on the nesting tree. On both tags, the surveyors write the following information: Date; Nest height; Nest bearing; Nest number; Tree species.

Data collection: As with *standing crop count*, for each nest, the precise perpendicular distance to the transect is measured with a measuring tape, as well as the size, dbh and species of the nesting tree.

Observers look for the nests that were identified during the previous survey(s). When found, the age class of the nests is re-assessed. Observers write the new age class on the data sheet and on the plastic tag in the forest. If the nest is no longer visible, plastic tags are removed and the data entry line for this nest is terminated.

When observers detect new nests that have been built between the two successive surveys, they collect the usual data (nesting trees, nest height and class, horizontal and perpendicular distance from the transect), and two tags are placed in the forest (one along the transect and one for marking the nesting tree).

ii. Counting dung along line transects.

A dung count is the standard method to estimate elephant population size in tropical forests. An elephant defecation event consists of a pile of up to six or seven *boli.*

Data collection: For each pile, the precise perpendicular distance from the center of the dung pile to the transect is measured with a measuring tape. If the elephant was standing still and was not moving when it defecated, all the boli are close together (amorphous pile); in this case, measuring the perpendicular distance of the pile to the transect is straightforward (Figure B.7). If the elephant was moving while defecating, the pile is dispersed. In this case, carefully examining the tracks, the boli size and age will allow for determining the spread of the pile.

The perpendicular distance of the pile is obtained by measuring the furthest and the

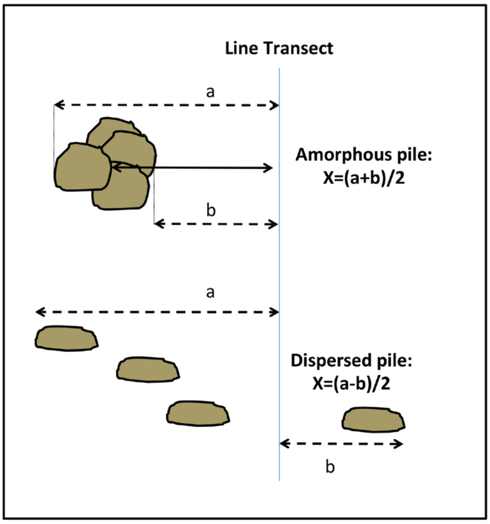


Figure B.7: Recording elephant dung data nearest edges of the boli that are part of the same pile and dividing the sum by 2. If a dispersed pile lies both ways of the transect, the most distant point on either side of the transect is measured, then the smaller value is substracted from the larger and the result is divided by 2 to obtain the average perpendicular distance of the pile.

In addition to elephant dung, other signs of presence such as feeding signs, rubbing trees, trails and footprints are recorded, especially in areas where elephants are uncommon or present only at specific times of the year.

iii. Mammal community surveys along line transects.

Field Methodology: The surveys are conducted early morning by one or two surveyors maximum;

- ⇨ The survey team must move slowly and quietly (approximately 1 km/hour), never leave the line, and stop for 5 minutes every 15 minutes to listen for animals and other noises;
- ⇨ It is important that the team does not smoke and minimizes all source of noises not to scare animals away;
- ⇨ Line transects can also be used at night to survey nocturnal species: in this case, the team moves very slowly along the transect, looking for eye shine with a headlamp. Because of differences in activity patterns, night transects should be run during different phases of the moon and at different times of the night throughout the year: (1) shortly after dusk; (2) in the middle of the night; (3) early morning before sunrise.

Data collection: Data are collected about each species detected.

- ⇨ For solitary species, the perpendicular distance to the transect is measured from the estimated location of the animal at first sighting. As such, it is important to try detecting the animal before it starts running away from the team.
- ⇨ For social species (monkeys), the approximate location of the centre of the group to the transect is estimated and measured. It is important to record the approximate group size and composition. Additional information that are recorded during this type of survey includes all calls and vocalizations, with their location, the time, the approximate distance and bearing from the transect, and species.

7.5.7. Recording wildlife data with camera traps.

Camera traps are becoming increasingly popular to assess the presence of and to monitor small elusive or nocturnal species often overlooked by conventional methods. A manual entitled "Handbook for wildlife monitoring using camera-traps" has been developed by Sabah Parks and BBEC Phase II for Sabah. We refer the reader to this manual for further information (*Ancrenaz et al.*, 2012).

7.5.8. Collecting samples for DNA analysis.

Feces, urine and hair can be collected for DNA analysis (see sections A.3.2.2. and B.6.2.2.). Fecal samples can be dessicated on silica gel or stored in a DMSO-EDTA-Tri-salts solution, in a 70%-95% ethanol solution or RNA later solution. Urine is stored in a 95% ethanol solution, and hair is placed in dry envelopes. Invasive samples (blood, tissues) are sometimes accessible and should also be collected for further DNA analysis. A new approach using leeches as a possible source of DNA for the prey they fed on was also recently successfully developed (Schnell et al., 2012).

A huge range of information can be derived from genetic analyses, including but not reserved to species ID; individual ID for capture-recapture analysis; relatedness and paternity analysis; pathogen and health screening. However genetic analyses are still relatively costly, and financial considerations often limit their use for regular monitoring activities.

Western Tarsia (*Tarcius bancanus*): This small nocturnal Prosimian is sometimes encountered in the forest at night. It is easily recognizable by its large eyes and ears, its long tail, as well as its fast leaps on vertical supports.

Chapter 8: KEY WILDLIFE SPECIES TO BE MONITORED IN SABAH

This Manual focuses on key wildlife species to be monitored in Sabah, all of which are terrestrial mammals. This chapter is a brief presentation of each of these species (*Key Wildlife Features*) and of the Attributes that need to be recorded and monitored by the field teams. It is important for wildlife practitioners and people recording data in the field to be familiar with the attributes included in the wildlife strategy. It is a good idea to have a list of attributes monitored on the first page of each field logbook. Table B.3 presents some of these attributes. Most of the drawings are taken (with permission) from "A field Guide to the Mammals of Borneo", Payne and Francis, 2007.

Table B.3: Some of the attributes commonly monitored for wildlife monitoring.

	Direct sightings	Indirect sightings
Orang-utan	• Number of individuals; size; sex • Presence of young and/or babies • Identification of food species	• *Vocalizations*: long call; kiss squeak • *Nests*: location; tree species; nest class • Footprints and food remains
Proboscis monkey	• Group size and structure (harem, bachelor males) • Location of the sleeping sites	
Sumatran rhinoceros	• Presence of young (indicative of breeding females)	• Footprints (measurements for individual identification)
Bornean elephant	• Group size and composition • Presence of injured elephants	• Dung presence and age • Noise and signs of passage
Tembadau	• Number of individuals • Presence of young (breeding groups)	
Sun bear	• Presence of young	• Claw marks on tree trunks • Footprints; Nests; Vocalizations; • Presence of conflicts
Clouded leopard	• Pelt markings (individual identification)	• Footprints; Feces (Scat)
Bornean gibbon	• Number of individuals in the group; • Presence of young • Coloration (individual identification) • Tree species (i.e. feeding, resting)	• *Vocalizations*: Early morning duets – loud bubbling long call (adult female); short call (adult male) (up to 2 km away)
Monkeys	• Taxa identification • Number of individuals in the group • Presence of young	• Footprints • Signs of feeding
Small carnivores	• Taxa identification • Number of individuals • Presence of young	• Footprints • Pungent odor (e.g. Malay badger, civets) • Scat (turns whitish over time)
Porcupines, Pangolins, Moon rat, Treeshews, Squirrels	• Number of individuals • Presence of young	Footprints
Deer	• Taxa identification • Number of individuals; age class; sex • Presence of young	• Footprints; Pellets (feces) • Presence of active saltlicks or wallows • Signs of feeding (Sambar deers) • Presence and cases of hunting activities
Wild boar	• Number of individuals • Presence of young • Body condition (e.g. skinny, fat)	• Footprints and feces; Nests • Presence and cases of hunting activities
Salt licks Wallows	• Location - Size and depth • Status (i.e. active or inactive); Species frequency (type and abundance of footprints)	
Hunting	• Species hunted; Number of individuals	
Road kill	• Species killed; Location	

The series of Tables below is a very brief presentation of the wildlife features that need to be considered for wildlife monitoring activities in Sabah. Species are organized according to the protection status conferred by the SWD Enactment, 1997.

8.1. Totally Protected Species (Schedule 1).

8.1.1. Orang-utan (*Pongo pygmaeus morio*) – Primates, Pongidae.

<table>
<tr><th>Description</th><td colspan="2">Large and red primate (only Asian great ape)
No tail
Mostly arboreal</td></tr>
<tr><th>Distribution</th><td colspan="2">Highest densities in lowland dipterocarp forests
Also found in montane and swamp forests, secondary and degraded forests</td></tr>
<tr><th>Ecology</th><td colspan="2">Usually solitary, although young remain with mother until eight to ten years of age
Temporary associations occur in large fruiting trees
Two types of males (unflanged: size of a female; flanged: twice the size of a female and producing long call)
Diet: mostly fruits, but also leaves, bark and insects</td></tr>
<tr><th>DATA</th><td>Direct sightings:
• Number of individuals; size; sex
• Presence of young and/or babies
• Identification of food species consumed</td><td>Indirect sightings:
• Vocalizations: Long call (deep and loud only by flanged males) – Kiss squeak when animals are stressed (males and females)
• Nests: exact location; tree species; nest class (see below)
• Footprints and food remains</td></tr>
</table>

Orang-utan signs:

- **Orang-utan nests**: all adult orang-utans build nests to sleep in at night and sometimes during the day. Depending on their shape and form it is possible to age orang-utan nests using five successive stages of decay. Several factors influence the decay rate of the nests including tree species, forest type, weather condition.

