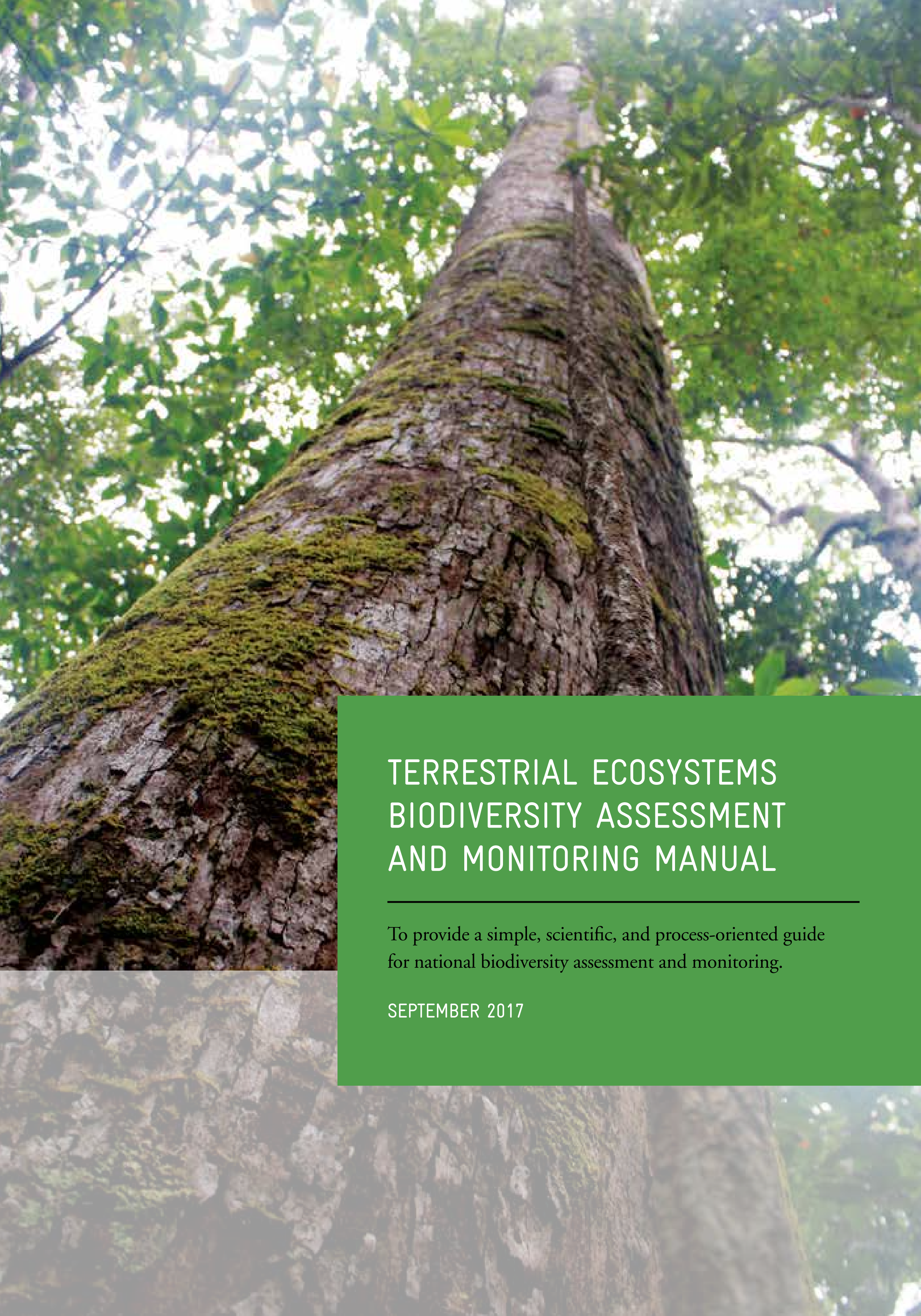

TERRESTRIAL ECOSYSTEMS BIODIVERSITY ASSESSMENT AND MONITORING MANUAL

To provide a simple, scientific, and process-oriented guide for national biodiversity assessment and monitoring.

SEPTEMBER 2017

TERRESTRIAL ECOSYSTEMS BIODIVERSITY
AND ASSESSMENT MONITORING MANUAL

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1. About This Manual

1.1 At a Glance

BIODIVERSITY ASSESSMENT AND MONITORING IS A KEY ACTIVITY IN PROTECTED AREA (PA) Management. Its outcomes greatly influence the PA Work and Financial Plans, which form a fundamental part in the PA Report.

Being a crucial step in the PA Management process, a scientifically-robust, objective, relevant and sustainable biodiversity assessment and monitoring system must be in place. Hence, this manual is made for the terrestrial ecosystems, whether classified as a NIPAS protected area or otherwise.

1.2 Why Another Manual?

WITH THE CONSTANT CHANGES AND NEW KNOWLEDGE BROUGHT AND INTRODUCED BY THE scientific community, several updates had to be made. With appreciation for the value of the 2001 BMS Manual that was developed by the Nordic Agency for Development and Ecology (NORDECO) and Department of Environment and Natural Resources (DENR), this new manual has an added feature of established permanent monitoring plots for an in-depth monitoring of selected habitats and species.

As an updated version, this manual brings to the Biodiversity Assessment Monitoring System (BAMS) additional:

1. criteria for locating the permanent plot, including the presence of important and indicator species;
2. instruction on how to join the International Long Term Ecological Research (ILTER) Network, which shares information regarding environmental changes worldwide;
3. assessment methods that will determine the presence of key monitoring species in larger areas encompassing the different elevation gradients;
4. stakeholder consultation in order to determine which among the identified ecologically and eco-nomically important species in the area will be best used as indicator species for monitoring, and
5. the potential for an interactive Geographic Information Systems (GIS) map of permanent plots for easier information access and guidance on the scientific management of PAs.

This How-To Guidelines are designed for use in the Philippines.

1.3 What are the Goals of this Manual?

THIS MANUAL AIMS TO:

1. provide a comprehensive guide on national biodiversity assessment and monitoring system;
2. contribute to the management planning, profile updating, and biodiversity monitoring of protected areas, and
3. help capacitate the personnel involved in the management of protected areas.

IN A NUTSHELL

THIS MANUAL FOR TERRESTRIAL BIODIVERSITY ASSESSMENT AND MONITORING WAS made possible through the partnership of the DENR, particularly its Biodiversity Management Bureau (BMB) and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH of the Federal Republic of Germany and the University of the Philippines Los Baños (UPLB) through the UPLB Foundation, Inc. It is one of the many institutional steps undertaken by the DENR as a testament to its solidarity with the international community and in fulfilling its obligation to conserve the environment.

WITH THE PUBLICATION OF THIS MANUAL, ITS READERS ARE HOPED TO BE MORE equipped in the management of protected areas, guided by a revamped Biodiversity Assessment Monitoring System.

BEFORE YOU BEGIN: IS THIS MANUAL FOR YOU?

THIS MANUAL IS FOR YOU IF YOU ARE EITHER:

A. A TECHNICAL PERSONNEL OF TERRESTRIAL PAS UNDER THE NATIONAL INTEGRATED Protected Areas System.

B. A PROSPECTIVE TECHNICAL SERVICE PROVIDER WITH KNOWLEDGE AND SKILLS FOR the efficient and effective management of biodiversity conservation.

IF YES TO ONE OR BOTH, LET'S PROCEED!

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2. Organization and Planning

2.1 Team Formation & Tasking

2.1.1 Identify major stakeholders in the PAs.

These include the BMB, CENRO, LGUs, local communities, CSOs, research institutions and academe.

2.1.2 Invite identified stakeholders to a BAMS Orientation Session.

> BAMS Orientation Session Goals

i. To create awareness about the need for BAMS in the protected area.

ii. To mobilize support from the various stakeholders.

iii. To emphasize the value of biodiversity and ecosystems to the daily life and general well-being of the people.

iv. To make stakeholders aware on the various threats to biodiversity and ecosystem integrity and on how BAMS could facilitate the reduction of exposure to these threats.

v. To highlight the need for the committed participation of the stakeholders in biodiversity assessment and monitoring.

vi. To get stakeholders' expression of commitment to participate and support the implementation of BAMS in the PA concerned, ideally through signing of a Memorandum of Agreement.

2.1.3 Form the BAMS Team.

THE TEAM SHOULD BE FORMED BY THE Parks Operations Superintendent (PASu) as designated by the DENR Regional Director.

TEAM COMPOSITION

THE MINIMUM COMPOSITION OF THE BAMS team should include the following:

1. PASU AS THE BAMS COORDINATOR.

2. PASU STAFF MEMBERS ASSIGNED either at the PENR or CENR Offices with adequate expertise on watershed monitoring; biodiversity database and mapping; flora assessment and monitoring; faunal assessment and monitoring.

3. TECHNICAL LGU STAFF MEMBERS who are involved in environment and natural resources management projects.

4. REPRESENTATIVE OF INDIGENOUS peoples within the protected area.

5. FACULTY AND RESEARCHERS FROM higher education institutions with research interests in the protected area and have academic agreements with the DENR.

6. VOLUNTEERS FROM MOUNTAINEERING or outdoor clubs, environmental action movers or supporters, media or radio communication clubs, concerned civil society organizations, private and industry sectors.

