# MODULE 5: FIELD TECHNIQUES
# LECTURE NOTES

## Learning Objectives

Students will be able to:

- Understand and be able to practice common field techniques in conservation research and management.
- Follow data collection protocol.
- Provide a preliminary description of species
- Describe and be able to practice rigorous data collection, entry and analysis.
- Describe and implement flora and fauna surveys to assess current population trends and threats to biodiversity.

## Key Topics

- Defining Protocols
  - Pilot studies & Reconnaissance Surveys
- Logistics and Data Collection Protocols
  - Scheduling and Logistics
  - Field Equipment
  - Safety and Security
- Navigation
  - Principles of navigation
  - Maps and compass reading
  - Geographic Positioning Systems (GPS) and Geographic Information Systems (GIS) technologies
- Baseline Studies
  - Establishing Biodiversity values
  - Soil and water testing
- Flora survey protocols
  - Plant identification and field sampling
  - Describing plant ecology and phenology
  - Measuring diversity & abundance
  - Quantifying Forest vegetation
    - Plots & Transects
  - Distance Methods
- Fauna survey protocols
  - Identification of key species
  - Overview of relevant survey techniques
  - Threat survey protocols
    - Types of threats
    - Overview of relevant survey techniques
- Invertebrate survey techniques

Key Topics

- Basics of surveys

A biological **survey** is a recording of the presence or absence data for species or populations at a given site, based on direct or indirect counts and generally expressed as frequencies of observation. Surveys may also include collection of plant and animal material for subsequent analysis. **Monitoring**, or surveys conducted periodically over an extended period, allows for comparisons between different seasons or points in time and provides a temporal analysis of biodiversity. Biodiversity surveys support conservation objectives such as species and landscape management, environmental management and monitoring, and preservation of biodiversity-rich areas.

A biological survey provides essential information about a species' occurrence, distribution, and abundance; it can also be used to evaluate the condition of a site or habitat. Data collected from this type of survey contributes to our understanding of the organisms present in a given area and enhances our capacity to determine priorities for conservation action. Recording all individuals present at a given time at a given location is possible if animals are easily detectable and move slowly with respect to the observer. Ideally, the data you collect through surveying and monitoring will permit evaluation of the sources and impacts of threats such as hunting, habitat degradation, and fragmentation.

Characterization of biodiversity from surveys helps managers to identify gaps in knowledge of a species or an area, confirm environmental problems or identify emerging issues, and determine key species or areas that require protection. Surveys can also raise awareness of the value of an area and establish guidelines for the development of appropriate management strategies. Specifically, biodiversity surveys help us understand …

- Local species richness and diversity;
- Patterns in local endemism;
- The location and status of biologically rich areas; and
- Areas that should be prioritized for protection.

Investigating biodiversity in the same location over time could serve as the basis for the development of monitoring programs that document long-term changes in species composition and distribution, thereby aiding in the development of guidelines for action plans.

**READING**:
Jongkind, "Rapid survey of the plants of North Lorma, Gola and Grebo National Forests"
Conservation International, "A Rapid Biological Assessment of North Lorma, Gola and Grebo National Forests, Liberia"

The application of survey results depends on the scale of the survey and the level of biodiversity being considered. Whereas traditional biotic surveys often account for all the species in the designated area, some survey designers may choose to select a specific organism or group of organisms to focus on or identify biodiversity surrogates to ascertain conservation status. Because diversity in biotic communities exists at different levels of organization, from genes and populations to ecosystems (e.g., marsh ecosystem) and landscapes (e.g., tropical forest landscape), these components should be measured at various scales in order to detect changes in patterns in space and over time. By considering these different levels, many questions can be examined, such as:

1) What species are present in the area?
2) What is the spatial arrangement of species in the defined location?
3) Is the observed diversity evenly distributed across the landscape?
4) Does the observed biodiversity pattern correlate to other elements in the natural or human modified environment?
5) What areas have high conservation value?
6) What levels of diversity can be found in this area?
7) What communities of organisms exist?
8) What are the population attributes (e.g. density) of the species observed?

It is important that specific questions or management goals be identified before the survey is implemented. Biodiversity survey results should answer the original questions posed for the project and lead to prioritization of those questions, which is essential for identifying how the survey data will be organized, evaluated, applied and presented. In addition, information from the surveys may also suggest appropriate modification to the surveying methodology to improve effectiveness or for on-going analysis.

Products from biodiversity surveys include biotic inventories, species collections and distribution databases, and taxonomic keys for use by resource managers. Results should be published (e.g., as technical reports, fact sheets, maps, or in peer-reviewed journals) and distributed to appropriate parties – e.g., local and regional land owners, stakeholders, managers, and/or decision-makers – for consideration and action. The ideal publication should give an account of the main findings of the survey, general impressions, interesting observations, and conservation recommendations. Survey data have many potential conservation applications, from management of a single species to protection of a particular area, which often requires the collaborative efforts of all parties for effective regional planning.

General strategies for coordinating biodiversity survey projects involve three phases: design and planning, implementation and logistics, and post-collection analysis.

PRACTICUM: USING A DICHOTOMOUS KEY TO IDENTIFY SPECIES

Design and Planning

Before a survey is executed, the goals and objectives of the investigation need to be well defined. An important aspect of project design is to consider the ultimate application of the information being gathered. What questions or problems does the project address? What is expected from the project? Who will be involved? As a start, identify the scope of the investigation. Be clear about what is being sampled (e.g., an entire ecological community or a subsample of a community) and how well that sampling strategy will help you to extrapolate from the data the real pattern in the surveyed community. Determine the best strategies for surveying the target area and the components of the community to be surveyed. A well-planned survey allows for effective data collection, smooth project operation, improved quality of the information being gathered by surveyors, and adequate appropriation and distribution of resources (Conroy and Nichols 1996).