I	new:	presence of green leaves;
II	recent:	all leaves dry and brown;
III	old:	some leaves already gone, the others still attached, nest still firm and solid; the sky is not visible through the nest structure
IV	very old:	holes visible in the nest structure;
V	almost gone:	a few twigs and branches, original nest shape no longer evident.




Orang-utans are the only Great Apes found in Asia. A young will remain with his mother between eight and ten years before dispersing and needs to learn all the skills he needs to survive from his mother. The common lifespan of orang-utan in the wild is about 45-50 years.

• **Footprints:** very distinctive and large. Sometimes found close to salt licks or across forest clearings.

• **Vocalizations:** the long call is only emitted by flanged adult males and can be heard up to one kilometer away. The long call is usually used to repel other males, attract females or when the animals are stressed.


Bark of trees spat by an orang-utan after the animals has eaten the sap.

8.1.2. Proboscis monkey (*Nasalis larvatus*) - Primates, Cercopithecidae.

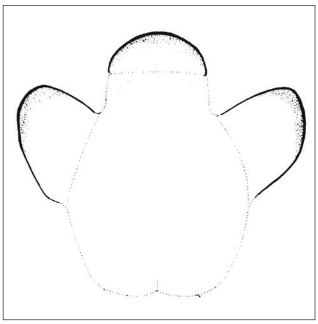
Description	Large monkey found in groups along water bodies Adult males: white tail and rump, large nose Diurnal, sleeps close to water bodies Typically found in one male units (or harems)
Distribution	Endemic to Borneo Primarily live in coastal areas (mangroves, nipah, swamps and riparian habitats); can also be found close to water bodies in the interior of the State (upper parts of river basins)
Ecology	Diet: leaves, fruits and shoots - Live in One-Male Units or Harems (one adult male has the monopoly over up to five or six adult females and their young) - Bachelor males and all-males groups also occur
DATA	Direct sightings: • Group size and structure (harem; group of bachelor males) • Location of the sleeping sites

8.1.3. Sumatran rhinoceros (*Dicerorhinus sumatrensis*) – Perissodactyla, Rhinocerotidae.

Description	Large stocky body Short legs with three toes on each foot	
Distribution	Previously occurred in a variety of habitats, though currently restricted to remote areas	
Ecology	Mainly active from late afternoon to early morning Rest in mud wallows during the day Territorial and solitary Roaming over several tens of km2 Diet: mostly leaves and twigs of many plant species, also fruits and bark	
DATA	Direct sightings: • Presence of young (indicative of breeding females)	Indirect sightings: • Footprints (measurements taken for individual identification)

Rhinoceros signs:

- **Feces**: balls of coarsely chopped woody material not more than 10 cm diameter. Usually found in small piles.
- **Footprints**: typical shape (three toes). Measurements allow for individual identification (see Data sheet in Part II, Annex I).



8.1.4. Bornean elephant (*Elephas maximus*) – Proboscidea, Elephantidae.

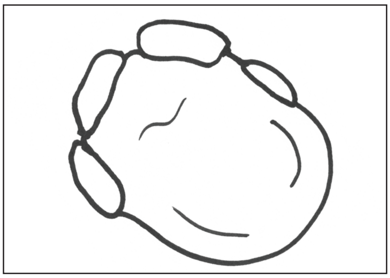
Description	Distinctive size and shape with long trunk	
Distribution	Wide variety of habitat; mostly lowland forests, degraded habitats and agricultural landscapes	
Ecology	Active both during the day and at night Live in family herds (up to 40-50 individuals) led by matriarch females Males are solitary or form small groups Range over very large territories Usually only males have tusks of significant size Need daily water access Diet: mostly grass, but also bark, leaves and fruits; feed on crops such as banana and oil palm trees	
DATA	Direct sightings: • Group size and composition • Presence of injured elephants	Indirect sightings: • Dung presence and age • Noise and signs of passage • Damages to people's properties

Elephant signs:

- **Feces**: elephant dung is made up of a set of 3 to 7 boli consisting of non-digested fiber originating from grass and bark. Knowing the age of feces allows for estimating elephant abundance. Age of feces can be estimated visually and categorized into five different age-classes. Values given below as an example originate from an on-going study conducted in Lower Kinabatangan.

Class 1: Dung is fresh; boli are still covered with a layer of mucus (epithelial cells from the intestines) and shiny fatty acid coat; Average duration in Kinabatangan: 3 weeks (associated Standard Deviation, SD of about 2 weeks);
Class 2: Boli are dry but shape still clearly visible. Average duration: 4 weeks days (SD=2.5 weeks);
Class 3: Boli begin to disintegrate: some are flattened but some are still their original shape. Average duration: 5 weeks (SD=2 weeks);
Class 4: Boli are flattened and start to disintegrate. Average duration: 4 weeks (SD=2 weeks);
Class 5: Boli are flattened, their original shape has completely disappeared and mostly fiber remains. Average duration: 8 weeks (SD=5 weeks).

- **Footprints**: they are characteristic because of their size and of shape: the forefoot is nearly circular while the hind foot is more oval in shape (see diagram). The diameter of a full-grown adult footprint can reach more than 45 cm.



Hind foot (Bornean elephant)

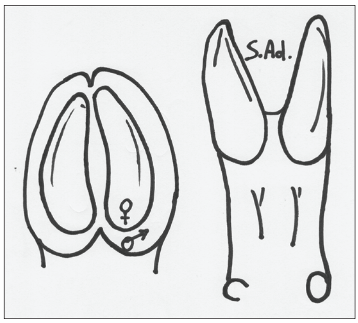
8.1.5. Tembadau or banteng (*Bos javanicus*) – Artiodactyla, Bovidae.

Description	Resemble domestic cattle Adult males are black and females are brown Adult have 'white stockings' and white buttocks
Distribution	Dipterocarp, swamp and coastal forests Browse in open areas
Ecology	Primarily nocturnal where hunting pressure is heavy Occur in small groups (5-10 individuals), but sometimes in larger herds Males may be solitary or in bachelor herds Highly attracted by artificial and natural salt licks Diet: mostly grass and herbs The number of tembadaus has plummeted throughout Borneo as a result of over-hunting. Their ecology is still poorly known, but browser ungulates are expected to benefit from forest disturbance due to increased food sources (grass, open areas)
DATA	Direct sightings: • Number of individuals • Presence of young (breeding groups)

Tembadau signs:

- **Feces**: resemble cattle dung. Age classification can be done following elephant dung classification.

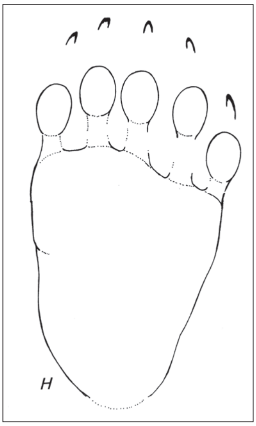
- **Footprints**: can estimate animal age depending on print size: adult, juvenile, young.



8.1.6. Sun bear (*Helarctos malayanus*) – Carnivora, Ursidae.

Description	Black body except for a grey muzzle and a whitish "C" or "V" shaped mark on the upper chest Very short tail	
Distribution	Occur in dense forests at all elevations, but is also found in degraded forests, gardens and agricultural landscapes	
Ecology	Both diurnal and nocturnal Usually solitary although young (1 or 2 individuals) remain with the mother until fully grown Diet: fruits and plant parts, honey, termites and other invertebrates, small vertebrates	
DATA	Direct sightings (rare): • Presence of young	Indirect sightings: • Claw marks on tree trunks • Footprints • Presence of conflicts • Vocalizations

Bear signs:



- **Footprints**: large footprints with five digits and claw marks a fair distance from toes (sometimes the claws are not visible). Their feet point inwards towards the body when they walk.
- **Feces**: the scat is more difficult to identify although it is characterized by its relatively large size. Its composition will primarily depend on diet, and can include seeds, exoskeletons of termites and invertebrates, and some fiber.
- **Nest**: sometimes, sun bears build nests in trees to rest. These nests can be confused for orang-utan nests.
- **Claw marks**: these marks are left on tree trunks when the bears climb trees to get access to a food source. These claw marks are typical of bears and cannot be mistaken for other species.
- **Vocalizations**: utter hoarse grunts or loud roars(similar to orang-utan long calls). Sometimes, emit short barks similar to muntjacs (see Cervids).