7. CONCERNED GOVERNMENT AGENCIES or entities like water districts, area development projects, interagency task forces in the locality.

8. LOCALS IN THE AREA AS GUIDES, climbers and porters.

> Number of Personnel

The BAMS Team in every protected area should include at least four (4) core personnel with adequate expertise in the following major tasks:

- Watershed monitoring
- Biodiversity database and mapping
- Flora assessment and monitoring
- Faunal assessment and monitoring

In many PAs some of the above personnel may not be present within the concerned DENR offices/ units and will most likely come from academic institutions and research organizations.

2.1.4 Get approval on the TEAM that was formed.

THE PROTECTED AREA MANAGEMENT BOARD (PAMB) should approve the formation of the BAMS Team and the conduct of the program through a PAMB resolution.

> Expertise and Qualifactions of BAMS Team Members

1. The BAMS Team should involve DENR personnel who are currently or about to be assigned to the tasks of assessing and monitoring biodiversity in key biodiversity areas or priority conservations areas in the region.

2. Team members should have academic preparations or have attended training courses on biodiversity assessment, flora and fauna inventory, watershed monitoring, geographic information system and other allied fields.

3. Whenever possible, former participants of biodiversity assessment and monitoring trainings conducted by the GIZ PAME project should be assigned to the regional teams to serve as trainers.

2.1.5 Schedule your activities efficiently.

FOR EFFICIENCY, THE VARIOUS MONITORING activities should be coordinated and synchronized to avoid unnecessary duplications and overlaps and to maximize synergy and complementation. For details see "Table 2.1. Parameters for Watershed and Ecosystem Level Monitoring" on page 128

2.1.6 Create a budget.

A SAMPLE LINE-ITEM BUDGET (LIB) FOR conducting biodiversity assessment and monitoring can be seen in "Table 2.2 Sample Line-Item Budget (LIB) for Biodiversity Assessment and Monitoring (Duration: 1 Year)" on page 132. Prices of each item may change depending on local prices.

2.1.7 Conduct training workshops for the Team.

THE BAMS TRAINING SHOULD BE ORGANIZED and conducted for at least five (5) days. Preferably the training and subsequent field assessments should be done during the dry months or before the onset of rainy season that is from February to May in most PAs.

> Key Topics for BAMS Training Workshop

THE TRAINING WORKSHOP SHOULD COVER key BAMS aspects that include the planning and organization of BAMS and specialized lecture-discussions for the physical, flora and fauna assessment and monitoring modules ("MODULE TOPICS" on page 12).

HOW TO CONDUCT THE BAMS TRAINING SESSIONS

1. Include plenaries on how to organize BAMS, sampling stratification, and specialized lecture-discussion for the physical, flora, and fauna modules.

2. BAMS specialists from the DENR national or regional office and partner higher academic institutions should facilitate the training sessions.

MODULE TOPICS

PHYSICAL MODULE TOPICS

- Introduction to watershed management
- Refresher on Geographic Information System and remote sensing
- Watershed delineation and characterization
- Measurement of streamflow and water quality
- Soil sampling
- Ground-truthing and validation of maps and other geographical information
- Vulnerability and risks assessment related to changes in rainfall and temperature, landslides and other geohazards
- Preparation of maps for the Bataan NP

FLORAL MODULE TOPICS

- Introduction to forest formations and major plant groups
- Plant classification and identification
- Methods for floral assessment
- Establishment of 2-km transect
- Habitat ground-truthing
- Transect survey
- Specimen processing and identification
- Assessment of mangrove and beach forest

FAUNA MODULE TOPICS

- Introduction to major fauna groups (arthropods and vertebrates)
- Methods on arthropods and herpetofauna
- Methods on birds and mammals
- Traps and mist net set-up
- Vertebrate sampling
- Arthropods sampling
- Specimen processing and identification
- Compilation and processing of collected data

Figure 1. Module Topics

3. Each training participant should be provided with a training kit containing writing pads and pens, fieldwork supplies, and a copy of the training manual.

4. Training participants should be notified in advance on personal items to bring. These should include the following:

- Laptop, preinstalled with word processing and spreadsheet software. For GIS, laptop must be installed with the latest versions of QGIS and ArcGIS
- Smart phone, tablet and/or digital camera
- Headlamp/flashlight
- Clothes for at least 4 days of lectures and 4 days of fieldwork
- Hiking shoes/rubber boots
- Slippers
- Jacket
- Raincoat/poncho
- Toiletries and medication
- Insect repellent
- Water bottle
- Spoon and fork
- Binoculars (required for fauna participants only)

Optional items to include:

- Swiss knife
- Compass
- Handheld GPS device
- Laser rangefinder
- Field identification guides

5. Choose an appropriate training venue. The BAMS Coordinator should make arrangements for the training venue. The venue should be located nearest the field site but with basic training facilities and amenities for lectures, audio-visual presentations, group discussion and workshops. The venue should have sleeping quarters and services of a food caterer or kitchen crew.

2.1.8 Conduct a post-training evaluation.

TO ASSESS THE OVERALL EFFECTIVENESS OF training management, the timeliness and appropriateness of delivery and generate feedback from the participants, a post training evaluation should be conducted. The post – training evaluation form can be seen in "Table 2.3 Sample Post-Training Evaluation Form" on page 134.

3. Biodiversity Assessment

3.1 Physical Assessment

3.1.1 Watershed delineation using hydrology tool in ARCGIS™

> Dataset Preparation

1. Copy the **Watershed Delineation** folder to **C:\CapDev_Terrestrial** directory.

2. Open **ArcMap**.

3. Click on the **Add Data** button. Navigate to **C:\CapDev_Terrestrial\Watershed Delineation** folder then double click on **Watershed.gdb** then choose **dem** then click **Add**.

4. Click on **Geoprocessing > Environments.**

5. From the **Environment Settings** window, expand **Workspace**.

6. Click on the directory icon on the **Current Workspace** then click the **Connect to Folder** icon.

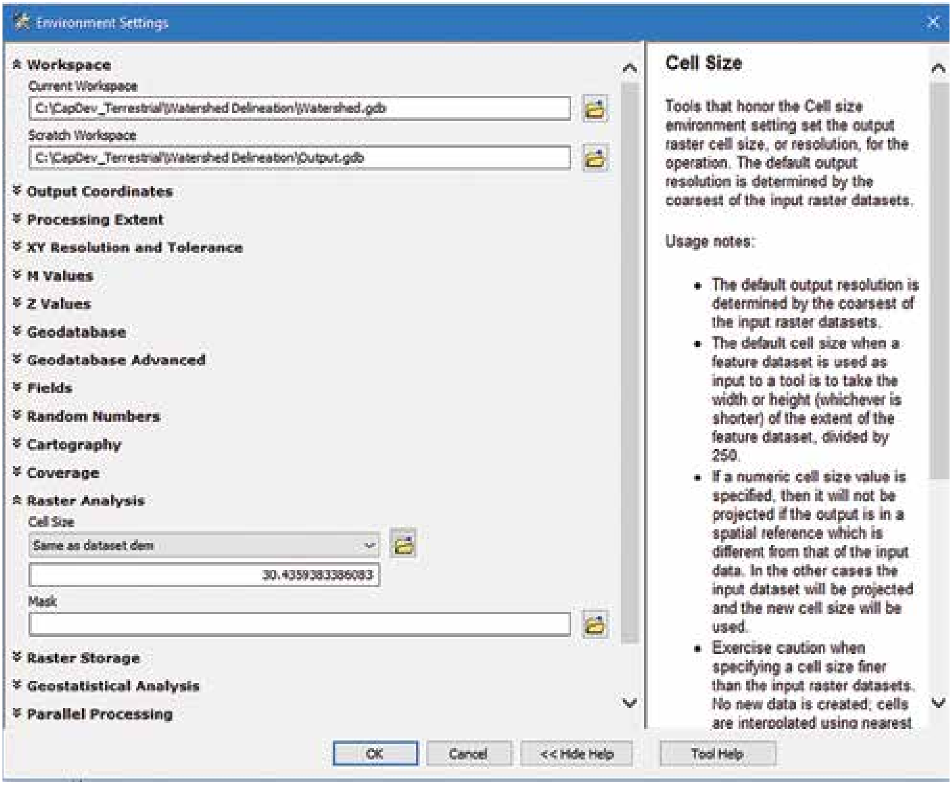


Figure 2.

7. Navigate to **C:\CapDev_Terrestrial\Watershed Delineation.**

8. Set the **Current Workspace** to **C:\CapDev_Terrestrial\Watershed Delineation\Watershed.gdb** then click **Add**.

9. In the **Scratch Workspace** box, navigate to **Current Workspace** to **C:\CapDev_Terrestrial\Watershed Delineation \Output.gdb** then click **Add**.

10. Next, expand the **Raster Analysis** from the **Environment Settings**.

11. Set the **Cell Size** to **Same as dem** or **Same as dataset dem**. (Figure 2)

12. Click **OK** to close the **Environment Settings** window.

> Dataset Preparation

13. To begin the delineation of watershed, open your **ArcToolbox**.

14. Go to **Spatial Analyst Tools** then expand the **Hydrology** toolset.

15. First click on the **Fill** tool. This tool is used to remove any imperfections (sinks) in the digital elevation model. A sink is a cell that does not have a defined drainage value associated with it.