In designing biodiversity surveys for management and conservation applications, there are a number of issues regarding the sampling strategy that needs to be considered, including:

- Funding: e.g., funding provided from your organization or funding that needs to be requested from an outside source;
- Spatial scale or sampling unit: e.g., limited survey area, habitat-based, or geographically comprehensive;
- Sampling strategy and sample size: e.g., random (samples taken randomly from the whole community) or systematic (samples taken at regular intervals) sampling; for sample size, the desired level of precision for a population estimate often depends on the sampling method, the parameter being measured, and its distribution pattern.
- What taxa to survey: e.g., all species or indicator taxa;
- What sites to sample: e.g., selecting areas of significance or a general habitat-based sampling approach;
- Best time of year to conduct field work: e.g., single season or any time during the year (frequency of surveys is situation specific and depends on factors such as weather, taxa being surveyed, and timing of collaborations among other things);
- Optimal duration of data collection: e.g., single day, several days, monthly, once every year (depends on what is being surveyed and how often);
- Best survey and collecting techniques: techniques vary based on the species;
- Possible standardization of methods: e.g., development or use of standard techniques that can be or have been used so that the results or outcomes can be compared;
- Sample storage: e.g., identify storage fluids and containers that need to be used;
- Analytical results desired and methods of data analysis: e.g., examining relationships using multivariate analysis;
- Types of qualitative and quantitative data required to complete such analyses: e.g., considering this will help determine what type data or specimens to collect.
- Project evaluation: e.g., assessment of expenditures, equipment needs and availability, personnel time, and future expertise required.

Generally, biotic survey methodologies fall into two categories (although, survey types are variable between these types) – a baseline strategy and a comprehensive strategy – that differ in the extent of participation and the degree of site evaluation. A baseline, or pilot, survey provides valuable preliminary biodiversity information with minimal equipment and expert scientific support. This type of survey is particularly useful for small groups in training, for establishing field methods and protocols suitable for the designated site, and for sites with very little existing data.  In contrast, a comprehensive survey is designed to be more detailed, to require more technical equipment, and to incorporate support from experts for detailed site assessments (see Box 1).  The information collected from both survey types is valuable for guiding management decisions and public awareness.  Nevertheless, identifying the magnitude of the survey will be an important step towards planning the project.

## Stages for planning a biodiversity survey

| **Issues to Consider** | **Stage of Survey** | | |
|---|---|---|---|
| | **Preliminary Planning** | **Implementation and Logistics** | **Post-Survey Measures** |
| **Survey Objectives** | <u>Action</u>: *Identify the objectives.*<br><br>Have the objectives been clearly defined, and are they practical and attainable?<br><br>Do the survey objectives build on existing information about the region/taxa under study? | <u>Action</u>: *Establish achievable goals*.<br><br>How will the survey be implemented in order to meet the objectives?<br><br>Can permits be obtained?<br><br>Are there cultural and political considerations that need to be taken into account? | <u>Action</u>: *Consider data analysis and research applications*.<br><br>What post-collection analysis is necessary to meet the objectives?<br><br>Are there adequate research resources available to do the post-collection analysis?<br><br>Who will be responsible for the post-collection analysis, and where will this be done? |


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| | about the region/taxa under study? | Are there cultural and political considerations that need to be taken into account? | Who will be responsible for the post-collection analysis, and where will this be done? |
| **Available Literature and Data** | Action: *Collect information; conduct a literature search; determine gaps in scientific knowledge; obtain existing species lists*<br><br>Have there been previous studies in the region and, if so, what aspects were studied?<br><br>What bibliographic resources (indexes, abstracts) will be used to search for relevant literature?<br><br>Has all available literature been assimilated and reviewed? | Action: *Determine whether existing data can be used.*<br><br>Is there existing information that can help guide the fieldwork operations (e.g., ground access to sites and site selection)? | Action: *Compare datasets.*<br><br>Does the post-collection analysis complement results from existing publications and fill gaps in knowledge? |

| Issues to Consider | Stage of Survey<br>Preliminary Planning | Implementation and Logistics | Post-Survey Measures |
|---|---|---|---|
| **Spatial Scale** | Action: *Determine the scale for the survey.*<br><br>What size region will need to be surveyed? (This will depend on the organisms being surveyed and the objectives of the project).<br><br>Are you surveying populations or species, and how widespread are they?<br><br>Are you looking at patterns of regional endemism or wider patterns of distribution?<br><br>Are suitable maps available for the selected region? | Action: *Determine if the selected spatial scale is feasible.*<br><br>Is it feasible to survey at the spatial scale?<br><br>Can the area be covered in a single survey, or will several field programs be required?<br><br>What logistic support will be required (personnel and equipment)?<br><br>Is the spatial scale sufficient to achieve the survey objectives? | Action: *Re-evaluate whether the spatial scale is achievable*.<br><br>Are geospatial analytical resources (e.g., GIS, remote sensing data and software) required and available for post-collection analysis of data? |
| **Taxa** | Action: *Identify taxa to be included in the survey and their conservation status.*<br><br>What taxa will be sampled in the survey?<br><br>Will the survey place special emphasis on certain taxa (for filling | Action: *Determine ease of access to selected taxa and expertise for species identification.*<br><br>Where are the selected taxa found in the selected region? | Action: *Determine if selected species were adequate for the survey.*<br><br>Are the selected taxa sufficient to achieve the survey objectives?<br><br>Does the research team have sufficient expertise in the selected taxa to conduct the necessary post-collection analysis? |

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| | gaps in scientific knowledge, or gaps in existing collections)?<br><br>Are any of the selected taxa protected (regionally or nationally, e.g. CITES)? | How difficult will it be to collect the taxa, and will this significantly affect the equipment and time required?<br><br>Are there people locally available in the collection area that know the taxa and can assist in finding them? | Will the research team be collaborating with other scientists and institutions for the post-collection analysis? |

| Issues to Consider | Stage of Survey<br>Preliminary Planning | Implementation and Logistics | Post-Survey Measures |
|---|---|---|---|
| **Site Selection** | Action: *Choose optimal sites.*<br><br>What criteria will be used for selecting sites (e.g., habitat type, elevation, geology)?<br><br>How much information is available for these criteria, for the regions selected for the survey?<br><br>Are maps available to locate and access the sites?<br><br>Are there alternate sites that can be visited if there are problems reaching the preferred sites? | Action: *Consider accessibility to and from sites.*<br><br>How will the sites be accessed?<br><br>What is the proximity of the sites to roads, trails, airstrips?<br><br>Will it be necessary to bring special equipment to reach the sites, or for camping at the sites (e.g. water or power generators)?<br><br>Are special precautions necessary for security or for a possible emergency evacuation? | Action: *Re-evaluate the utility or effectiveness of the selected sites*.<br><br>Are the selected sites sufficient to achieve the survey objectives? |
| **Equipment** | Action: *Compile a list of supplies necessary to conduct the survey.*<br><br>What special equipment will be required for making the survey (e.g. nets, traps, cameras, nightlights), for | Action: *Determine if supply needs differ among survey sites.*<br><br>What sampling methodologies will be used at each site, and what collection equipment will be needed at those sites? | Action: *Identify storage accessibility.*<br><br>What facilities will be available for long-term preservation/storage of the collected material, so that it is available for post-collection |