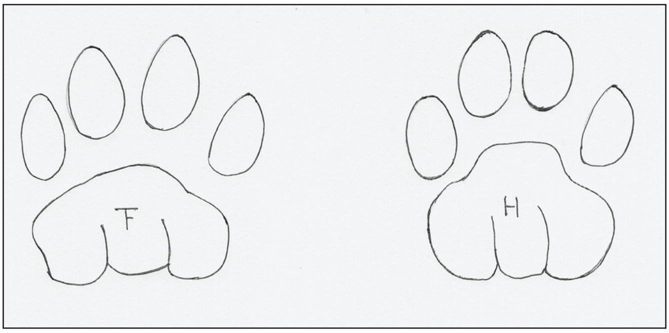
Sun bear's nest. (Photo courtesy of Bornean Sun Bear Conservation Centre)

8.1.7. Clouded leopard (*Neofelis diardi*) – Carnivora, Felidae.

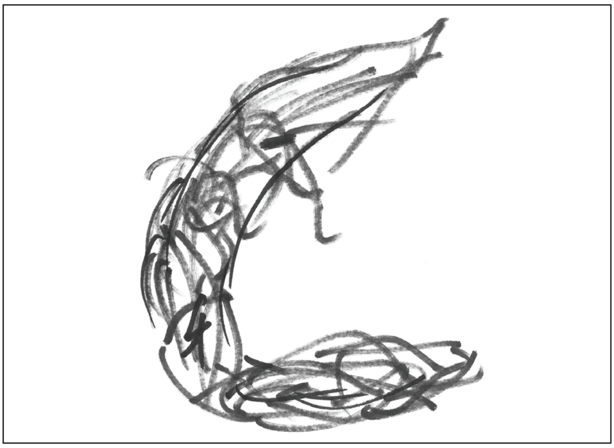
Description	Largest cat in Borneo Pelt with a cloud-like marking ranging from very dark to light brown Long tail	
Distribution	From lowlands to montane habitats (2500 m asl), rarely found in extensive agricultural landscapes (oil palm plantations)	
Ecology	Both nocturnal and diurnal Good climbers and often sleep in trees Usually solitary and range over large territories Diet: top predator feeding on deers, pigs, monkeys and other live preys	
DATA	Direct sightings: • Pelt markings allow for individual identification	Indirect sightings: • Footprints • Feces (Scat)

Clouded leopard signs:

- **Footprints**: easily distinguishable by their large size and long stride.



- **Feces**: look for bones or hair of prey.



Old dry scat of clouded leopards are recognized by a quantity of hair from their prey as well as bone fragments.

8.2. Protected species (Schedule 2).

8.2.1. Bornean gibbon (*Hylobates muelleri*) – Primates, Hylobatidae.

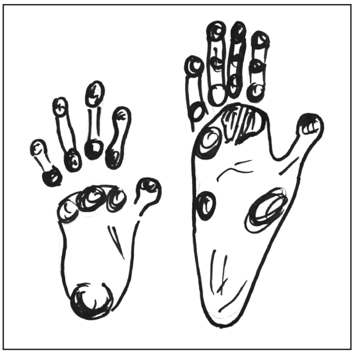
Description	Medium size primate with long arms and legs – No tail Different colorations: grey, brown, cream	
Distribution	Wide range of habitats, from lowland to highland forests (1500 m asl) Primary and degraded forests Not found in industrial plantations	
Ecology	Completely arboreal Diurnal Territorial (20 to 50 ha) Live in small family groups (one pair of adults plus one or two young) Diet: mostly ripe fruits, but also leaves, young shoots and invertebrates Recent studies in Sabah show that this charismatic species is sensitive to habitat over-degradation. Decrease in food resources results in malnutrition, increased miscarriage rates, neo-natality mortality, decrease in conception rates as well as changes of social and territorial behavior.	
DATA	Direct sightings: • Number of individuals in the group • Presence of young • Coloration of the individuals for individual identification • Trees used for feeding or resting	Indirect sightings: • Vocalizations: Duets heard early morning - loud bubbling long call (adult female); short call (male) (heard to up to 2 km)

8.2.2. Monkeys (5 species) – Primates, Cercopithecidae

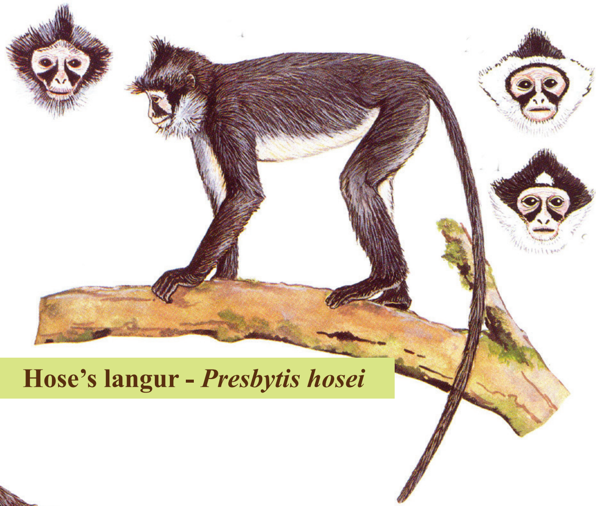
Description	**Red langur** (*Presbytis rubicunda*): **Hose's langur** (*P. hosei*): **Silver langur** (*P. cristata*): **Pig-tailed macaque** (*Macaca nemestrina*): **Long tailed macaque** (*M. fascicularis*):	Red – Long tail Mostly arboreal One male unit (groups of 4 to 10 individuals) Dark grey with white cheeks – Long tail One male unit Dark grey – Long tail One male unit Stocky with no tail Mostly terrestrial Multi-male-multi-female groups (can be more than 50 individuals) Slender with long tail Mostly terrestrial Multi-male-multi-female groups
Distribution	Wide range of habitats, from coastal and lowland to highland forests (1500 m asl), in intact and degraded habitats Macaques are found in industrial plantations, gardens, villages and even cities	
Ecology	All these species are diurnal Diet: mostly ripe fruits, but also leaves, young shoots and invertebrates	
DATA	Direct sightings: • Taxa identification • Number of individuals in the group • Presence of young	Indirect sightings: • Footprints • Signs of feeding

Monkey signs:

- **Footprints**: Distinguished by the length and slimness of digits. Langur prints are thinner and more slender than macaque prints. Note that langur and macaques footprints are almost impossible to distinguish to the species level.



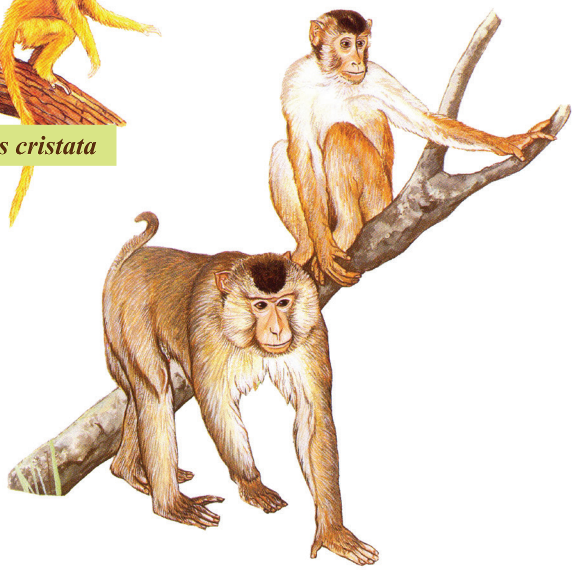
Red langur - *Presbytis rubicunda*



Hose's langur - *Presbytis hosei*

Silver langur – *Presbytis cristata*

Long tail macaque - *Macaca fascicularis*



Pig tail macaque - *Macaca nemestrina*

8.2.3. Small carnivores.

Small carnivores include seven species of Mustelidae (marten, ferret, weasel, badger and otters), 8 species of Viverridae (civets), 2 species of Herpestidae (mongooses), 1 species of Prionodontidae (banded linsang), and four Felids (cats: note that the clouded leopard is not considered a "small carnivore"). These taxa play a prominent function in forest ecosystems by regulating prey populations and for seed dispersal. Most of these species are cryptic, nocturnal, shy, elusive and occur at low density in the forest, rendering direct sightings and population monitoring an arduous undertaking.

DATA	Direct sightings: • Taxa identification • Number of individuals • Presence of young	Indirect sightings: • Footprints • Odor (pungent with some species e.g. Malay badger, civets) • Scat (become whitish with age)

Carnivore signs:

- **Footprints**: Four toes. Among carnivores, cats have four toed prints without claw marks. Large prints with four toes and claw marks belong to domestic dogs (more than 40 mm width) or to the Malay civet (maximum width of 35 mm).
  Five toes. Footprints of all other carnivores have five toes, all with claws (although it is sometimes hard to detect the mark left by the print in hard substrate), except for otters. Footprints of otters are distinguished by their proximity to water bodies and by the web between toes.
- **Feces**: Scat of small carnivores are commonly found during field work. Their content and size will inform about the family or even the species. Scat containing fish bones, scales and mollusc shells belong to otters and flat headed cats. Scat rich in seeds belong to civets; scat containing bones and hair of small terrestrial vertebrates belong to cats. Many scat turn white after a period of time, distinguishing fresh and aged droppings.

Badger (Mustelidae): Long thin claws and five digits on each toe.

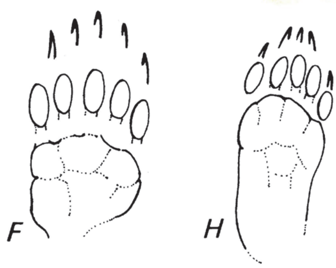
Malay badger – *Mydaus javanensis*

Characteristics: Terrestrial and nocturnal species (sleeps in burrows during the day).

Habitat: Occurs in primary forest, but more common in secondary or open forest and gardens.

Diet: Includes earthworms and larvae.

Identification: The easiest way to tell the two badger species apart is by looking at the hind foot. The pad is elongated in *Mydaus javanensis* while the toes are positioned closer together. Emits characteristic musky smell that can be detected from a distance.