16. From the **Input raster** drop down list, select **dem**. (Figure 3 on page 15)

17. In the **Output surface raster**, just change the file name to **Fill**. Click **OK**.

18. Double click the **Flow Direction** tool. A flow direction grid assigns a value to each cell that indicates the direction of flow. This is important in hydrologic modeling because it determines the destination of the water flowing across the surface of the landscape.

19. For every 3x3 cell neighborhood, the grid

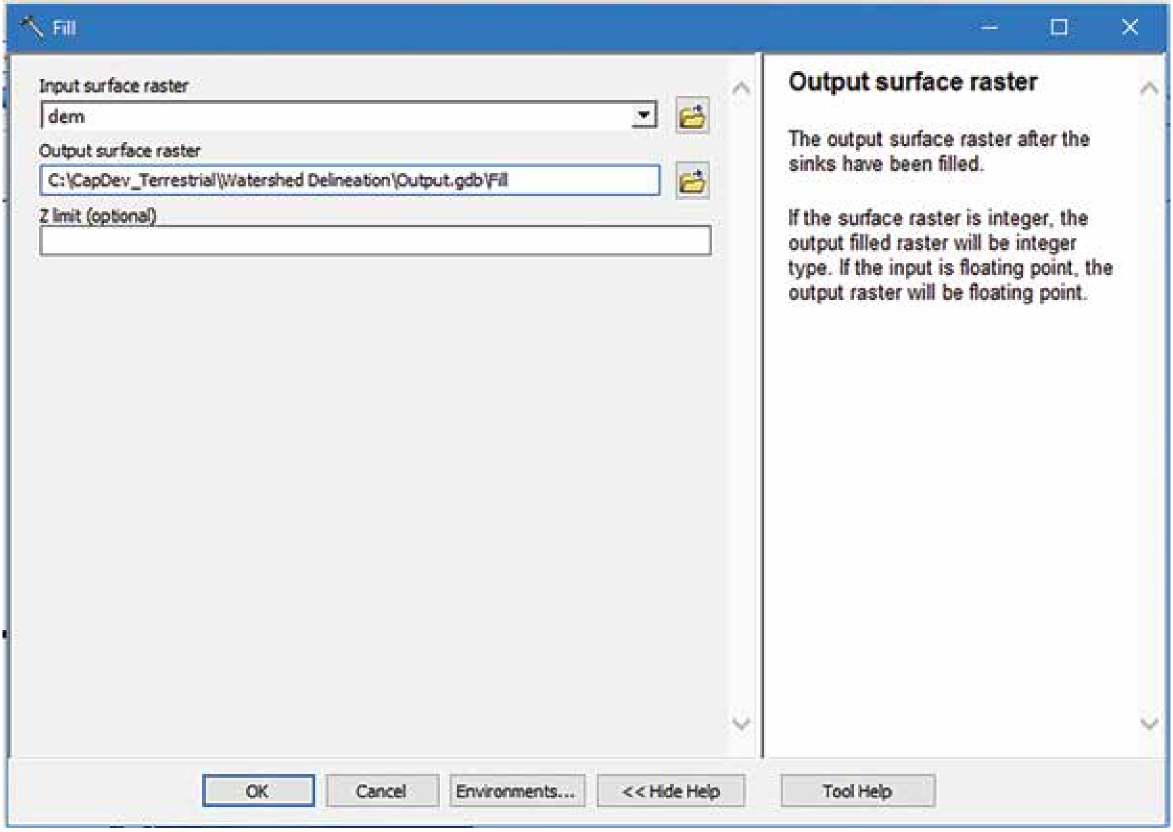


Figure 3.

processor finds the lowest neighbouring cell from the center. Each number in the matrix below corresponds to a flow direction, e.g. if center cell flows due west, its value will be 16; if it flows north, its value is 64. (Figure 4 on page 16)

20. From the **Input surface raster**, click the drop down arrow and choose **Fill**.

21. In the **Output flow direction raster**, set the file name to **FlowDir**. Click **OK**. (Figure 5 on page 16)

22. From the **Spatial Analyst Tools > Hydrology**, double click on **Flow Accumulation**.

23. The **Flow Accumulation** tool calculates the flow into each cell by accumulating the cells that flow into each downslope cell.

24. From the **Flow Accumulation** window, set the **Input flow direction raster** to **FlowDir**.

25. In the **Output accumulation raster**, change the name to **FlowAccu**. Click **OK**. (Figure 6 on page 16)

26. Right click the **FlowAccu** in the **Table of Contents** then click **Properties**.

27. Click on the **Symbology** tab. Set the **Show:** to **Classified**, **Classes** to **2** then click **Classify**. (Figure 7)

28. From the **Classification** window, change the value of the first class found in the **Break Values** to **1000**. Leave the highest value in the second class as is. Click **OK**.

29. On the **Color Ramp**, change the white color of the symbol to yellow. (Figure 8)

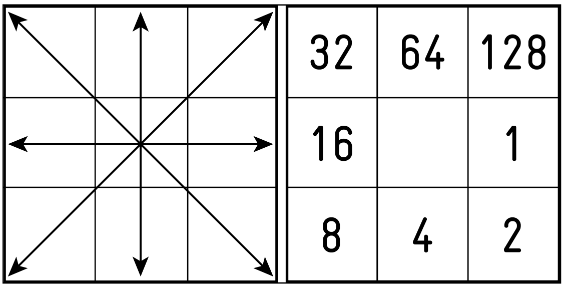


Figure 4.

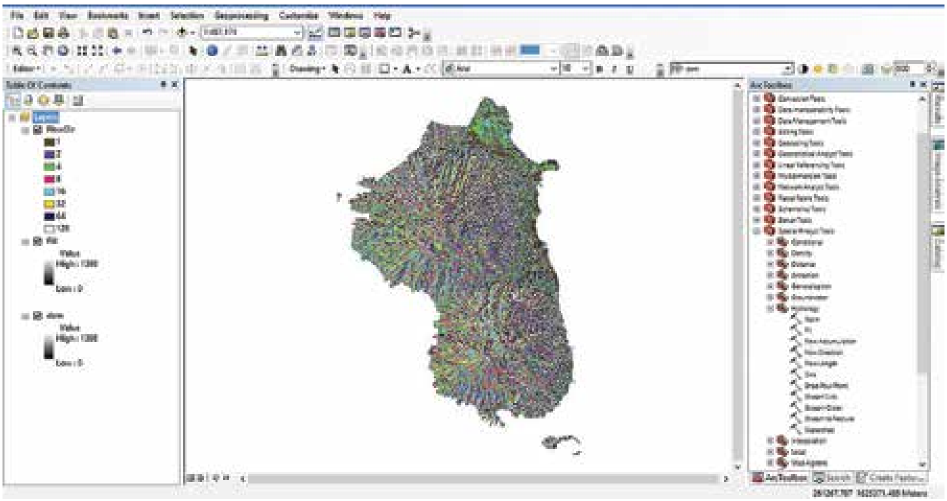


Figure 5.

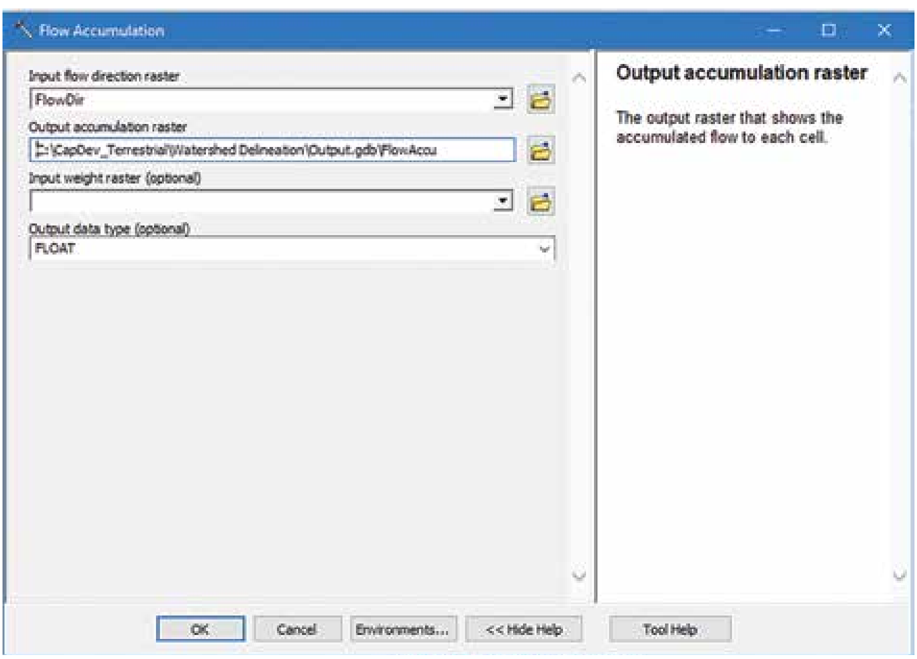


Figure 6.