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| | transporting and storing it (e.g., containers, chemicals) and for field support (e.g., cars, camping equipment, field guides)? | Will chemicals for preserving specimens be locally available?<br><br>Will cars/trucks be locally available?<br><br>What spare parts and equipment will be available locally and what must be brought in by the research team? | analysis by the scientific community?<br><br>Where are these facilities (where will the material be stored)? |

| Issues to Consider | Stage of Survey | | |
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| | **Preliminary Planning** | **Implementation and Logistics** | **Post-Survey Measures** |
| **Preparation for Fieldwork** | Action: *Plan to obtain the necessary travel documents and survey permits well in advance.*<br><br>What visas are necessary to visit the country?<br><br>What health certificates or insurance are necessary (and have vaccinations been obtained)?<br><br>What permits are necessary for collecting the selected taxa and for approval of the collection techniques (e.g. for use of chemicals or electroshockers)?<br><br>What permits are necessary for export/import of collected specimens? | Action: *Be aware of restrictions or limitations associated with the permits.*<br><br>Are there restrictions on species that can be collected and on numbers of specimens that may be collected?<br><br>Are there protocols for avoiding over-collection/bycatch?<br><br>Have permits been filed at the correct offices at all stages of the fieldwork?<br><br>Are there special agreements concerning sharing of collected specimens or results with the host country? | Action: *Prepare post-survey documentation*.<br><br>What permits must be filed with local institutions, government offices, on completion of the fieldwork?<br><br>Do reports of the post-collection analysis need to be filed with supporting organizations?<br><br>Are specific publications planned as part of the post-collection analysis? |
| **Optimal Collection Time** | *Action: Structure survey to account for seasonal trends.*<br><br>What time of day/time of year is optimal for collecting the target organisms?<br><br>Are the organisms diurnal/nocturnal/seasonal in terms of | Action: *Determine if access will be granted during the survey to account for the seasonality.*<br><br>Is access possible at the optimal collection times of day/night, and optimal times of year? | Action: *Determine if the survey objectives will be achieved with this method.*<br><br>Will the planned collection times be sufficient to obtain representative collections for post-collection analysis, and for achieving the survey objectives? |

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| | presence or activity (hence ease of detection)?<br><br>Do the organisms have distinctly different developmental stages at different times of year (e.g., some plants, insects, amphibians) | Is special equipment needed for collecting at night? | |
| **Optimal Duration** | <u>Action</u>: *Allow sufficient time to meet survey objectives.*<br><br>How much time is required to cover the area and sites selected?<br><br>Is extra time necessary to buffer for delays due to bad weather, political, or administrative problems? | <u>Action</u>: *Use criteria to determine survey completion points*<br><br>Will this be a single survey or several independent surveys?<br><br>Are there back-up plans to move to other sites if work at any site is completed early or is cut short?<br><br>Will species equitability and accumulation curve criteria be used to develop stop rules to terminate sampling? | <u>Action</u>: *Compare results with other surveyed sites and sampling methods*.<br><br>Is the duration of the collection pe sufficient to provide the quantity a quality of data to meet the surve objectives?<br><br>Will the results of the post-collection analysis be compared with other surveyed sites where comparable sampling methods were used?<br>Will alternative indexes of diversity be used? |
| **Personnel and Training** | <u>Action</u>: *Determine personnel size required to conduct the survey.*<br><br>How many people will be required to conduct the surveys?<br><br>How many people can be covered by the budget? | <u>Action</u>: *Consider alternate sources for field assistance for the survey.*<br><br>Can students in the host country be included in the survey team (giving them valuable | <u>Action</u>: *Determine personnel for post-survey analysis.*<br><br>Are personnel identified for post-collection analysis? |

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| | Does the proposed survey provide an opportunity to train students or provide professional development for other colleagues in survey/collection techniques? | experience as well as providing useful support to the field team)?<br><br>Does the number of personnel match the resources available (e.g., not too many people for easy transportation, lodging etc.)? | Can students/interns be included in the post-collection analysis?<br><br>Can students from the host country (where the collections/surveys were made) be brought to laboratories overseas for international training? |
| **Funding** | Action: *Create a budget for the survey and identify funding sources.*<br><br>What is the expected budget for the survey, and what are the available sources for funding?<br><br>Are all expected costs covered by the funds? | Action: *Determine distribution strategy for acquired funds.*<br><br>How will money be brought to the collection site?<br><br>How will collaborators be paid?<br><br>Are special arrangements necessary? | Action: *Consider post-survey requirements*.<br><br>Is final funding contingent on publication of the results of the post-collection analysis?<br><br>Is a report required to the granting agency upon completion of the survey?<br><br>Can the results of this study be used as leverage for obtaining further funding for this or a related project? |

| Comparison of different survey design strategies: baseline/pilot survey design versus a comprehensive approach. | | |
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| **Survey Strategy** | Baseline/Preliminary Design | Comprehensive Design |
| **Project** | Results of a preliminary small mammal survey in Sapo National Park, Liberia | Priority areas for freshwater conservation action: a biodiversity assessment of Liberia |
| **Goal** | To provide baseline data for future monitoring efforts and standardization of protocols, particularly due to growing development plans in the area. | To understand diversity patterns across large scale for ecoregional planning efforts. |
| **Duration** | 6 days | Several months |
| **Survey Team** | 5 personnel from various institutions | Several surveyors from federal and state agencies, academic institutions, industry, and conservation organizations; plus a host of experts that contributed pre- and post-survey |
| **Site Selection** | Based on reconnaissance field work as part of survey | Based on previous assessment by Fauna & Flora International |
| **Sampling Methods** | Used pitfall and standard traps to see what worked best | Following those developed for the Nature Conservancy |
| **Sampling Target** | Small mammals (e.g., rodents, insectivores) | Wide range of aquatic species and aquatic systems/processes |
| **Product** | Species inventory in the dry forests | Identification and mapping of freshwater ecosystem types and communities |

Many of these issues can be addressed if certain efforts are made beforehand in a structured fashion. For example, if a region has been identified for a biotic survey,

1) Become familiar with the natural history of the area by reviewing the available information about the selected community. Conducting a background search

into the study area will help generate a preliminary list of the species that may be encountered during the survey.