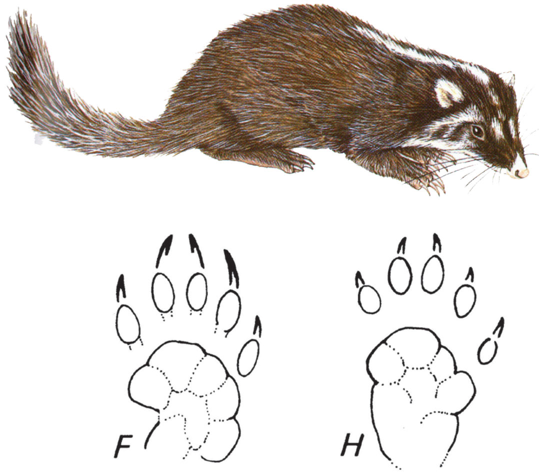
Ferret Badger – *Melogale personata*

Characteristics: Mostly nocturnal and terrestrial.

Habitat: Occurs in montane forests.

Diet: Includes earthworms, lizards, birds and bats.

Identification: The tracks of *Melogale personata* are most easily confused with both the Malay badger, *Mydaus javanensis* and the Yellow-throated Marten, *Martes flavigula* (see Martens), as well as some of the civet species. Identification of these species is better done by direct sighting (the ferret badger has a long tail).



Weasel (Mustelidae):

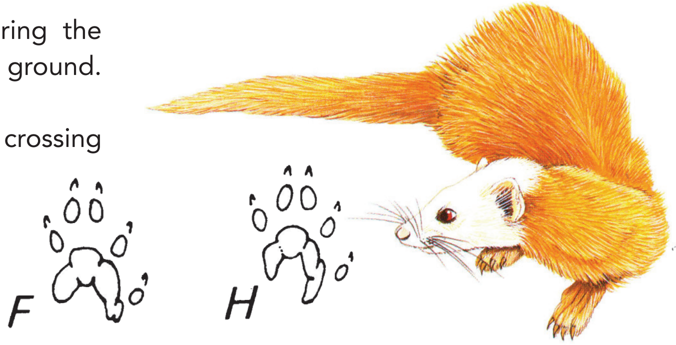
Malay Weasel - *Mustela nudipes*

Characteristics: Terrestrial, active during the day and night. Sleeps in holes in the ground. Bright orange to yellow fur.

Habitat: Occurs in forests, may be seen crossing roads.

Diet: includes small mammals.

Identification: Tracks are very small and similar to the Banded Linsang, *Prionoodon linsang* (see Civets).



Marten (Mustelidae):

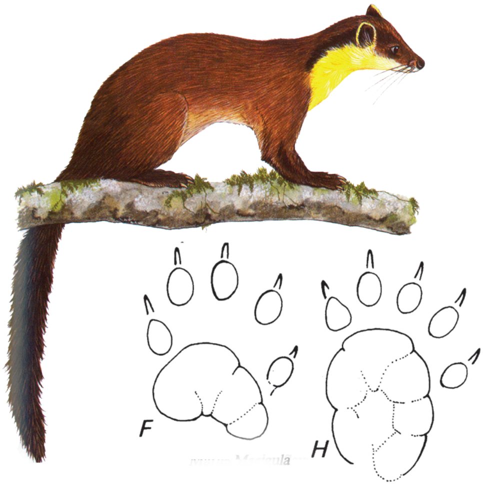
Yellow-throated Marten – *Martes flavigula*

Characteristics: Active during the day and night, both arboreal and terrestrial.

Habitat: Occurs in primary and secondary forests, from lowlands to high mountains, and often enters gardens and plantations.

Diet: Includes small vertebrates and invertebrates, eggs, fruit, bee's nests and nectar.

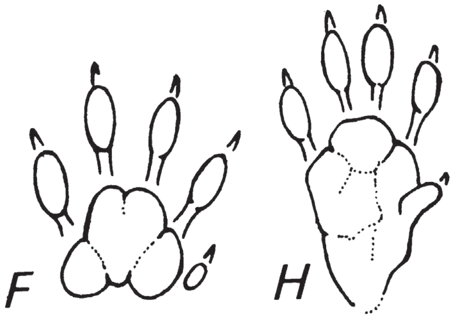
Identification: The tracks of Martes flavigula are large enough to be confused with badger and many civet species. The major difference is the larger gap between the pad and toes on the fore foot, as well as the toe positioning.



Mongooses (*Viverridae*): Mongoose tracks are very distinctive due to their small size and the reduced "thumb". It is clearly visible at the base of the fore foot pad. The reduced "thumb" is also visible on the hind. Claws can be clearly seen.

Short-tailed Mongoose – *Herpestes brachyurus*

Characteristics: Blackish brown. Primarily diurnal and terrestrial.
Habitat: Occurs in primary and secondary forests, may enter plantations and gardens.
Diet: Includes arthropods and small vertebrates.
Identification: Similar fore foot track to the Malay civet, *Viverra tangalunga* (see Civets).



Collared mongoose – *Herpestes semitorquatus*

Characteristics: Reddish brown wit fine markings on the back. Mainly terrestrial. Active during the night and day.
Habitat: Occurs in primary and secondary forests, as well as plantations and partially cultivated lands.
Diet: Includes small animals.
Identification: Very similar tracks to the Short-tailed mongoose, *Herpestes brachyurus*.

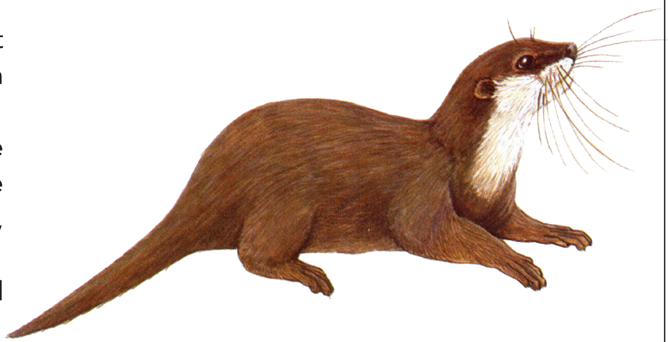
Otters (*Mustelidae*): Otter tracks are distinctive through the visible web stretched between the toes, although this is not always seen in poor substrates. One can expect to see these tracks close to water sources although they are also known to travel some distance between water bodies. Five digits are present on each foot. Presence of otters is detected by piles of feces (called spraints), consisting of the hard parts of fishes, crustaceans and mollusks deposited on open places, near water bodies.

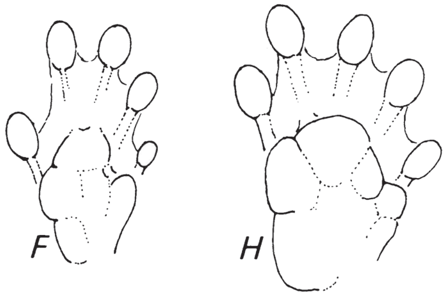
Small-clawed Otter – *Aonyx cinerea*

Characteristics: Generally the most commonly encountered otter. Often seen in groups (up to 5-6 individuals).

Habitat: Occurs in many habitats where there is permanent water and some tree cover, including the coast, large rivers, small streams, ponds and lakes.

Diet: Includes molluscs, crustaceans and fish.





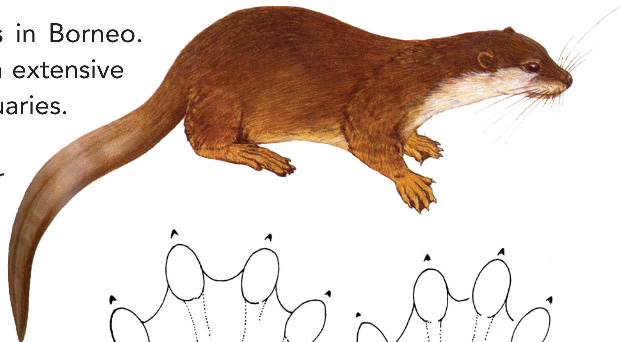
Smooth Otter - Lutra *perspicillata*

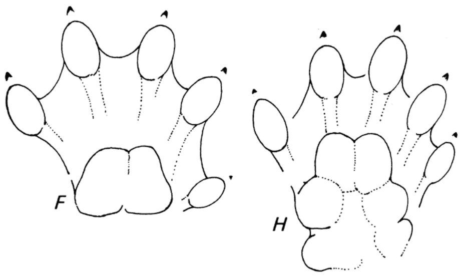
Habitat: Little is known about this species in Borneo. Elsewhere, it lives on the coast or inland on extensive sandflats, along lakes, river mouths and estuaries.

Diet: Fish, turtles and crustaceans.

Identification: Has the largest of the otter tracks from Borneo, with a distinctive pad on the front foot. The hind foot is similar to the Small-clawed otter, *Aonyx cinerea* but the size difference is obvious.

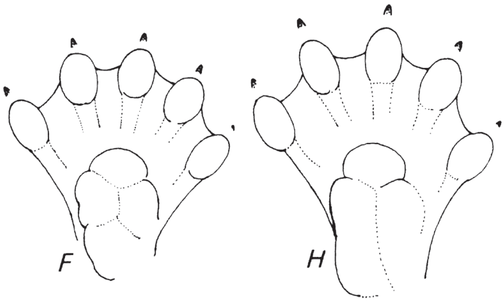
The webbing between the toes is visible as well as the distinctive toe pattern of the fore foot.