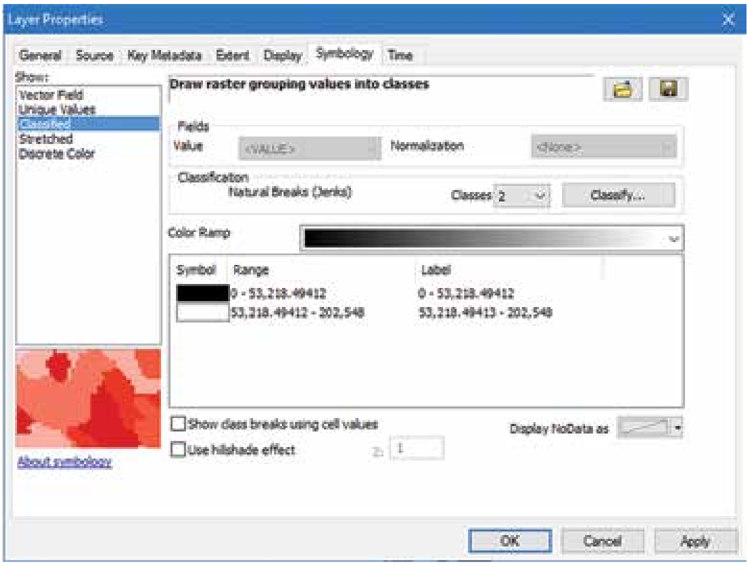


Figure 7.

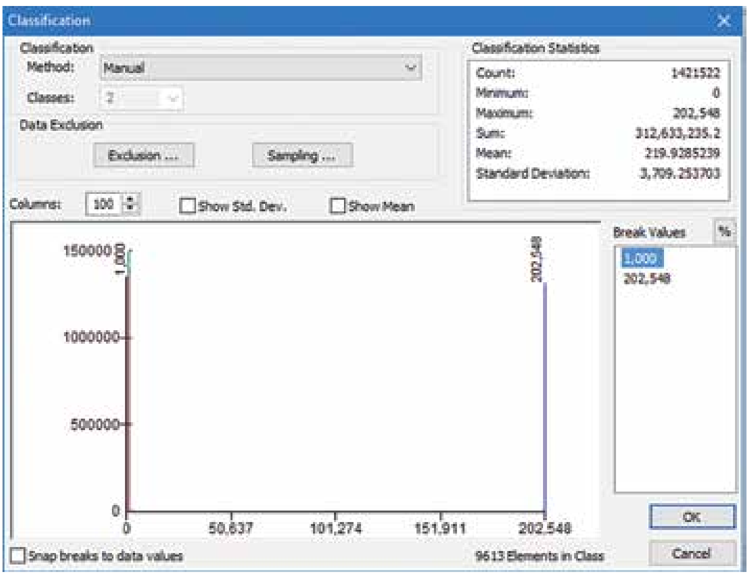


Figure 8.

30. Double click on the symbol then choose any shade of yellow. Click **OK**.

31. Cells displayed in yellow have at least 1000 upstream cells flowing through them. (Figure 9 on page 18)

32. Flow accumulations are significant because they allow us to locate cells with high cumulative flow. Each cell has an outlet called pour point that indicates the location where water would flout out of the cell. Pour points must be located in cells of high cumulative flow.

33. Next is to create pour (outlet) points. Open **ArcCatalog** and navigate to **C:\CapDev_Terrestrial\Watershed Delineation**.

34. Right click over the **C:\CapDev_Terrestrial\Watershed Delineation**, then click **New** then

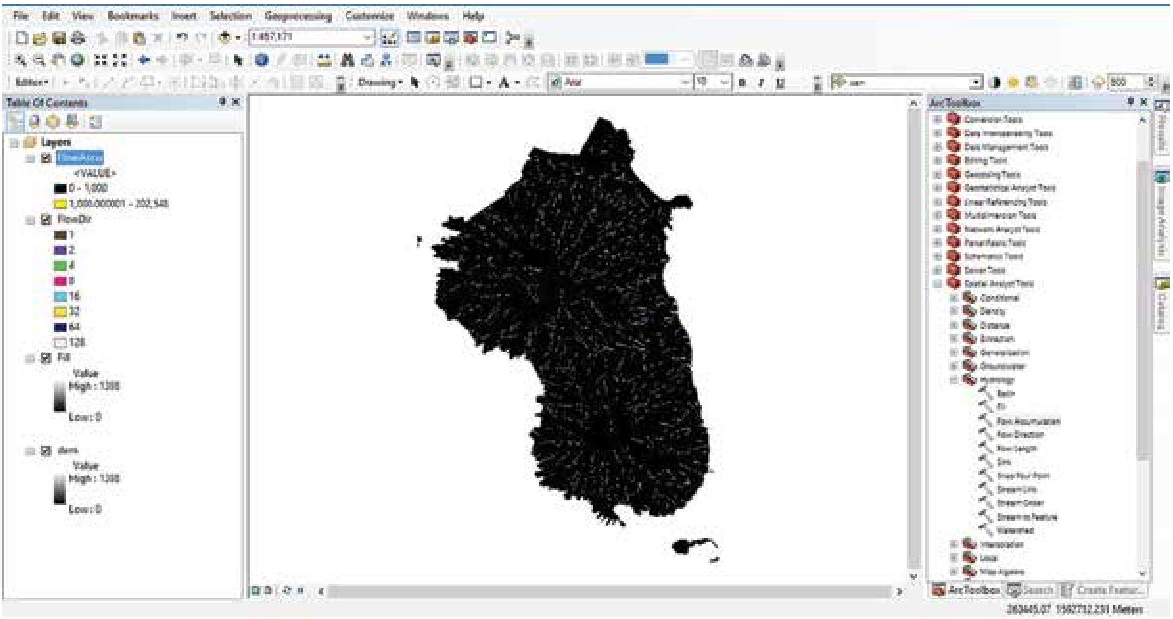


Figure 9.

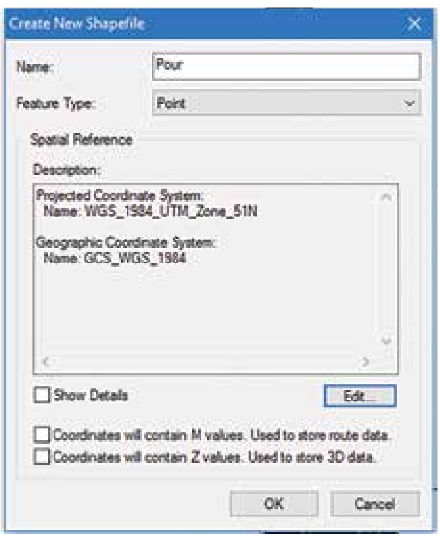


Figure 10.

choose **Shapefile**.

35. Type **Pour** in the **Name** text box the set **Feature Type** to **Point**.

36. Click **Edit** then expand **Projected Coordinate Systems**. Go to **UTM > WGS 1984 > Northern Hemisphere > WGS 1984 UTM Zone 51N**. Click **OK** then click **OK** again. (Figure 10)

37. The **Pour** shapefile is now added to the **Table of Contents**.

38. Double click on the **Pour** symbol to open the **Symbol Selector**.

39. Choose any symbol and color then hit **OK** when done.

40. Click the **Editor Toolbar**. Click the **Editor** drop down then click **Start Editing**.

41. Select **Pour** then click **OK**.

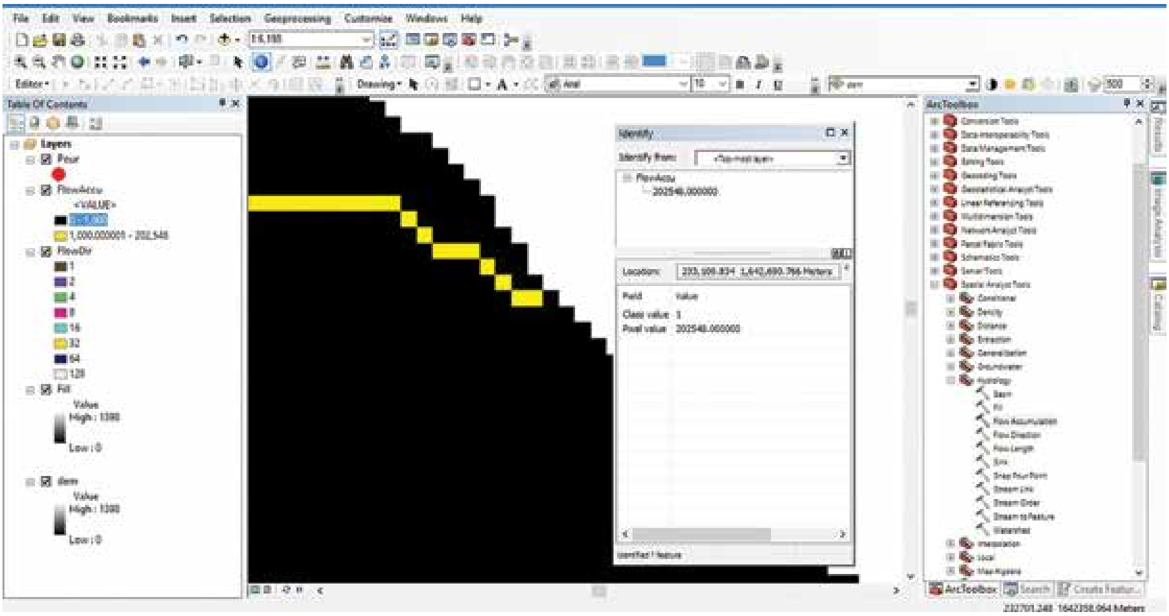


Figure 11.