2) Choose where within the region the survey should be conducted. Ultimately, the selection process will depend on the goals of the survey. Ideally, the survey region should be representative of the community being surveyed in terms of proportion of habitats and species. In a comprehensive survey, assessments of each habitat or ecosystem type may be necessary.

3) Next, identify the species or species groups that will be included in the survey. Because invertebrate diversity is extensive, many surveys typically select targeted or indicator species as a proxy for the extent of biodiversity in the area. Also, time, financial, or permit/license constraints may prohibit a comprehensive survey.
4) Then, choose field techniques for investigating species richness and abundance, if that is the goal. Several techniques may be employed if multiple species are to be surveyed. Best techniques will vary based on the specific questions that the project aims to address, the species being surveyed, and the collections being made. Focused collections are necessary to enhance the feasibility of specimen analysis.
5) Determine the timing and duration of the survey. This will depend, for instance, on the organisms being surveyed and the environmental conditions in the region.
6) Citizen Science: recruit volunteers, train them to become citizen scientists, and distribute the task of data collection and biomonitoring.

This is by no means a complete set of tasks to undertake, but it provides an idea of the process one goes through when designing a survey.

The planning phase for any biodiversity survey must address the issues noted above to achieve study objectives. Planning should be multidisciplinary and well integrated in order to meet the needs of diverse partners and to utilize standard methods. It is imperative to incorporate local involvement in order to ensure stakeholder interest and commitment to supporting longevity in sampling programs and the ultimate and ongoing application of data gathered to local conservation management. Introductions and consultation with local communities are also important if any survey work (especially at night) is planned in private land, in close proximity to places of residence, or areas of special significance including protected areas or sacred sites.

Issues to consider in biodiversity survey design include geographic scale and site selection, timing and duration, and determination of appropriate specimen sample size. Additional important considerations include the determination of evidence to be collected and data to be recorded. Also critical is planning for specimen preservation, storage, and identification. Practical considerations include obtaining necessary permits to collect biological material and transport such material internationally. Creating a checklist may help organize the important tasks and plan for the field expedition (see Box below).

Tasks that require consideration when coordinating a biodiversity survey

Preliminary Planning

-  Survey design completed
-  Background information and maps
-  Contact with potential collaborators, scientists, field experts, etc.
-  Establish community outreach
-  Site inspection before expedition
-  Funding procured

Logistics

-  Identify survey participants
-  Determine and obtain necessary permits or licenses for research, specimen collection and/or exportation
-  Determine and obtain necessary site access authorizations
-  Calculate lodging, food and other expenses during survey.
-  Negotiate local guides' compensation and other expenses during survey.
-  Identify transportation needs

Equipment

-  Purchase or borrow necessary field equipment, supplies, and preservation liquids (e.g. ethanol, lysis buffer, formalin).

Post-Survey

-  Post-survey retreat to discuss preliminary findings
-  Preliminary report (preferably before scientists or participants leave site)
-  Ambiguous specimens sent to appropriate expert for identification

Geographic scale and site selection are some of the most important factors involved in the design of a survey or inventory. Choice of geographic scale is heavily dependent on available resources and survey objectives. By contrast, site selection usually represents a compromise between research and logistics criteria. Logistics criteria require attention to access issues, including proximity to roads, trails, airstrips and rivers, and water availability. Security and emergency evacuation concerns are critical as well.

A major purpose of surveys is to collect evidence of species occurrence, distribution, and possibly abundance. Surveys for specific taxonomic groups often require specialized strategies and techniques. In most cases, the evidence of occurrence must have characteristics or features that allow the identification of the species. Traditionally, a whole specimen or diagnostic parts of a specimen were required.

- Logistics and Data Collection Protocols
    - Scheduling and Logistics

Duration must be sufficient to meet the principal objectives of the survey. Consequently, the survey objectives and the required data quantity and quality must be well defined prior to beginning fieldwork.

If the target organisms are seasonal in terms of activity or presence (such as amphibians, migrating birds or hibernating/aestivating mammals) or seasonal in terms of ability to identify specimens (such as fertile plant characters or adult invertebrate stages), such factors must be considered in survey planning. Multidisciplinary surveys may require multiple survey times. Climate seasonality is almost ubiquitous across the globe, including most tropical regions.

- Equipment

Navigation equipment is important. Standard equipment should include the highest quality maps available, a compass, a GPS (Geographic Information System) unit, and an altimeter. The survey team must know how to use all of these items effectively. GPS units are becoming the standard means of recording localities for collected biological material.

- Safety and Security

All fieldwork involves taking increased risks concerning safety such as the lack of immediate health support, emergency evacuation problems, potentially dangerous activities such as rock climbing, caving, exposure to insects and other potentially dangerous animals or security issues. The following general guidelines will reduce health risks:

- No team member should have a pre-existing medical condition which endangers them in the field
- Have a well-equipped medical and first-aid kit and know how to use it
- Have a source of reference in the field for help.

Suggestions:

- Have a first aid-trained individual on the team
- Have communication available to reach a doctor and get emergency evacuations underway.  In remote areas consider taking a satellite phone.
- Have an emergency evacuation plan, with contingencies in place.
- Avoid dangerous activities.
- Get support from local authorities or colleagues.

- Baseline Studies
    - What is a baseline study?

A biodiversity **baseline study** is the work done to collect and interpret information on the biodiversity values occurring at a site, their current condition, and trends before a project commences

- A baseline study is the work done to collect and interpret information on the biodiversity values occurring at a site, their current condition, and trends before a project commences.
- The biodiversity baseline study plays important roles in supporting the assessment of impacts and risks of a project and designing the long-term biodiversity monitoring program.

Step 1: Identify the biodiversity baseline study area. The baseline study area should encompass the geographic area of anticipated project activities and impacts. Does the study area include direct, indirect, and cumulative areas of influence?

Step 2: Identify the biodiversity values that will be included. The scope may also describe methodologies that should be used, define the spatial and temporal scale of the study, and identify the stakeholders to be consulted.

Examples: RAPS done by FFI in Wonegezi (Mammals and Birds, 2018) and in Sapo National Park (2019).

Step 3: Review existing information on the biodiversity values that fall within the scope of the baseline study. Summarize this information in a preliminary baseline report.

Step 4: Conduct a field-based assessment of biodiversity values to fill the information gaps identified from desktop analysis, stakeholder consultation, and other sources.

- Are field surveys adequately designed to assess variation in biodiversity values over time and within the baseline study area?
- Does the methodology include a power analysis or another approach to assess whether the sampling effort is sufficient?
- Have species surveys been organized with respect to specific natural habitat types?