Hairy-nosed Otter – *Lutra sumatrana*

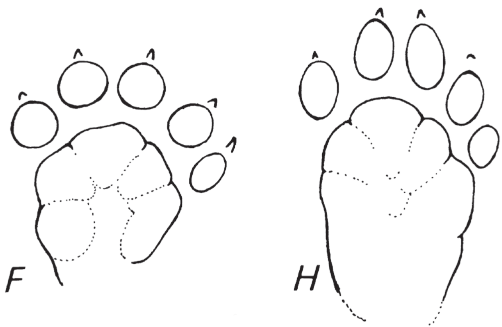
Characteristics: May be solitary or in small groups.
Habitat: Occurs in coastal areas and large inland river systems, including lakes and streams.
Diet: Includes fish.
Identification: Very similar prints to the common otter, *L.* lutra, but claws are often present in their tracks.



Civets (*Viverridae*): Civet tracks vary greatly but can be easily identified if the substrate allows. Claws are present in all species and each foot has five digits. Footprints of the three larger civets can be easily confused. The shape of the segments on the pad is one of the few tell-tale signs.

Common Palm Civet - *Paradoxurus hermaphroditus*

Characteristics: Nocturnal, sleeps in trees during the day. Both arboreal and terrestrial.
Habitat: Found in secondary forests, plantations and gardens, rarely in primary forests.
Diet: Includes fruits, leaves, seeds, arthropods and molluscs.
Identification: The claws of this species are relatively small.



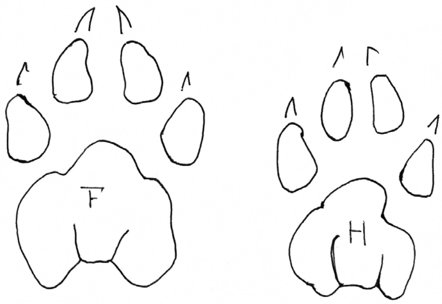
Malay Civet – *Viverra tangalunga*

Characteristics: Nocturnal and primarily terrestrial. Not afraid of people and can enter forest camps at night to look for food scraps.

Habitat: Occurs in forests and cultivated lands adjacent to forests.

Diet: Includes invertebrates, small vertebrates and plant matter.

Identification: The only civet species on Borneo where the prints show four digits on each foot. Not to be confused with the felids, the Malay civet also has claws present in its prints. It is a very common track.



Hose's Civet – *Hemigalus hosei*

Characteristics: Very rare - little is known about this species. Probably nocturnal and mainly terrestrial.

Habitat: Occurs in lower montane forests.

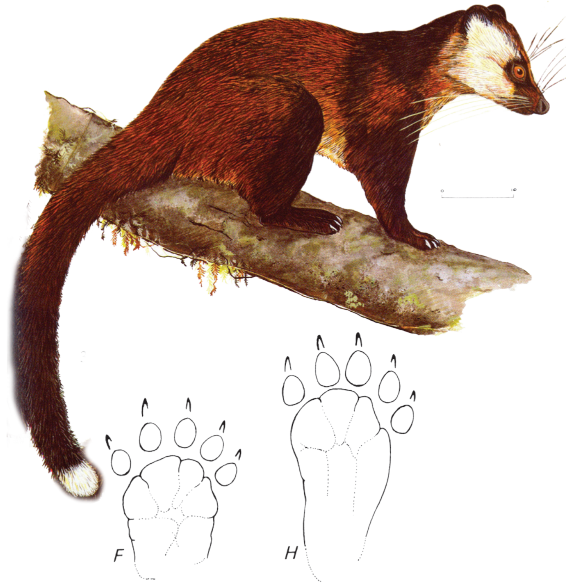
Diet: Includes insects and small animals.

Malay Weasel (*Mustela nudipes*)

Banded palm civet (*Hemigalus derbianus*)

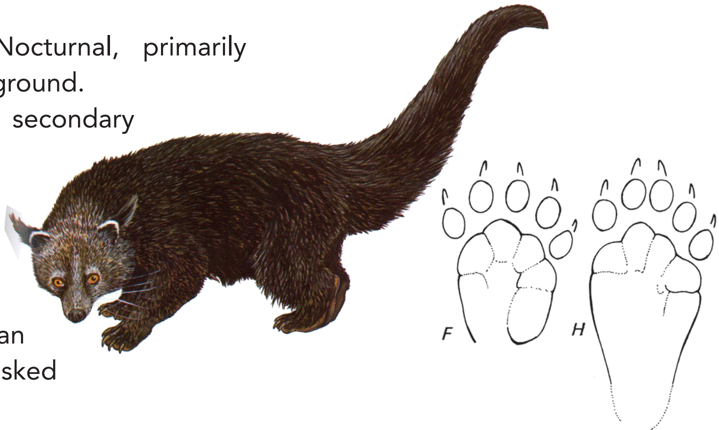
Masked Palm Civet – *Paguma larvata*

Characteristics: Some individuals (but not all) have a whitish/yellowish tail tip. Nocturnal, but occasionally active during the day.
Habitat: Primarily arboreal, but will forage on the ground. Occurs in primary and secondary forest, plantations and gardens.
Diet: includes fruit, leaves and small animals.
Identification: Tracks are similar to *Arctictus binturong* and very difficult to tell apart.



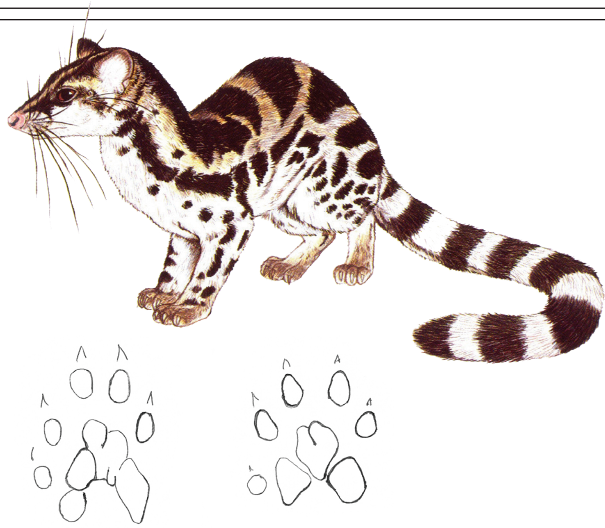
Binturong – *Arctictus binturong*

Characteristics: Entirely black. Nocturnal, primarily arboreal but also travels along the ground.
Habitat: Occurs in primary and secondary forest.
Diet: Includes fruits, especially ripe figs, as well as a variety of small animals.
Identification: The largest of the civet footprints although they can still be easily confused with the Masked palm civet, *Paguma larvata*.



Banded Linsang – *Prionodon linsang*

Characteristics: Nocturnal, sleeps during the day in trees or in hollows on the ground. Black tail rings all the way to the tip of the tail. Short legs.
Habitat: Arboreal and terrestrial. Occurs in both primary and secondary forests.
Diet: Mostly carnivorous (birds, small mammals, arthropods and reptiles).
Identification: The tracks are similar to those of the Malay weasel, *Mustela nudipes* (see Weasels). Scat don't contain fruit remains.

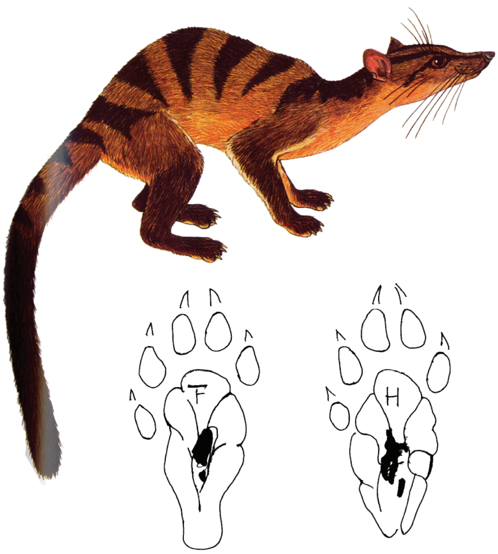


Small-toothed Palm Civet – *Arctogalidia trivirgata*

Characteristics: Dark animal. This species is also known as the three-striped palm civet. Primarily nocturnal and arboreal.

Habitat: Prefers primary forest, but also occurs in secondary forest.

Diet: Includes mainly fruit, but also eats birds, small mammals, nectar and pollen from flowers.



Banded Palm Civet or Banded Civet– *Hemigalus derbyanus*

Characteristics: Nocturnal. Travels and feeds mainly on the ground but climbs well. Often sleeps in trees. Body coloration varies from reddish to whitish.

Habitat: Occurs in primary and secondary forest.

Diet: Includes insects, other invertebrates, and small aquatic animals.

Identification: Tracks are similar to Small-toothed palm civet, *Arctogalidia* trivirgata and the Otter civet, *Cynogale bennettii*.

Otter Civet – *Cynogale bennettii*

Characteristics: Prominent lips and long white whiskers. Little is known about this species as it is very rare in Borneo.

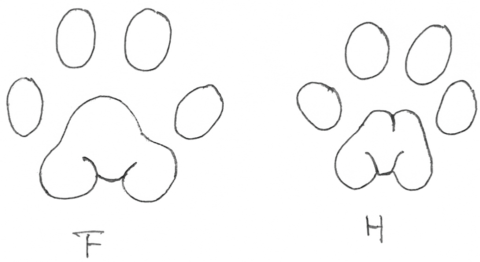
Habitat: Terrestrial and semi-aquatic. Occurs in primary and secondary forests.