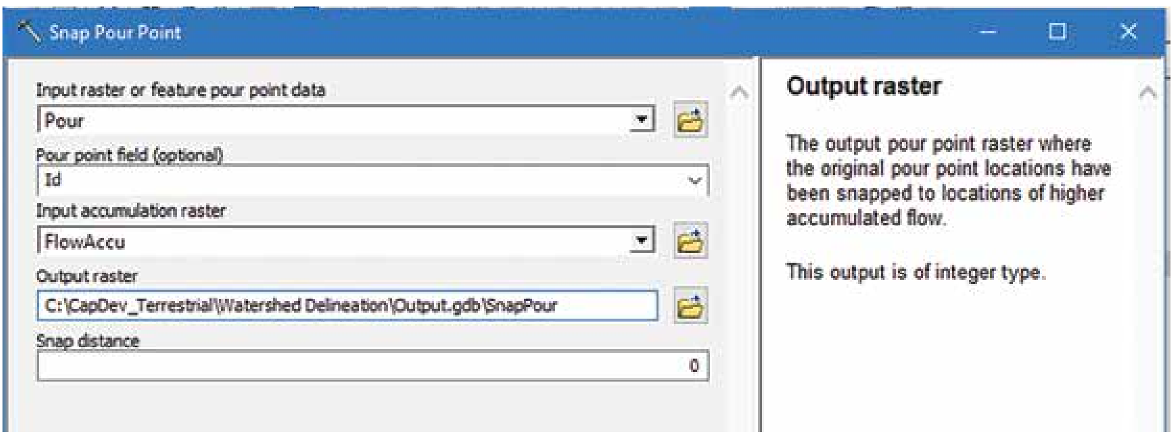


Figure 12.

42. From the **Editor Toolbar**, click the **Editor** drop down then go to **Editing Windows > Create Features**. Now we are ready to identify the outlet of our watershed. The outlet of the watershed usually has the highest flow accumulation value in a given stream network. (Figure 11)

43. If done, click **Editor** then **Stop Editing**. Click **Yes** when prompted to save your edits.

44. Now click the **Snap Pour Point** from **Spatial Analyst Tools > Hydrology**. The tool snaps to the closest area of high accumulation and converts the pour points to the raster format needed for input to delineating the watersheds.

45. From the **Input raster or feature pour point data** in the **Snap Pour Point** window, choose **Pour**.

46. Set the **Pour point field** to **Id** the set the **Input accumulation raster** to **FlowAccu**.

47. Change the **Output raster** name to **SnapPour**. Click **OK**. (Figure 12)

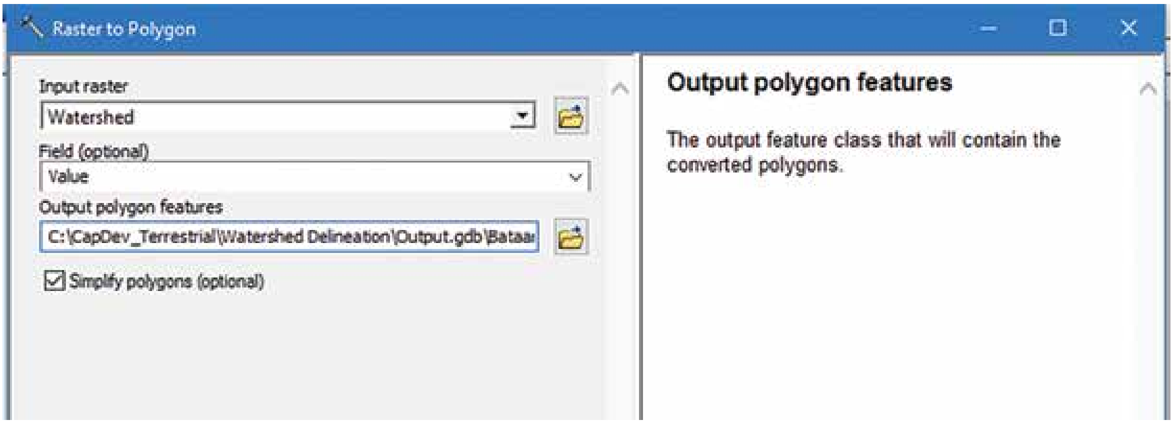


Figure 13.

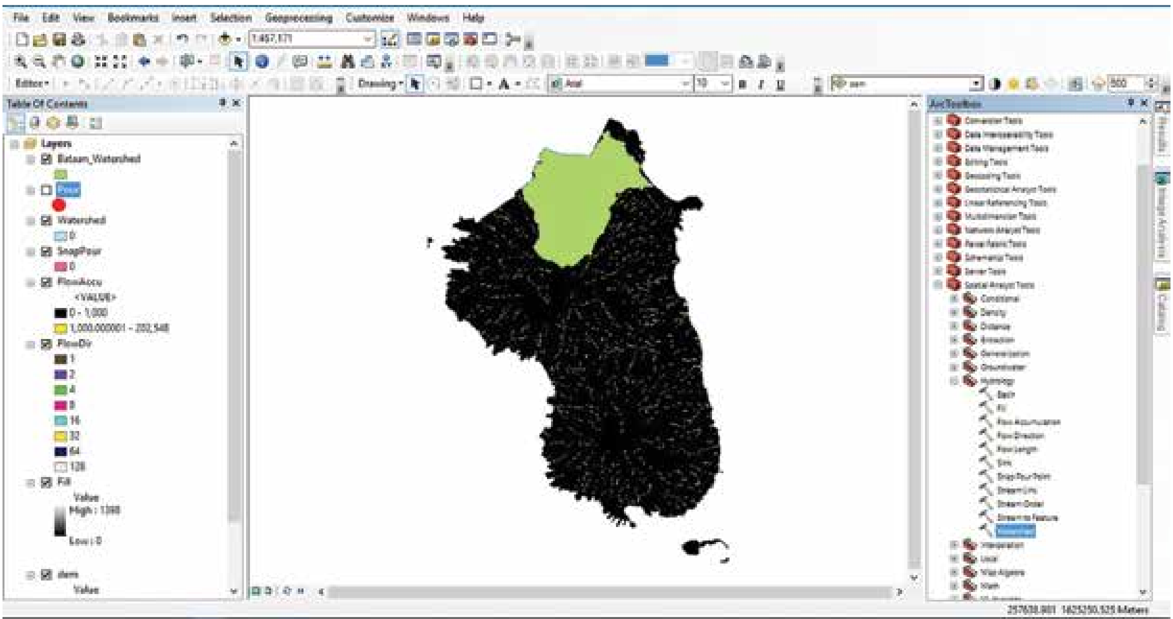


Figure 14.

48. It's time to delineate the watersheds. Double click on the **Watershed** tool from the **Spatial Analyst Tools > Hydrology**.

49. Set the **Input flow direction raster** to **FlowDir**, **Input raster or feature pour point data** to **SnapPour**, and **Output raster** to **Watershed**. Click **OK**.

50. To convert the watershed to shapefile, go to **ArcToolbox** and click on **Conversion Tools > From Raster > Raster to Polygon**.

51. In the **Raster to Polygon** window, set the **Input raster** to **Watershed** and the **Output polygon** features to **Bataan_Watershed**. Make sure the **Simplify polygons** box is checked. Click **OK**. (Figure 13)

52. Then **Save** your map document and name it **Watershed Delineation**. (Figure 14)

> Stream Order Generation

1. Using the same map document, extract the flow

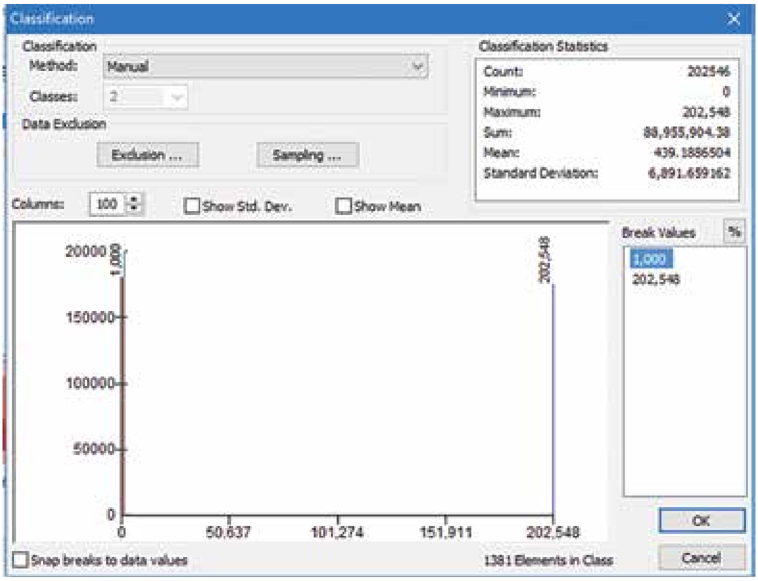


Figure 15.