- Are maps available that show the distribution (and ideally abundance) of biodiversity values in the baseline study area?

Step 5: Integrate the data into a baseline report. The report will combine the information from the preliminary baseline report with the information collected from the field-based assessment to describe the biodiversity values present, including the following information:

- list and description of the natural habitats, species, and ecosystem services within the baseline study area, and their current conservation status;

- quantitative measures of abundance, distribution, and other measures of viability and/or function, sufficient to support impact assessment;

- identification and discussion of limitations, uncertainties, and data gaps;

Data on species richness, presence/absence of individual species, or the distribution of species, may be inaccurate or unavailable. This is due to a variety of factors, for example, the resolution of mapping of the occurrence and distribution of species may be too coarse.

A preliminary assessment for conservation purposes might include:

- Description of the baseline study area, including biogeographic and landscape settings
- Available habitat maps indicating the likely types and extents of terrestrial and aquatic habitats
- Identification of biodiversity values that fall within the project's area of influence
- Description of the context of biodiversity values, including ecosystem services
- Discussion of possible effects, both positive and negative, to biodiversity values from the proposed project
- A list of relevant experts, including NGOs, institutions, and individual researchers
- Identification of key biodiversity stakeholders
- A list of references and data sources used

Surveys can be divided into **general surveys** and **focal surveys**. General surveys are used to characterize biodiversity values such as communities of species, or habitat types. For example, a biologist might walk timed transects, recording all the bird species she observes, in order to characterize the bird community within different habitats. The data obtained would allow a comparison of the number of species present in each of the habitat types and provide estimates of the relative abundance of at least the most common species.

There are various ways in which scientists allocate their sampling effort over the baseline study area. Three approaches to locating sampling sites for general surveys, in increasing order of preference, are:

- *Systematic*: an evenly spaced grid of sampling points can be laid out over the study area, with the location of the first point randomly located. This approach may be relatively easy to implement in the field, but may not achieve the goal of adequately sampling all of the biodiversity values that occur on the landscape. It may also bias results if some biodiversity values occur with the same systematic distribution as the sampling points, or if there are small localized patches of specialized or distinctive habitat.
- *Random*: sampling points can be located in a completely random manner, but for low sampling intensities, some types of biodiversity values may not be adequately sampled.
- *Stratified random*: a map of habitats provides the ideal basis for deciding where to locate general surveys. Sampling points can be randomly located within each of the habitat types and broken down further by considering degree and type of disturbance within each habitat type. It is important that all habitat types are sampled. By locating sampling sites in a random manner, the results can be reliably extrapolated to the study area as a whole. It is important to note that subjective selection of "representative" sampling sites is vulnerable to bias and is not a valid approach for locating sampling sites for general surveys.

Determining when to survey

The detectability and abundance of biodiversity values may vary temporally, including time of day, time of month (e.g., in relation to phase of moon), time of year (e.g., local or large scale movements or migration), seasonally, annually, and over periods of multiple years. Variation on longer scales is also possible, for example, caused by climatic phenomena such as El Niño events. It is good practice for baseline surveys to be structured in such a way as to help understand regular large changes in detectability and abundance of biodiversity values that may occur in the baseline study area over time (e.g., wet and dry seasons at tropical sites; some combination of spring/ summer/autumn/winter at temperate sites).

Habitat quality/condition

Measures of condition typically consider some combination of information on the structure, composition, and ecological function of habitats, and assess the condition of the habitat at a particular site in relation to benchmark sites. Measures of condition may also incorporate landscape considerations, for example, the size of the habitat patch, or degree of habitat fragmentation in the vicinity of the survey site. Approaches may be qualitative, using expert judgment to assign habitat to broad categories of condition (e.g., intact, somewhat degraded, severely degraded), or quantitative, for example, using plots or transects to produce a numeric score of the condition of a habitat.

Habitat degradation

- Selective physical removal or alteration of habitat components
- Changes in hydrology (e.g., natural flow regime of rivers, changes in groundwater levels)
- Reduction in air quality (e.g. dust)

- Reduction in water quality (e.g., nutrient loading, sedimentation
- Changes in water temperature
- Introduction of invasive species

    - Establishing Biodiversity values

**Biodiversity values** are specific species, habitats or ecosystems, and ecosystem services occurring at a project site that may be included in a biodiversity baseline study. For example, biodiversity values at one project site might include game species that play an important nutritional role in the diets of local communities. At another site, biodiversity values might include rare habitats that occur in only a few places in the world.

Studies of **individuals** are concerned mostly about physiology, reproduction, development or behavior, and studies of populations usually focus on the habitat and resource needs of particular species, their group behaviors, population growth, and what limits their abundance or causes extinction. Studies of **communities** examine how populations of many species interact with one another, such as predators and their prey, or competitors that share common needs or resources.

Biodiversity baseline study is the work done to collect and interpret information on the biodiversity values occurring at a site, their current condition, and trends before a project commences.

    - Soil and water testing

- Flora survey protocols

Botany is the scientific study of plants, and includes studies of their form (anatomy), function (physiology), diversity (classification), reproduction, metabolism, diseases, cultural relevance, medicinal uses, and evolution. It is also sometimes referred to as Botanical Science, Plant Science, or Plant Biology. Regardless of the name, the fundamental tools of study are dried and preserved plant specimens, which have been collected in the wild, as part of a
botanical research expedition.

Plant material is traditionally collected for fertile plants (with flowers and seeds) that have characters that allow the species to be identified fully. Often repeat visits to the same area, during different flowering seasons, are required. With specimens larger than a plant press, only a sample of the complete plant can be made. This requires taking sections of leaf blades, stems, bark, etc., that represent the morphological diversity of the specimen. Photographic records of the plant are also valuable. Collecting voucher specimens from tree species may require the use of collecting poles with cutters and the use of climbing gear to gain access to the canopy.

    - Plant identification and sampling

- Describing plant ecology and phenology
- Collecting plant samples

**Vascular plants**: the main groups of vascular plants include horsetails, ferns, gymnosperms and flowering plants.

**Vascular plant surveys** are typically conducted when the majority of plants are flowering, easing detection and identification. Multiple surveys within a year may be required to capture the plant species in distinct seasons (e.g., wet versus dry seasons) and to document plants occupying temporary habitats, such as spring seeps and ephemeral wetlands. If the objective of the vascular plant surveys is to maximize the number of species detected, then some combination of unstructured or semi-structured collecting may be appropriate. If the objective is to provide a quantitative description of the plant communities of the various habitats present within the baseline study area, then plots or transects should be located randomly within habitat types.