Diet: Includes aquatic animals.

Cats (*Felids*): Felid tracks all have four digits on each foot and the claws are retracted during locomotion, hence they are not visible in the print. The prints are difficult to tell apart and size is one of the main indicators of species, especially in the larger felids. The smaller felids are more difficult to distinguish. All small cat species have similar footprints.

Leopard Cat – *Prionailurus bengalensis*

Characteristics: Nocturnal and predominantly terrestrial. The most commonly encountered of the cat species.
Habitat: Occurs in a wide variety of habitats from primary forest to scrub, gardens and plantations.
Diet: Includes frogs, lizards, birds and small mammals.
Identification: Tracks are similar in size to the Flat-headed cat, *Prionailurus planiceps* and the Domestic cat, Felis catus. There is however a distinctive indent at the base of the pads in this species, and another indent at the front of the hind pad.

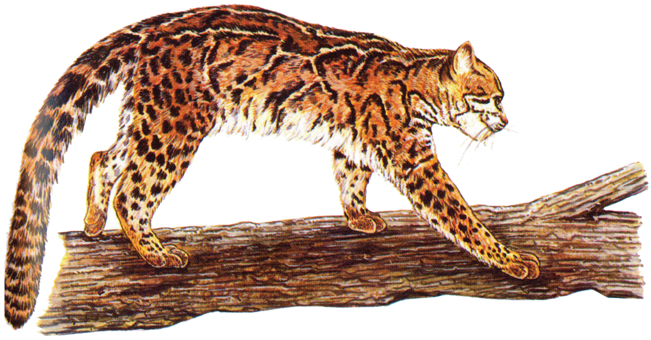


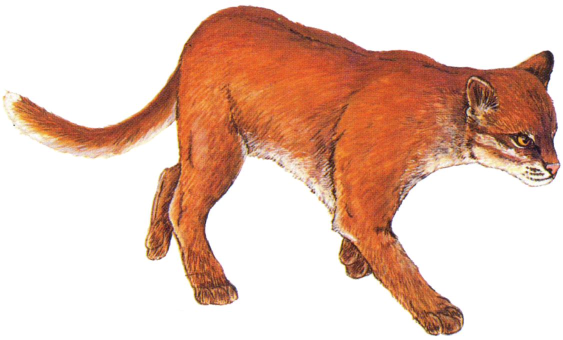
Flat-headed Cat (Kuching Tandang) – *Prionailurus planiceps*

Characteristics: Nocturnal and terrestrial.
Habitat: Occurring in primary and secondary forest, close to water bodies.
Diet: Consists primarily of fish, frogs and crustaceans.
Identification: Tracks are similar to those of the Leopard cat, *Prionailurus bengalensis* and the Domestic cat, Felis catus. The pad of the hind foot is relatively elongated. The top of both pads is flat.

Domestic Cat - *Felis catus*
Habitat: Common wherever humans have settled, usually not found far from settlements.

Marbled Cat – *Pardofelis marmorata*
Characteristics: Very long tail, held horizontal when walking. Nocturnal, and both arboreal and terrestrial.
Habitat: Occurs in primary and secondary forest.
Diet: Includes birds and small rodents such as squirrels and rats.
Identification: Tracks are larger than the smaller felids. Similar in shape to the Flat-headed cat, *Prionailurus planiceps*, but the size difference is obvious.

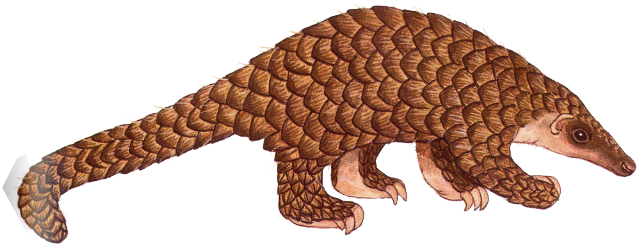




Bay Cat – *Pardofelis badia*
Characteristics: Very rare species.
Habitat/Diet: Little is known about the ecology and habitat of this species.
Identification: The known track is similar to the Marbled cat, *Pardofelis marmorata*.

8.2.4. Sunda Pangolin (*Manis javanica*) – Pholidota, Manidae.

Description	Body covered with scales	
Distribution	Primary and secondary forests, sometimes into cultivated lands	
Ecology	Nocturnal Diet: ants and termites	
DATA	Direct sightings: • Presence of young	Indirect sightings: • Footprints • Signs of feeding



Pangolin signs:

- **Footprints**: Pangolin prints are easy to identify; walking on the outer claw of the fore foot, leaving claw marks rather than a full pad as the clearest sign of their fore foot. However, the hind foot is placed down in a more conventional method.
- **Feeding signs**: Pangolins often leave ripped open termite mounds, but not as thoroughly destroyed as a sun bear would do.
- **Other signs**: In many places, pangolin hunters often use dogs to find the animals inside hollow trees, then they cut open the tree with a parang. So a tree that's been hacked open to its hollow core with a parang (or chainsaw) is probably indirect evidence of pangolin hunting.

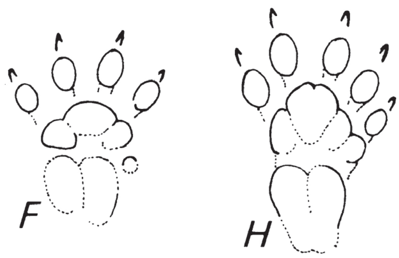
8.2.5. Porcupines – Rodents, Hystricidae.

Two species of porcupines are included in Schedule 2, while a third is in Schedule 3 (see following section).

Description	Body covered with long hair and quills on the back and tail	
Distribution	Primary and secondary forests, sometimes into cultivated lands	
Ecology	Nocturnal Diet: roots, plants, bark and wood	
DATA	Direct sightings: • Presence of young	Indirect sightings: • Footprints

Porcupine signs:

- **Footprints**: Porcupines are easy to tell apart from other rodents because of their large print size. The strong nails are clearly visible and there is a unique pad when the print is defined. Another identifying feature is that you will often see drag marks of the quills in softer substrates, though more apparent in tracks for the Common porcupine, *Hystrix brachyura* (see Schedule 3).



<u>Thick-spined Porcupine</u> - *Thecurus crassispinis*

Characteristics: Short and thick tail.

Habitat: Occurs in forest and cultivated land.

Diet: Feeds on fruitS and other fallen matter.

Identification: The print is similar to the Malayan porcupine *Hystrix brachyura*. (see Protected Species schedule 3).

Long-tailed Porcupine – *Trichys fasciculata*

Characteristics: Smaller than the Thick-spined porcupine with a long bare tail.

Habitat: Occurs in forest and cultivated lands, is terrestrial and arboreal.

Diet: Feeds on shoots, leaves and seeds.

Identification: The pad of the fore foot is visibly more complete than in the other porcupine species. Shares many similar characters to the other porcupine prints but smaller in size.

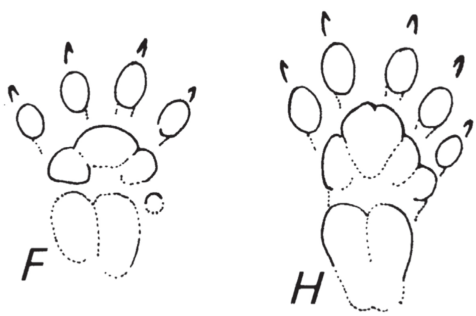
8.3. Protected Species (Schedule 3).

8.3.1. Common Porcupine (*Hystrix brachyura*) – Rodent, Hystricidae.

Description	Generally black with long spines (quills) banded black and white – Short tail	
Distribution	Lowlands to montane habitats; forest and agricultural landscape	
Ecology	Feed on fallen fruits, stems and roots	
DATA	Direct sightings: • Presence of young	Indirect sightings: • Footprints • Presence and cases of hunting activities

Porcupine signs (see Schedule 2 for more details):

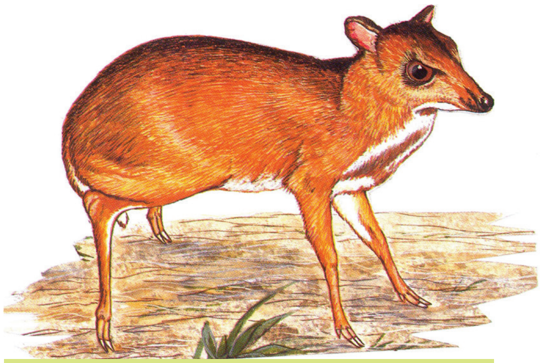
- **Footprints**: Nails and unique pad print is defined. Drag marks of the quills visible in softer substrates. Similar print to the Thick-spined porcupine, *Thecurus crassipinnis*.



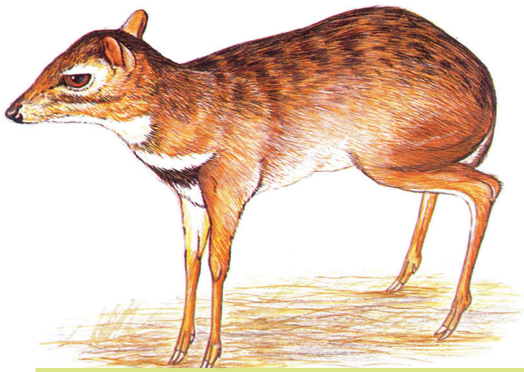
8.3.2. "Deers" – Artiodactyla, Cervids & Tragulids.