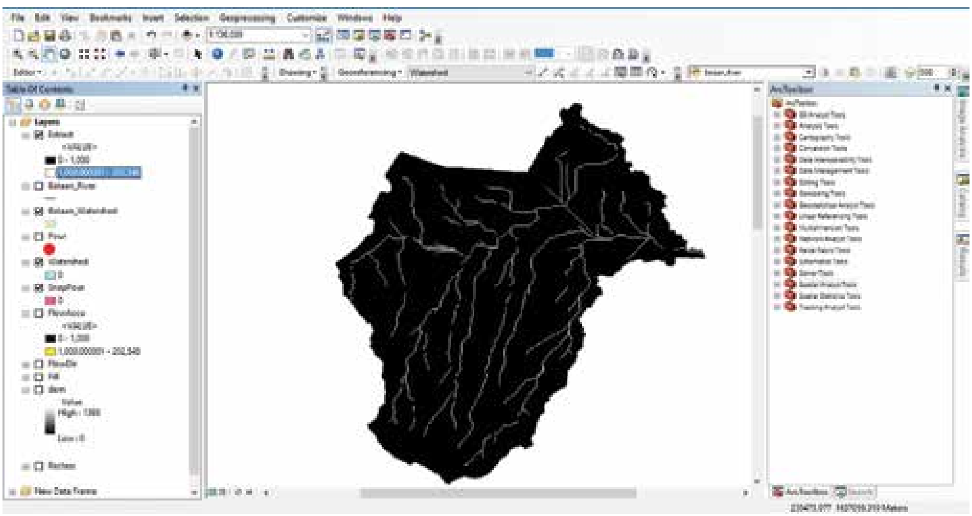


Figure 16.

accumulation first of the Bataan Watershed. Go to **ArcToolbox > Spatial Analyst Tools > Extraction > Extract by Mask** and a window appears.

2. From the **Input raster** box, choose **FlowAccu** while in the **Input raster or feature mask data**, select **Bataan_Watershed**.

3. Lastly, in the **Output raster**, just type **Extract**. Click **OK**.

4. Right click on **Extract** from the **Table of Contents** then go to **Properties**.

5. From the **Properties** window, select **Classified** from the **Show** box and set the number of **Classes** to **2** only then click **Classify**.

6. In the **Break Values**, set the threshold of the first class only to **1,000** while maintaining the threshold value of the second. Click **OK** then another **OK**. (Figure 15)

7. Go to **ArcToolbox > Spatial Analyst Tools > Reclass > Reclassify.**

8. From the **Reclassify** window, choose **Extract**

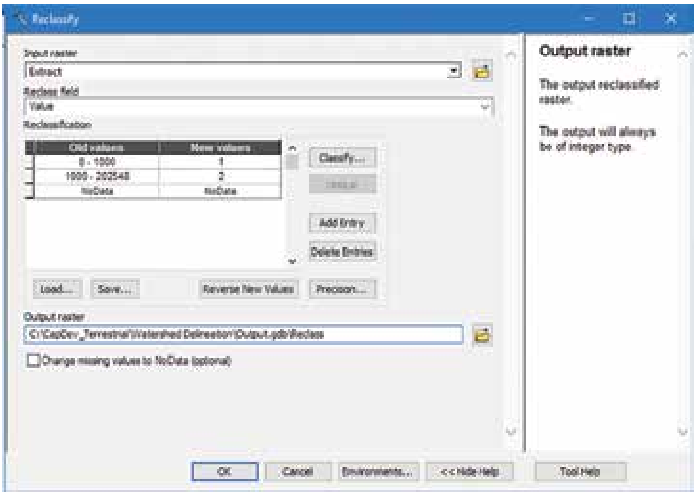


Figure 17.

Figure 18.

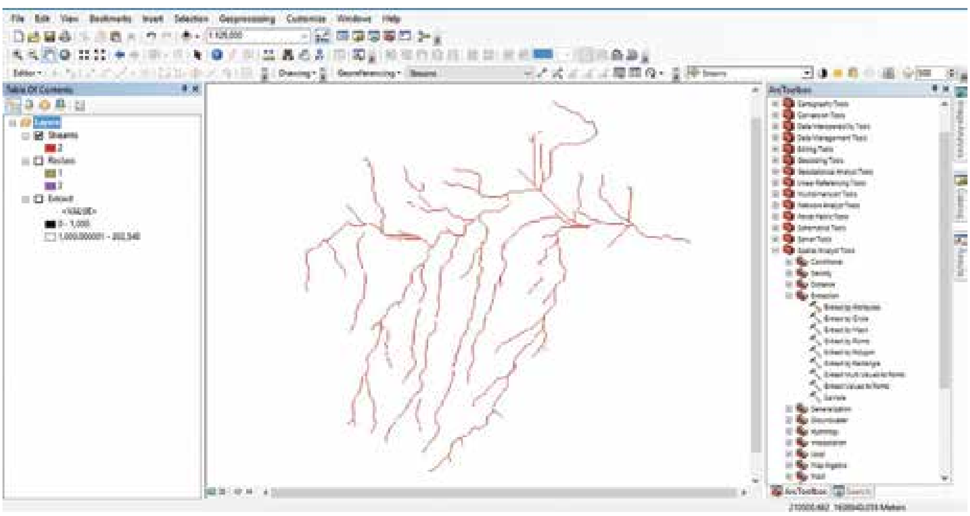


Figure 19.

from the **Input raster** and the **Reclass field** should be **Value**. Click on **Classify**.

9. Set the number of **Classes** to **2** and the **Break Values** to **1000** in the first class while maintaining the threshold value in the second. Click **OK**. (Figure 16 on page 21)

10. Name the **Output raster** as **Reclass** then click **OK**. (Figure 17)

11. Go to **ArcToolbox > Spatial Analyst Tools > Extraction > Extract by Attributes** to extract the stream raster.

12. From the **Extract by Attributes** window, choose **Reclass** file for the **Input raster** then click on the **SQL** window from the **Where clause** box.

13. In the **Query Builder** window, double click on **Value** then click on the **equal sign (=)** and click the **Get Unique Values** and double click on **2**. Click **OK**. (Figure 18)

14. Name the **Output raster** as **Streams**. Click **OK**. (Figure 19)

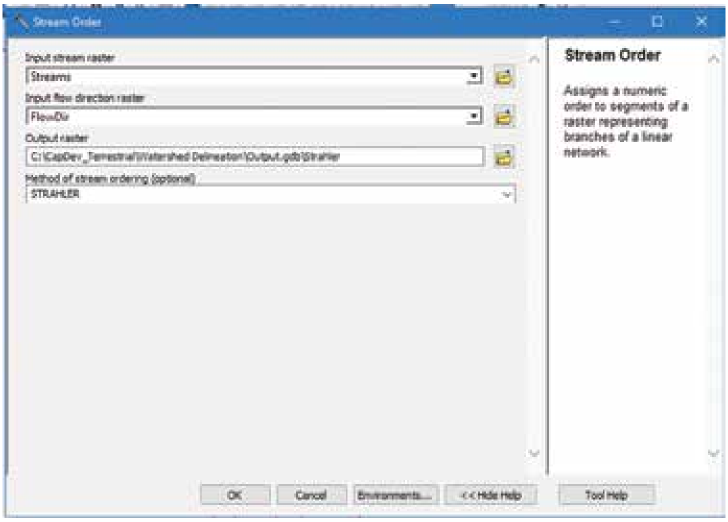


Figure 20.

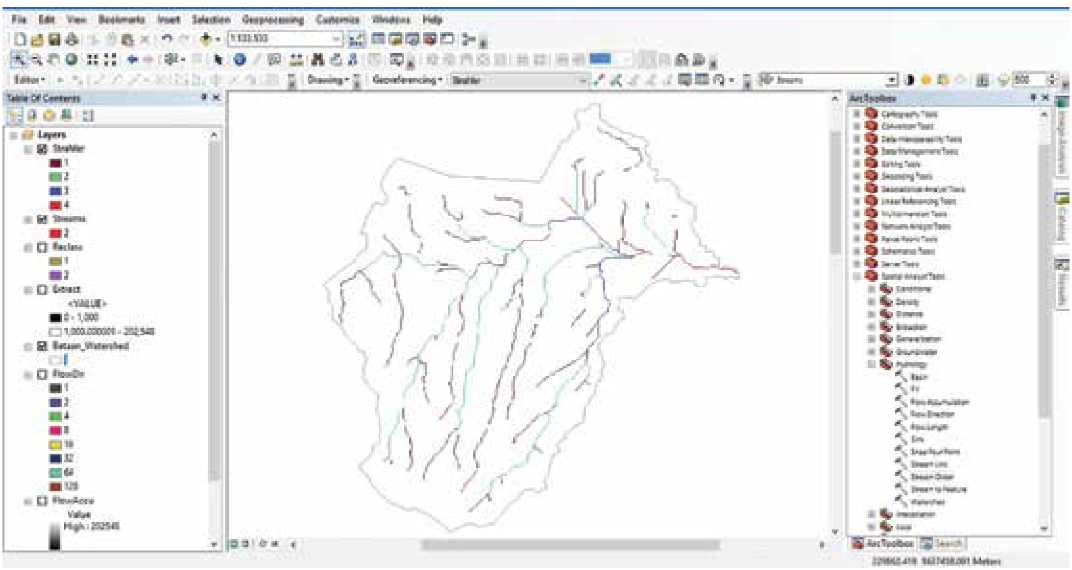


Figure 21.