- Measuring diversity & abundance

There are two major methods of sampling flora: **sample units** (plots), or **plotless sampling** methods.

<u>Representative Sampling</u>
All sampling units should be representative of the sampling area or population. The proportion of the different things in the sample, or how they are dispersed should reflect the reality in the wider area. For example, if you only sample close to roads, you miss a lot of individuals.

**Sample units or plots** comprise a subset of the total population from which measurements are taken during sampling. Sample units are distinct, non-overlapping entities, such as quadrats or transects, individual plants, branches within a plant, etc.

A **quadrat** is a 2-D shape (e.g. square or rectangle, or other shape) used as a sampling unit. The choice of dimensions and shape of the quadrat will affect the precision and accuracy of the parameter estimates subsequently computed. Sometimes a tape is laid on the ground, but more often a frame is used to define the quadrat boundaries.

**Transects** are used to sample along narrow ecotones or to sample across ecotones to get better averages.

*Line transects* can be generally defined as a line walked/travelled and a defined distance to be surveyed on one or both sides of the line to collect observations of a given population.

*Belt transects* have a width as well as length.

*Pace-transects* are established when the observer strides along an imaginary line across the sample site, and uses their foot placement to determine specific sampling points.

Transect sampling in areas with broad-scale vegetation patterns increases the likelihood of encountering species that occur at a very low density. In difficult terrain, line transects allow estimates without having to locate quadrats. In open terrain, line transects allow sampling over large areas to provide more precise estimates.

<u>Assumptions</u>
1) Individual vegetation patches are randomly oriented with no preferred orientation of the major axis of the patch.
2) Sample lines are randomly oriented across the study area.

- Quantifying Forest vegetation
  - Plots vs. Transects

A **transect** (a sampling line with fixed length) or **plot** (a surface area with fixed dimensions) are frequently used for measuring relative abundance of species, and for long-term monitoring of local populations. Both these techniques aim to provide quantitative measures of abundance, and thus allow comparisons between sites or between time intervals.

Plots - count everything. Used for immovable things (botany).
Transects - no fixed width: you count what you detect from the center line. Used for moving things (animals).

<u>Is a Quadrat Needed?</u>
Counting the number of plants in a quadrat can be very time consuming. Therefore, alternative methods have been developed that are based on the distance between plants or the distance from a specific point and a plant. One unavoidable truth when measuring vegetation density is that plant Density and Distance between Plants is inextricably linked:

- High Density = Plants that are Close Together
- Low Plant Density =Plants that are Far Apart

Techniques based on this premise are called plotless or distance-based techniques. The basic idea of these distance techniques is that density can be calculated if the average space occupied by individual plants can be determined. These techniques assume:

- Plants occupy circular areas
- Plants are randomly distributed

- Distance Methods

**Distance methods** were generally developed in forests, but they can be applied to grasslands and shrublands. Plotless techniques can have several advantages over quadrat-based techniques:

- Usually faster (especially in sparse communities).
- Requires less equipment - just need a way to measure distance (e.g., meter stick, tape measure, or laser range finder).
- Does not require selection or adjustment in quadrat size.

**Distance methods** measure the distance from a sampling point (or plant) to the nearest plant or nth nearest plant. The results of such a technique can provide important information about the relationships between plants. Distance methods can help determine whether plants are growing in discernible (and often ecologically important) patterns or are randomly dispersed. Many inter and intra-specific plant relationships are difficult to observe without using distance based sampling techniques.

- Fauna survey protocols
  - Identification of key species
  - Overview of relevant survey techniques
- Threat survey protocols
  - Types of threats
  - Overview of relevant survey techniques
- Invertebrate survey techniques
- Fauna survey protocols: Methods for sampling terrestrial animals

**READING:**
**Collen et al, "Field surveys for the Endangered pygmy hippopotamus *Choeropsis liberiensis* in Sapo National Park, Liberia"**

**Mark-recapture method**
- Scientists capture, tag, and release a random sample of individuals(s) in a population
- Marked individuals are given time to mix back into the population
- Scientists capture a second sample of individuals ($n$), and note how many of them are marked ($x$)
- Population size ($N$) is estimated

**Birds**
- A variety of techniques are used to survey birds, including transects, point counts, mist nets, and camera traps for larger ground-dwelling birds.
- Observations may be visual or made by identifying vocalizations. Because birds are small and mobile, in some habitats the ability to reliably detect certain species is a challenge.

- Distinct surveys must be carried out for diurnal versus nocturnal birds. Surveys are typically carried out during both the breeding and the nonbreeding seasons and usually early in the morning when activity levels and detectability are greatest.

Large mammals
- Mammal inventory methods include walking transects of fixed length to obtain either direct or indirect measures of mammal abundance, conducting aerial surveys, and setting out systematic grids of camera traps over large areas.
- Large mammals may exhibit large-scale seasonal movements, and so it is important that surveys are carried out during the time or times of year when they are most likely to be present.

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Great ape survey techniques
- There are a variety of methods used to survey apes but the most commonly used is nest counts from line transects (a path along which one records and counts occurrences of nests and other signs).
- Recently non-invasive genetic sampling (for great apes faecal samples tend to be the most reliable source of DNA), camera traps and audio monitoring are increasingly used to survey apes.
- Camera trapping has also become an increasingly popular tool to assess species’ presence in a given area, monitor population trends, and identify individuals..

Small mammals (rodents, bats, and other insectivores < 1 kg)
- Bats are usually surveyed using mist nets and harp traps, or with sonograms.
- A variety of capture techniques are used to survey non-flying small mammals, including non-lethal baited box-type traps; snap traps, which kill the animal; and drift fences to direct small mammals to pitfall traps.

Amphibians and reptiles
- Amphibians and reptiles are surveyed along transects or within plots of fixed area.
- Survey methods include active searches as well as trapping including the use of drift fences and pitfall traps.
- Diurnal and nocturnal surveys are required to provide a complete picture of the amphibian and reptile communities.
- Most amphibians have an aquatic larval stage and so surveys may look for eggs and larvae in aquatic habitats.

- In temperate locations, surveys should be carried out between spring and fall. In tropical systems, surveys are ideally carried out in both the wet and dry seasons.