Description	Three species of Cervids are found in Sabah: **Red muntjac** (*Muntiacus muntjac*); **Yellow muntjac** (*Muntiacus atherodes*); **Sambar deer** (*Rusa unicolor*). Two species of Tragulids are found in Sabah: **Lesser mouse deer** (*Tragulus javanicus*); **Greater mouse deer** (*Tragulus napu*)
Distribution	Large variety of habitat from lowland to montane forests; primary, secondary, highly degraded forests as well as agricultural landscapes (Sambar deer)
Ecology	Active both during the day and at night Usually solitary animals (except Sambar deers that occur sometimes in pairs) *Diet*: leaves and grass mostly, but also tree bark, fallen fruits and fungi
DATA	Direct sightings: • Taxa identified • Number of individuals • Age class and sex • Presence of young Indirect sightings: • Footprints • Pellets (feces) • Presence of active saltlicks or wallows • Signs of feeding (Sambar deers) • Presence and cases of hunting activities

Mouse deer signs:

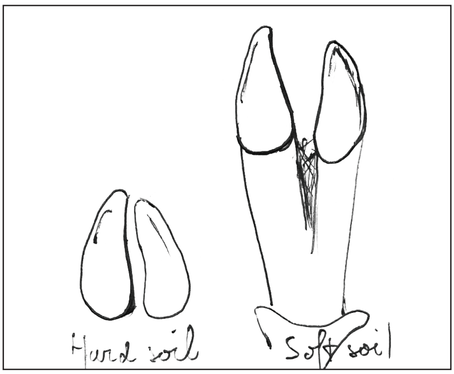


Lesser mouse deer - *Tragulus javanicus*



Greater mouse deer - *Tragulus napu*

- **Footprints**: For *Tragulus* species, the claw marks are very small. In softer substrates, the dew claws can be seen some distance behind the hoof.
- **Feces**: *Tragulus* spp. scat is found in large piles of pellets. The pellets are hard, consisting of compacted vegetation. In mouse deer, the length of a pellet is not more than 1 cm. There is an obvious size difference between the scats of the *Tragulus* spp. and the *Muntiacus* spp., but it might take a little practice to differentiate between them.



Barking deer signs:

- **Footprints and feces**: Similar to mouse deers, but larger (pellets are about 1 cm long).

Sambar deer signs:

- **Footprints**: Similar to the size of wild boars but slimmer.
- **Feces**: Scats are of similar shape than other cervids much thicker and larger (about 1.5 cm long).

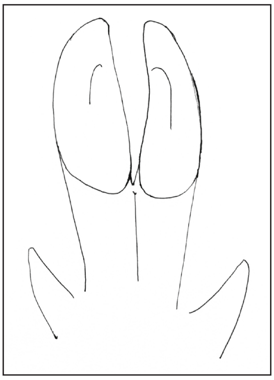
Pellets and footprints of sambar deer

8.3.3. Wild boar or bearded pig (*Sus barbatus*) – Artiodactyla, Suidae

<table>
<tr><td>Description</td><td colspan="2">Long head with long bristles
Body sizes fluctuate with food availability</td></tr>
<tr><td>Distribution</td><td colspan="2">Very large range; all types of habitats in Sabah
Also colonizes the agricultural landscape</td></tr>
<tr><td>Ecology</td><td colspan="2">Active both during the day and at night
Usually solitary or in small family groups
May form very large herds during migration
Diet: fruits, seeds, roots, herbs, earthworms, carcasses, etc.</td></tr>
<tr><td>DATA</td><td>Direct sightings:
• Number of individuals
• Presence of young
• Body condition</td><td>Indirect sightings:
• Footprints and feces
• Nests
• Presence and cases of hunting activities</td></tr>
</table>

Wild boar signs:

- **Footprints**: The major characteristic is the presence of dew toes except in hard substrate. The general shape is similar to Sambar deer prints, but is wider and more rounded.



Bearded pig (*Sus barbatus*)

- **Feces**: Scats are not found in pellets or piles and are much larger than feces of cervids. Their content depends on the diet.
- **Nests**: Adult females build large terrestrial nests to give birth and to take care of their new-born babies.
- **Wallows**

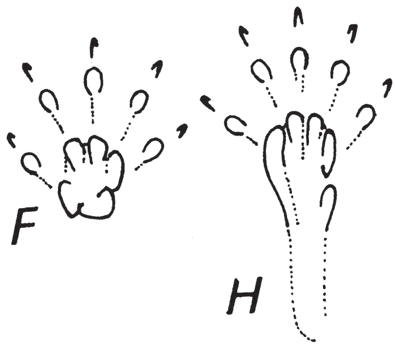
8.4. Non-protected small mammals.

8.4.1. Moon Rat (*Echinosorex gymnurus*) – Insectivora, Erinaceidae.

Description	Large white rat-like species	
Distribution	Occurs mainly in forests, in damp areas	
Ecology	Nocturnal, stays in burrows during the day Diet: Feeds mainly on earthworms and various small animals	
DATA	Direct sightings: • Number of individuals • Presence of young	Indirect sightings: • Footprints

Moonrat signs:

- **Footprints**: Insectivore and rodent prints can be confusing. *Echinosorex gymnurus* has one of the more characteristic prints in that the "thumb" on the fore foot points backwards.



8.4.2. Treeshrews – Scandentia, Tupaiidae.

Description	10 species occur in Borneo: eight species of Tupaia, one Ptilocercus and one Dendrogale: they all closely resemble each other	
Ecology	Diurnal, may be seen feeding among the branches of fallen trees Many species predominantly terrestrial Travel along the branches of smaller trees. Diet: includes insects, other arthropods, and fruits	
DATA	Direct sightings: • Number of individuals • Presence of young	Indirect sightings: • Footprints

Treeshew

Squirrel

Moon Rat (*Echinosorex gymnurus*)

Treeshrew signs:

- **Footprints**: Very similar prints to many of the rodents.

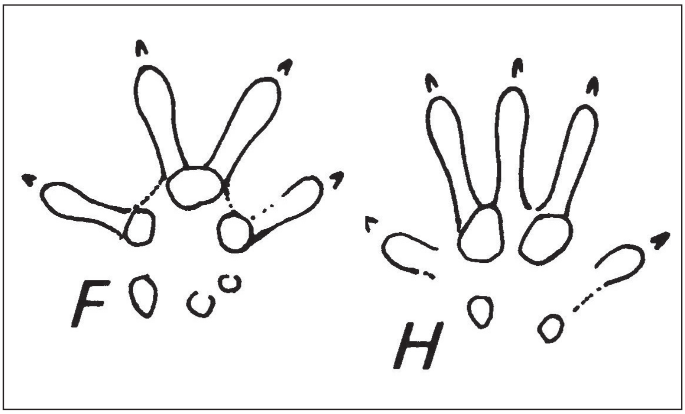
8.4.3. Small rodents: rats, squirrels.

There are many species of rats and squirrels present on Borneo. They are difficult to identify through the use of tracks and it is recommend to just identify the animal as a rodent (except porcupines). It is important to recall that squirrels are protected in Sabah being listed in Schedule 2.

DATA	Direct sightings: • Number of individuals • Presence of young	Indirect sightings: • Footprints

Small rodent signs:

- **Footprints**: The rodents are distinguishable as they have four digits on the fore foot and five digits on the hind foot.



Medium-sized Rat

8. 5. Environmental Key Features.

These features are some of the ecosystem components that need to be included in a wildlife strategy because they explain wildlife abundance and distribution. They include physical features (saltlicks and wallows) as well as human activities (hunting, road kills).

8.5.1. Saltlicks and wallows.

Saltlicks provide essential minerals to the ecosystems. They are used by large mammals to fulfil their salt requirements. They are rare in the forest and if present, need to be identified, mapped properly, protected and monitored. Wallows are used for bathing by several large mammal species, such as wild boars, Sumatran rhinoceros or elephants. Because of their attractiveness to wildlife, it is worth recording the distribution of wallows in the forest and whether or not they are actively used by wildlife. Saltlicks and wallows are elements included in HCVF (High Conservation Value Forest) assessments for wildlife.

Natural saltlicks at Deramakot: saltlicks are essential elements in the habitat that influence distribution and abundance of large mammal species.

Wallows are used by a wide array of animals for mud baths: wild boars, cervids and even rhinoceros or elephants.

Each time wallows and saltlicks are encountered in the forest pictures should be taken and data recorded (see following table).

Environmental Key Features	Data to be collected
Saltlicks	• Location • Size and depth • Status (active or not) • Species frequency (type and abundance of footprints)
Wallows	• Location • Size and depth • Status (active or not) • Species frequency (type and abundance of footprints)

Regular monitoring of saltlicks and wallows is done by repeated visits to the sites at regular time intervals. A *species visitation index* (presence/absence of footprints for the selected species at a given time) is estimated for each site and for each visit: tembadaus, rusa deer, wild boars, clouded leopard, sunbear, orang-utan.