15. To generate the stream orders, go to **ArcToolbox > Spatial Analyst Tools > Hydrology > Stream Order**. (Figure 20)

16. In the **Input stream raster**, select **Streams** while in the **Input flow diredtion raster**, choose **FlowDir**. Name the **Output raster** as **SO_Strahler**. Click **OK**. (Figure 21)

17. There are two methods in stream ordering in ArcGIS - **Strahler** method and **Shreve** method. In Strahler, the stream order only increases when streams of the order intersect. On the other hand, stream ordering in Shreve is done by magnitude wherein the magnitudes are additive downslope. This means when two links intersect, their magnitudes are added and assigned to the downslope link.

18. Try generating a stream order using Shreve method as well and name the **Output raster** as **SO_**

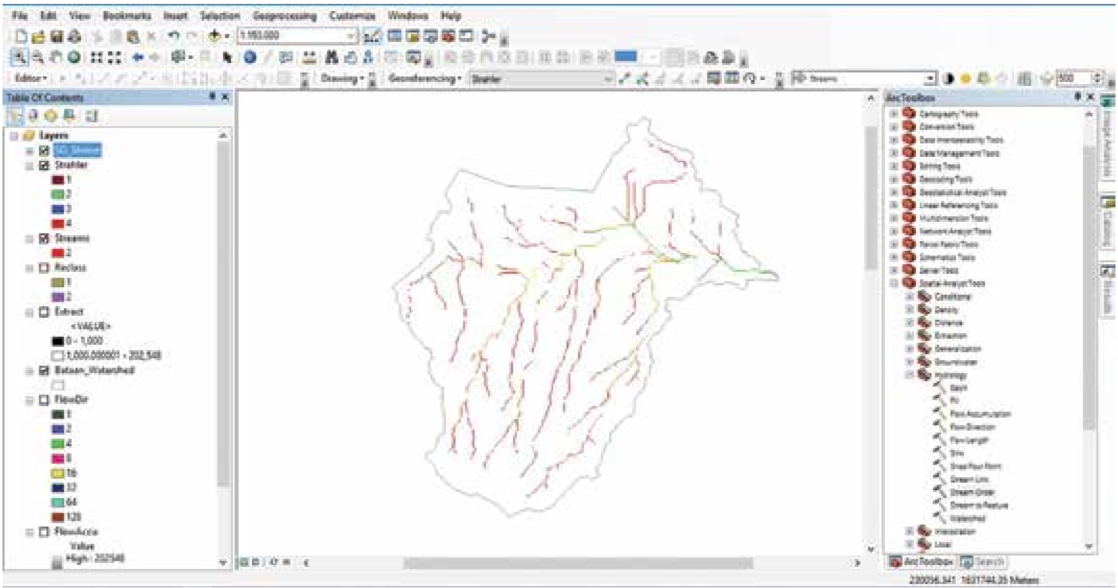


Figure 22.

Shreve. Compare the results of the two methods. (Figure 22)

3.1.2 Stratified Sampling For Resource Assessment

> What is Stratified Sampling?

A TECHNIQUE THAT DIVIDES THE POPULATION into non- overlapping subpopulations called strata, or dividing the population into a number of parts that are homogenous in nature. It aims to form groups that have more or less similar attributes.

> How do you stratify?

1. To stratify a certain population, a diverse spectrum of auxiliary information or criteria are commonly used such as:

a. Vegetation types

b. Species mixtures

c. Habitats

d. Ecological sensitivity

e. Elevation ranges

f. Administrative boundary

g. Accessibility

h. Slope classes

i. Vegetation indices such as the normalized difference vegetation index or NDVI.

2. For stratification, you may use a single criterion or a combination of parameters that are deemed important in achieving the objective of a particular assessment. However, applying a combination of these parameters will create an overlapping of identified layers using GIS. A scaling system may be developed also for each criterion to indicate the relative importance of such parameter to the overall objective and goal of the resource assessment.

3. Once you have chosen a criterion for stratification, allocate appropriate sample sizes for each stratum. Generally, one can allocate a fixed total number of samples to an individual strata or another scheme is the allocate samples in proportion to the size of the strata. However,

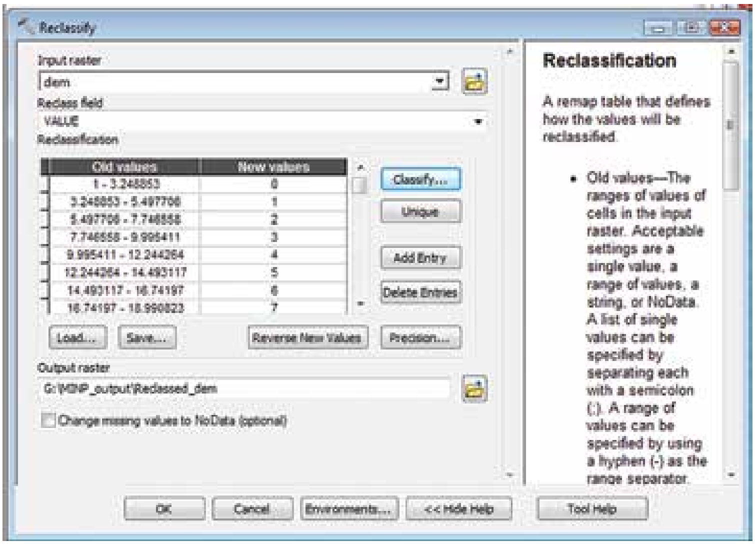


Figure 23.

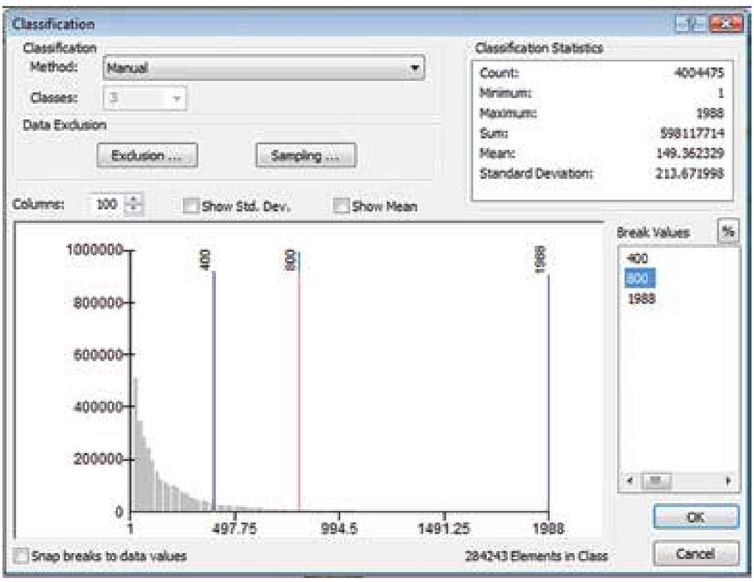


Figure 24.

these allocation schemes are also influenced by inventory cost and fund availability. So these factors must be taken into account.

4. After identifying the stratification criterion and the allocation of sample sizes, you must develop a sample design to help the assessment. A common technique is the use of a grid system.

a. Firstly, sub-divide the entire protected area or watershed into grids.

b. For each stratum, randomly select the grids to be considered as samples. This sampling design is called Stratified Random Sampling.

c. Assign unique codes in naming the grids and use the codes to populate relevant information about the grids. Bantayan et al. (2015) has developed a grid system called GIS-based Assessment, Monitoring and Evaluation or the

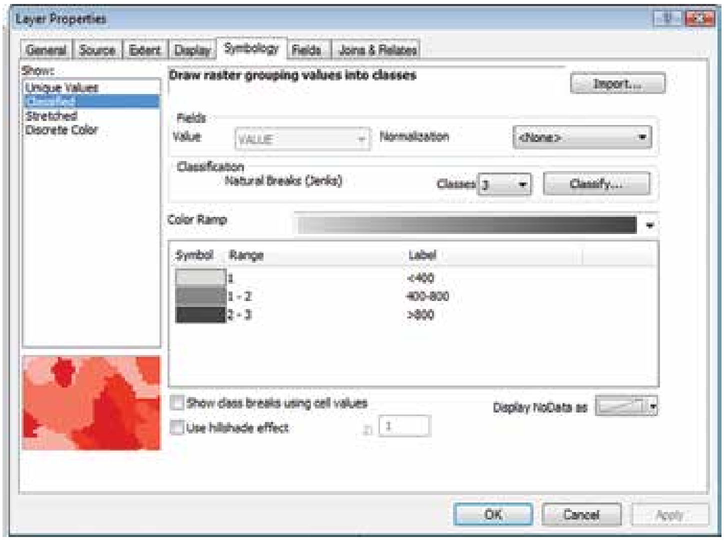


Figure 25.

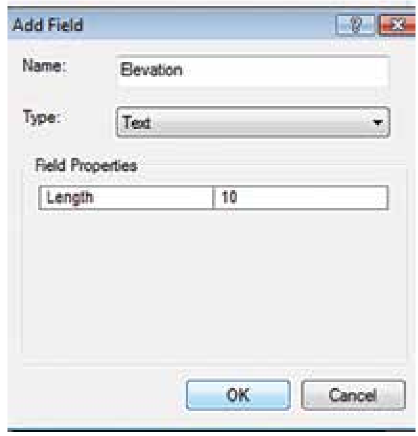


Figure 26.