<u>Fish</u>

- Fish are surveyed at specific sampling locations using a standardized effort of active or passive collecting techniques, including the use of seine nets, dip nets, trap nets, short-set gillnetting, push nets, visual counts (snorkeling) and electrofishing.
- In tropical systems surveys are ideally carried out in both the wet and dry seasons.
- Sampling for fish surveys may often be seasonal, either due to water levels and habitat, or life history, or a combination of both.
- In many parts of the world, important fish specimens can be obtained from local fish markets.

How do we collect spatial data about wildlife?

- Radio collars
- Direct observation and paper maps
- Museum records of collection locations
- GPS
    - Collars/patches that upload
    - Field indicators
        - scat, tracks
- Remotely sensed data
    - Satellite imagery
        - Vegetation, landcover, climate
    - Aerial photography
    - Radar etc.

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The diversity of invertebrate groups in most environments is potentially overwhelming and specimens can be difficult to manage in terms of quantity. Invertebrates are usually highly seasonal, which necessitates multiple visits to a site to collect all life stages and species. Photographic records may be helpful in some species, but complete specimens are almost always taken as vouchers. Management of collection lots is critical to avoid confusion, mislabeling, and loss. Estimating numbers of individuals and groups can present issues concerning permits.

- Field techniques

Due to the different faunal groups present in any one area, it is necessary to employ a range of techniques to obtain a representative sample. You must also carefully consider the aims of the survey, as this will dictate the faunal groups to be sampled. Sampling fauna can be a time-intensive exercise, so it is important to use the correct techniques.

Fauna use many different parts of the environment. Some are ground-dwellers, others arboreal and some live underground or in rock crevices. Prior knowledge of the habitat animals inhabit is important in planning surveys and selecting the right sampling technique. As with flora surveys, the amount of detail required in sampling fauna will influence the methods used in a fauna survey. For example, if there is a need to estimate population size, then animals will have to be captured, marked and measured. This will not be necessary if your aim is to develop a fauna list for your area.

Having some prior knowledge of what an animal looks like, its distribution and types of habitat it might prefer enables you to determine the most appropriate survey method to use. These types of decisions are critical for effective faunal surveys, and the time committed to researching and planning survey methodology should not be underestimated.

- Identifying wildlife species

In general, only surveys of birds and mammals rely heavily on photographs, tracks or marks, vocalization recordings, field note descriptions and measurements. For example, bird surveys often involve field descriptions, recordings, and photographs, where possible. Surveys of bird breeding sights, feeding sites, other areas of congregation, and migratory routes often are surveyed visually on a regular basis; radar may be used to track large-scale movements. Mammal surveys may place considerable reliance on measurements, tracks, and photographs including photographs from automatic camera traps or vocalizations.

- Tracking
- Diversity & census counts
- Status and trends
- Collecting Data on line transects

Transects are predefined lines across a survey area, along which you record all observations, vocalizations, and signs of animals and humans, ensuring that all are georeferenced. Transect lines are oriented to be representative of habitats and other gradients. Transects provide a measure of the relative distribution and abundance of animals (or subject of interest). Transects can estimate the density of animal signs, and they are statistically reliable when comparing sites, over time, or between different observers.

- Bird survey techniques

Liberia has 615 recorded bird species, of which 125-130 migrate between the country and the Palearctic region. Surprisingly an equal or even higher number of African species either migrates to or from Liberia or large fractions of their populations leave the country seasonally.

- Mammal survey techniques

**[READING: “Mammal species list of Liberia”]**

**[READING: Tweh et al, “Conservation status of chimpanzees in Liberia”]**

Mammals are some of the most difficult groups to survey due to the generally low abundance at which they occur, their often cryptic behavior and the wide range of environmental niches they occupy. In any one area, multiple techniques need to be used if an accurate assessment of the mammal fauna is to be made. The following trapping techniques are used with various mammal groups:

- pitfall traps
- hair tubes
- echolocation
- cage traps
- mist-nets
- tracks and scats
- elliott traps
- harp traps
- spotlighting

Pitfall trap
*Target group*: small mammals.
*Description*: small to medium size hole dug into the ground and plastic bucket placed in the hole. A drift-fence (variable height and length) is placed on the ground to intersect with the bucket and guide animals into it.

Cage trap
*Target group*: medium-sized ground dwelling and arboreal mammals.
*Description*: collapsible rectangular trap with one or two trap doors. Placed on ground and commonly baited with fruit or peanut butter and rolled oats, but may be placed in trees and baited with a variety of foods that may be preferred by target species.

Elliott trap
*Target group*: small ground-dwelling and arboreal mammals (rodents and marsupials).
*Description*: collapsible aluminum trap into which the animal is lured with food bait. Usually baited with mixture of peanut butter and rolled oats. Comes in a range of different sizes.

Hair tube
*Target group*: small group-dwelling and arboreal mammals.
*Description*: passive method that comes in a number of different designs. Usually a PVC tube with adhesive tape inside which collects hairs as animals brush against it. Requires reference collection of hairs from positively identified species. The diameter varies depending on size of target species.

Mist-net
*Target group*: bats
*Description*: fine, lightweight nylon mesh strung between two poles in which bats become entangled during flight. Often strung close to water holes and across creeks at dusk to catch bats as they come to drink. The fine nature of the nylon mesh avoids detection by bat's echolocation, therefore some bats fly into the net and become entangled. It is very important to remove captured individuals as quickly as possible to decrease stress and the risk of injury.

Harp trap
*Target group*: bats

*Description*: large, aluminum framed, collapsible bat trap that is designed to intercept bats in flight. Placed along flight paths (creeks and tracks) for small insectivorous bats. The trap has two vertical banks of nylon lines, supported on two sets of adjustable legs. A bat collecting bag is placed at the bottom of the vertical lines. Advantage of this method is the trap can be left overnight.

<u>Echolocation</u>
*Target group*: bats
*Description*: electronic devices that can permanently record the signals of bats for analysis either in the field or later in the laboratory. Its function is to convert the ultrasonic echolocation signals of bats into audible electronic signals that can be recorded and processed to assist in identification of the species. These bat detectors can be used in one hand, allowing control of a tape recorder, the addition of commentaries, and calibration tones. A large amount of processing time is involved after data collection if quantitative data is required.

<u>Tracks and Scat</u>
*Target group*: all mammals
*Description*: if you don't actually catch or see the animal, it may still be possible to know what it was. Signs of the animal's presence such as footprints or scats can be accurately interpreted. Bones, teeth and skulls can be used as well to positively identify species.