Monitoring can also be conducted with camera traps. From the survey effort (number of days the camera traps are active at a given site), it may be possible to conduct capture-recapture analysis. Monitoring saltlicks provides information about the differential use of these features by wildlife through time (monthly results) and allows for identifying individual of certain species (tembadaus, clouded leopard). When individuals can be identified, an identification book should be created for each camera station providing an estimation of index presence.

8.5.2. Road kill and hunting.

Human activities that must be systematically monitored in any wildlife strategy include road kills as well as hunting and/or poaching. Road kills need to be monitored to assess the possible negative impact of road frequentation on wildlife communities. The sampling should be systematic along the roads that are passable by car in the area of interest. Ideally, all vehicles striking an animal, or finding a dead animal along the road should report the case to the wildlife managers of the area. Whenever possible, the corpse of the animal should be brought to headquarters for further measurements, possible sampling (feces, hair) or storage in freezer.

Monitoring the hunting pressure is done through patrols, road blocks at night, control at entry points and interviews with surrounding communities. This monitoring should be continuous throughout the year. Monitoring poaching pressure will provide clues to designing the best possible awareness/enforcement activities to tackle this issue.

Environmental Key Features	Data to be collected
Hunting / Poaching	• Species hunted • Approximate number • Identification of the hunters
Road kills	• Species • Season • Location • Identity of the drivers

Annex: EXAMPLES of DATA SHEETS USED in the FIELD

1. Data sheet used for road survey by foot
2. Data sheet used for regular road monitoring by car
3. Data sheet used to record substrate toughness
4. Data sheet used to record track measurements
5. Data sheet used for boat survey
6. Data sheet used to record direct sightings from line transects
7. Data sheet used to record orang-utan nests from line transects
8. Data sheet used to record orang-utan nests from a helicopter (co-pilot)
9. Data sheet used to record orang-utan nests from a helicopter (nest recorder)
10. Data sheet used for describing transects
11. Data sheet used for phenology monitoring
12. Data sheet for assessing forest structure and composition within a botanical plot along a line transect

A night-shot of a clouded leopard (*Neofelis diardi*), taken using a camera trap in the Deramakot Forest Reserve.

1. Data sheet used for road survey by foot

Date:	**Location:**
Team:	**Transect Name:**
GPS Starting:	**GPS Ending:**
Weather the night before:	

Distance along Transect: 0-1000m / 1000-2000m / 2000-3000 m / 3000-4000 m / 4000-5000 m

Species	**Number of signs**				**Remarks (group size....)**	**Total**
	Footprint	**Feces**	**Call**	**Other**		
Wild boar	IIIII II	I			Two large bachelors One group of five	7
Gibbon			II		2 different groups heard	2
Clouded leopard	I					1
Rusa	IIIII IIIII II			1 DS		13

2. Data sheet used for regular road monitoring by vehicle

Date:	**Location:**
Team:	**Transect Name:**
GPS Starting:	**GPS Ending:**
Weather the night before:	

Road Segment	**Species**	**Wildlife sighting**	**Number**	**Time**	**Comments**
1: 0-500 m	**-**				
2: 500-1000 m	**Elephant**	**footprint**	**> 10 ind.**	**9.12**	**Fresh (2 days)**
3: 1000-1500 m	**Wild boar**	**Direct sighting**	**2**	**9.18**	
	Rhino Hornbill	**Direct sighting**	**1**	**9.35**	
4: 1500-2000 m	**-**				

3. Data sheet to record substrate toughness

Distance along transect	Score Substrate Type	Score depth of Impact	Total
0 m	0	1	1
50 m	3	2	5
100 m	1	0	1
150 m	2	2	4

4. Data sheet to record track measurements

Date	Species	Substrate	Age class	F/H	Width	Length	Other

F/H = Foot / Hand

5. Data sheet used for boat surveys

Observers: **Date:**
Weather:

General Location:

Start Location: **Start Time:**
End Location: **End Time:**
Total Distance Surveyed:

Time	Loc./ GPS/ WP number	River side	Behavior	Height	Species	Nb. of Indv.		Group composition					Comments
						Count	Est.	AM	AF	Juv.	Inf.	?	

Est.: Estimated number /AM: Adult Male; AF: Adult Female; Juv.: Juvenile; Inf.: Infant; ?: unknown

6. Data sheet used to record direct animal sightings from line transects

DATE:	**TEAM:**
BORANG Number:	
Starting Time:	**Ending Time:**
Weather before survey:	**Weather after survey:**
LOCATION:	**TRANSECT'S NAME:**
GPS start:	**GPS end:**

Distance on the transect	Observation Number	Obs. Time	Species	Perpendicular distance	Bearing / Slope	Number Individuals seen	Nb. Ind. Estimated	Behavior and comments

7. Data sheet used for counting orang-utan nests from ground line-transects

Form to be used for standing crop method of orang-utan nests

DATE:	**TEAM:**
BORANG Number:	
Starting Time:	**Ending Time:**
Weather before survey:	**Weather after survey:**
LOCATION:	**Cpt:**
TRANSECT'S NAME:	**GPS start:**
BEARING:	**GPS end:**

Distance on the transect	Nest Number	Tree height	Nest height	Nest class	Perpendicular distance	Bearing	Slope	Tree's species and comments

8. Data sheet used for counting orang-utan nests from a helicopter (co-pilot)

CO-PILOT DATA SHEET

DATE OF FLIGHT:	/ /	PAGE: 1 /
LEFT Observer:		RIGHT Observer:
RECORDER:		
AREA:		

TRANSECT NAME:		LENGTH:	
Starting Point (name):		Ending point (name)	
Starting Point (GPS):		Ending point (GPS):	
Starting Time:		Ending Time:	
True Starting Point (GPS)		True Ending Point (GPS)	

RF: Riparian Forest / SwF: Swamp habitat (few trees: totally inundated) / SIF: Semi inundated Forest / LDF: Lowland Dry Forest / U: Unsuitable / Deg.: degraded (+;++;+++) / Logging: old (>5 years); recent (< 5 years); on-going / Canopy: Close; Open or in between

TIME: EVERY 30 SEC	GPS (Waypoint-Distance)	NESTS		Forest type	COMMENTS
		L	R		
00':00 to 0':30"					
0':30" to 1':00"					
1':00" to 1'30"					
1':30" to 2':00"					

9. Data sheet used for counting orang-utan nests from a helicopter (co-pilot)

NEST RECORDER DATA SHEET

DATE OF FLIGHT:	/ /	PAGE:	/
LEFT Observer:		RIGHT Observer:	
RECORDER:			
AREA:			

TRANSECT NAME:		LENGTH:	
Starting Point (name):		Ending point (name)	
Starting Point (GPS):		Ending point (GPS):	
True Starting Point (GPS)		True Ending Point (GPS)	

TIME: ONE ROW FOR EVERY 30 SEC	Number nests LEFT	Number Nests RIGHT	COMMENTS
00':00 to 0':30"			
0':30" to 1':00"			
1':00" to 1'30"			
1':30" to 2':00"			

10. Data sheet used for describing a transect

DATE:	TEAM:
AREA:	
NAME OF THE TRANSECT:	Bearing:
Type of transect:	RECCE / LINE TRANSECT / OTHER
GPS Starting Point:	GPS Ending Point:
Starting time:	Ending time:
Transect length:	

Distance on the transect	Forest type and other physical features (hills, streams...)	Canopy: height, open/ close, degree of disruption	Trees: size and height, diversity, pioneer and climax species... Climbers: abundance, type	Signs of human disturbance: logging roads, hunting....

11. Data sheet used for phenology monitoring

DATE:	TEAM:
BORANG Number:	
Starting Time:	Ending Time:
Weather before survey:	Weather after survey:
LOCATION:	Cpt:
TRANSECT'S NAME:	GPS start:
BEARING:	GPS end:

Distance on Transect	Tree Species	Dbh Tree	Fruits/Flowers on Transect	Distance from transect		Phenological status		
				< 5 m	> 5 m	Flower	Fruits +	Fruits ++

12. Data sheet for assessing forest structure and composition within a botanical plot along a line transect

DATE:	**TEAM:**
LOCATION:	**TRANSECT'S NAME:**
GPS location of the Plot:	**Distance of the botanical along the transect:**
Length of the botanical plot: 50m / 100 m	**Width of the botanical plot: 5 m / 10 m**

TERRAIN:	**Flat – Hill – Valley – Ridge – Riverside**
TYPE OF FOREST:	**Swamp – Semi inundated – Dry – Hill – Limestone – Kerangas**
TREES:	**Many stems – Few stems**
	Mean canopy height:
CLIMBERS:	**Many – Few**
	Main species and size:
SOIL:	**Color:**
	Texture:
	Macroscopic composition:

COMMENTS: **Briefly describe the extent of human disturbance: presence of signs of logging activities, hunting, etc.**

Tree's species or Families	C:31-63 cm Dbh: 10-20	C: 63-94 cm Dbh: 20-30	C: 94-125 cm Dbh: 30-40	C: 125-157 cm Dbh: 40-50	C: 157-188 Dbh: 50-60	C>188 cm Dbh>60

NOTE: C: is the circumference of the tree trunk at 1.3 m above the ground (measured with a tape)
Dbh: Diameter at breast height: Dbh is obtained from the formula: Dbh = C / 3.14

Team of field researchers conducting a recce walk in the forests of Danum Valley Conservation Area. Recce walks are an essential way to conduct rapid assessments or preliminary surveys.

ISBN 978-967-0180-07-6

9 789670 180076