<u>Spotlighting</u>
*Target group*: all mammals, especially nocturnal arboreal species and bats.
*Description*: common method involving either a timed active search in specified area or more general search over a wider area. Habitats that are more structurally complex (e.g. rainforest and rocky escarpments) require more effort due to the greater number of places an animal may use. Eye shine is commonly detected but not always.

- Great ape survey techniques

**READING:**
**IUCN, "Best practices for ape surveys"**

The conservation of wild great apes requires a detailed understanding of their population size, spatial distribution and demographic trends. Survey and monitoring programs (monitoring refers to regular, periodic surveying of a population to detect and assess changes and patterns) are designed to provide exactly this kind of information. The conservation status of most wild ape populations is still poorly known. Great apes occur at low densities throughout their range, and often in remote places with difficult access. When these factors are combined with their cryptic nature, the implementation of efficient survey and monitoring programs is notoriously difficult. As a result, action plans issued for both African and Asian great apes over the past few years have emphasized the need to properly document the conservation status of wild populations.

Populations change over time as a result of both natural and anthropogenic (human induced) factors. They can change in size, composition, and also spatially. Detailed demographic data obtained at Gombe National Park, Tanzania over the past 40 years, a site made famous by Jane Goodall, has enabled the examination of population trends of this small population. Whilst the overall size of the population has remained stable the pattern of population change has varied between the different communities.

Surveys are used to detect the presence and absence of apes in a particular area at a particular time. For known communities of great apes such as those as Gombe National Park, direct monitoring is more likely to be possible and it can provide evidence of fluctuations in ape population size and structure. However, it is rarely feasible with great apes as they tend to be shy and elusive and consequently the majority of surveys are conducted using indirect signs of ape presence such as nests that can remain visible for weeks or months. There are a variety of methods used to survey apes but the most commonly used is nest counts from line transects (a path along which one records and counts occurrences of nests and other signs). Recently non-invasive genetic sampling (for great apes faecal samples tend to be the most reliable source of DNA), camera traps and audio monitoring are increasingly used to survey apes. Camera trapping has also become an increasingly popular tool to assess species' presence in a given area, monitor population trends, and identify individuals.

Monitoring refers to regular or periodic surveying of a population and this is how we detect and assess change and trends. It is important that methods of data collection used in surveying populations are comparable so that trends can be detected through periodic monitoring. With the appropriate methods trends can be determined at the community, population, sub-species and species level.

GoL, "Biomonitoring in the Proposed Grebo-Krahn National Park"

Data from monitoring programs can provide vital information to support and help design conservation management strategies and plans. The primary cause of the catastrophic ape declines have been attributed to commercial hunting, facilitated by the rapid expansion of mechanized logging. Ebola haemorrhagic fever has also been identified as a threat comparable to hunting. The action plan for central chimpanzees and western lowland gorillas provides a series of immediate response needs and longer-term mitigation strategies to combat these main threats which are consistent across the region. As the biggest threat, the plan argues that anti-poaching should be the foundation upon which all other ape conservation activities rest, as it is the most effective means of protecting apes in western equatorial Africa

Population fragmentation occurs as a result of both natural and anthropogenic causes, although the relevant literature on great apes is dominated by the impact of human induced activities. The type and extent of threats are continually changing and indeed in most cases increasing hence the IUCN listing of endangered status for all species of great ape

For known communities of great apes, direct monitoring is more likely to be possible and it can provide evidence of fluctuations in ape population size. However, it is rarely feasible with great apes as they tend to be shy and elusive and consequently the majority of surveys are conducted using indirect signs of ape presence. Great apes build nests that consist of vegetative structures that can remain visible for weeks or months.

The current standard method for estimating ape abundance is nest counts using line transect distance sampling. Observers applying distance sampling techniques follow either a series of line transects or cover a series of point transects. The size of the entire population in the predefined area is then estimated by extrapolating from the sample. Relative abundance provides useful information on spatial distribution and population size however baselines of absolute abundance (when possible) are more informative. A major assumption is that the sample is representative of the whole area, including threats, topography, vegetation and altitude. Indirect surveys aiming to provide density estimates must be based on known rates of production of the target objects and of their decay (e.g., nests), and the proportion of the population that actually leaves the 'detectable' signs (i.e., not infants), so that density can be calculated from the density of indirect signs.

- Observing and recording data
  - SMART Tracker

SMART (Spatial Monitoring and Reporting Tool) is a data collection method and a suite of best practices aimed at helping protected area and wildlife managers better monitor, evaluate and adaptively manage patrolling activities. SMART helps protected area agencies and other ranger-based programs to combat poaching and other illegal conduct. SMART can be used by rangers in their day-to-day work by capturing the data they collect while on patrol help improve management. SMART can help conservation managers get timely and accurate information on what threats are occurring, where they are occurring, and how their teams are responding.

- Data Management

  Organization, data entry, backups

Field catalogs should include associated habitat information, environmental variables, weather data, phases of the moon, soil type, and tree data. It is important to record all potentially useful data for corollary Geographic Information Systems/Remote Sensing studies, which are becoming increasingly important parts of biodiversity surveys and ancillary data that may be useful to partners working in the area in order to maximize the value of funds supporting field work.

Field data is especially vulnerable to loss through the following:

- Damage from water, chemicals and other field conditions

- Accidental loss
- Theft (from baggage or vehicle)

It is best to record all field data as hard copy, in permanent ink on water resistant paper. Make duplicate photocopies whenever possible and store them in a separate location. Do not rely on electronic data files without the availability of multiple back-up options, a good secure source of safe electricity, and good working conditions for electronic equipment (low humidity, dust free and no extreme temperatures). Most tropical countries represent severe environments for computers.

Field note books should be brightly colored, have durable paper and durable spine binding. Level books (used by surveyors) are widely used. Write a return address in the book, in case of loss. Keep field notes in a secure place. Never pack them in checked baggage.

Specimens, or specimen lots or sheets require a field numbering system, which should be used to cross-reference the sample with field data, and other associated data such as photographs and sound recordings. Use a specimen collection numbering system, usually your own field series (or institution field series). The numbering system need not be sequential but it must be unambiguously tied to the point and date of collection so that specimens may be cross-correlated to any other data associated with that specific collection point. Avoid the use of alternative numbering systems in the field. Pre-numbered tissue vials with bar codes may be a convenient exception.

- Record all data with a date tied back to a collection event. Chronology of data can help avoid potential errors in the data and allow reconstruction of fieldwork history.
- Record all data with a spatial reference, typically a GPS coordinate position.
- Keep notes on everything, especially data that may become easily confused such as photographs and sound recordings.