Figure 27.

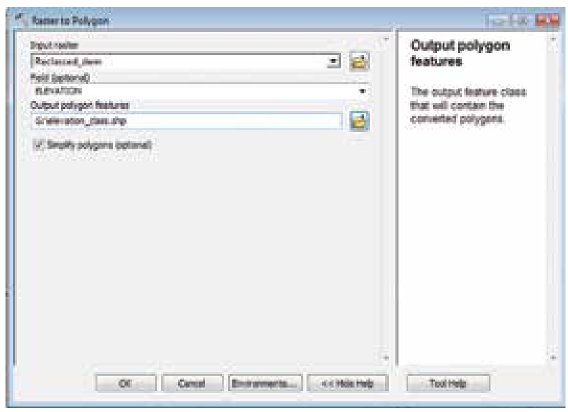


Figure 28.

GAME model which utilized varying grid sizes that range from a 1 km x 1 km grid to a 10 m x 10 m granule. This same system can also be adopted in the assessment and monitoring of various protected areas and terrestrial ecosystems in the country.

> Tutorial Guide for Stratification

1. Open **ArcMap** then add the working files: (**Boundary, Town, LandCover, Road, dem**)

2. Go to **Arctoolbox > Spatial Analyst > Reclass > Reclassify**. In the reclassify window, select **dem** as the input raster. **Value** as the input field. In the reclassification box, click **classify.** (Figure 23 on page 25)

3. A classification window will appear. In the classification method, select **Manual.** Click the **Classes** drop down arrow and select **3**. Edit **Break Values** and set the thresholds to **400, 800** and leave the last value as is. Click **Ok.** Rename the output raster as **Reclassed_dem.** Click **OK.** (Figure 24 on page 25)

4. On the table of contents, right click on the created **Reclassed_dem** layer. Select **Properties > Symbology**. Under the show contents, click **Classified.**

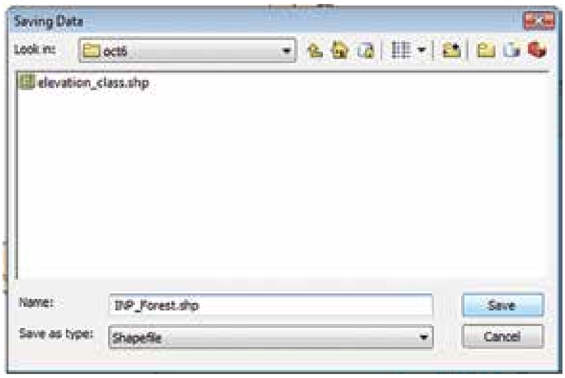


Figure 29.

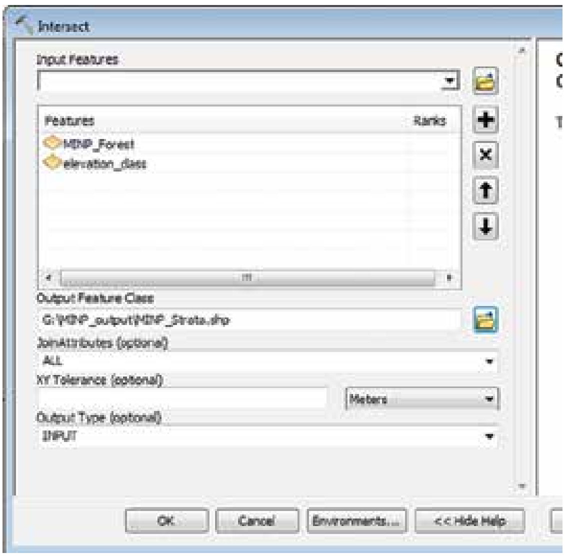


Figure 30.

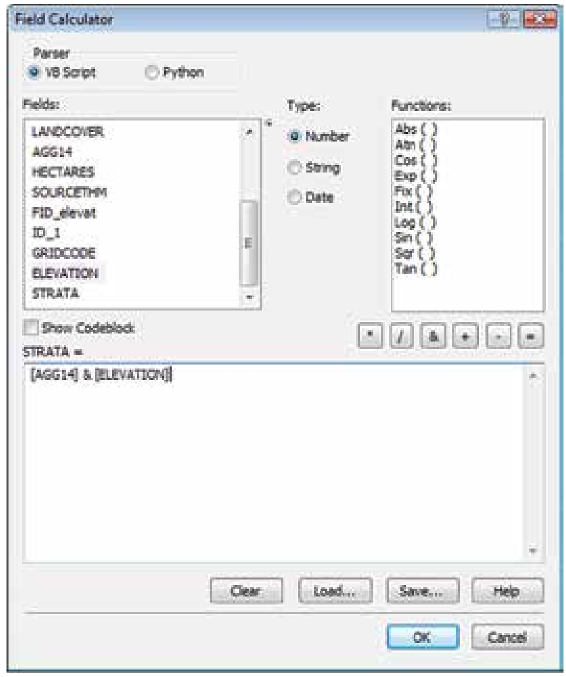


Figure 31.

5. On the Classification section, click on the drop down arrow for **classes** and select **3.** Edit the label into elevation **(<400, 400-800, >800).** Click **Apply** and **OK.** (Figure 25 on page 26)

6. Right click on the **Reclassed_dem** again, and select **open attribute Table**. A new table window will appear, then click on the **Table Options** drop down arrow and select **add field**. Type **Elevation** for the name and select **text** on the drop down arrow for the type. Under the field properties type **10** for the length. Click **OK.** (Figure 26 on page 26)

7. When the new field is added to the attribute table, you can now edit the contents by the editor tools which is found in **Customize > Tools > Editor.** Click the drop down arrow in **editor** and select **start editing**. (Figure 27 on page 26)

8. Start editing window appears, here select the **Reclassed_dem.vat** then click **OK.** You can now type the content for elevation **(<400, 400-800, >800)**. After that, you can now **save edits** and click **stop editing.**

9. To Convert raster to feature, Select **ArcToolbox > Conversion > From Raster > Raster to Polygon.** Select **Reclassed_dem** as the input raster, click drop down arrow for field and select **Elevation.**

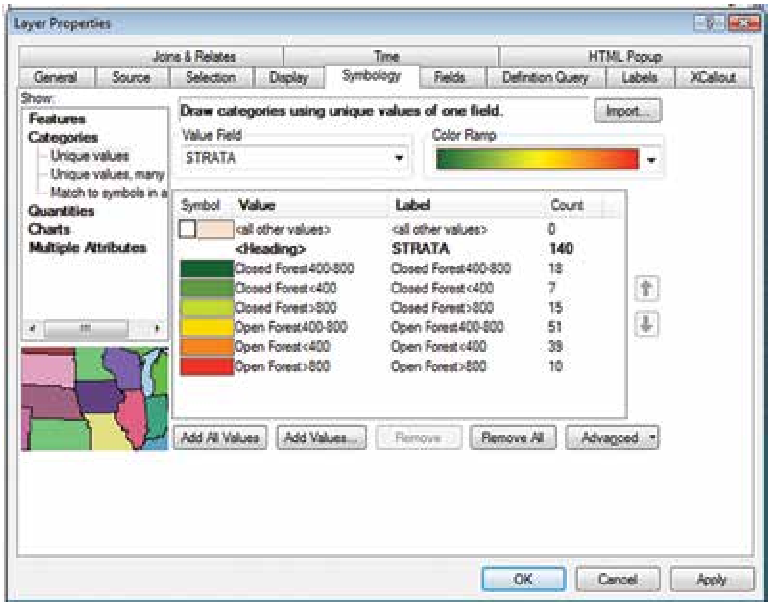


Figure 32.

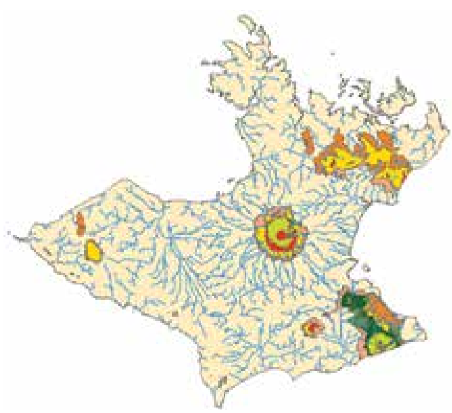


Figure 33.

Rename the output polygon features to **Elevation_Class.** Click **OK.** (Figure 28 on page 26)

10. Right click on **LC 2010**, Select all attributes that are **Closed Forest and Open Forest** under the **AGG14** column.

11. When the all the desired attributes are selected, right click on **LC 2010 > Data > Export Data.** Export data window appears, make sure that **Export** options is **Selected Features** and **this layer's source data** by the same coordinate system used. Rename the output feature class as **MINP Forest.** Click dropdown arrow on the **Save as type,** and select **Shapefile**. Click **OK.** (Figure 29)

12. Click **Yes** if the exported data will be added to the map as layer.

13. Click **Geoprocessing > Intersect**. Select **Elevation_class** and **MINP_Forest** as input layers. Type the output feature class as **MINP_Strata.** Leave the other field as is. Click **OK.** (Figure 30)

14. Right click on **MINP_strata > Open attribute table**. Click drop down arrow of **table options** select **Add Field**. Put **STRATA** for the name and

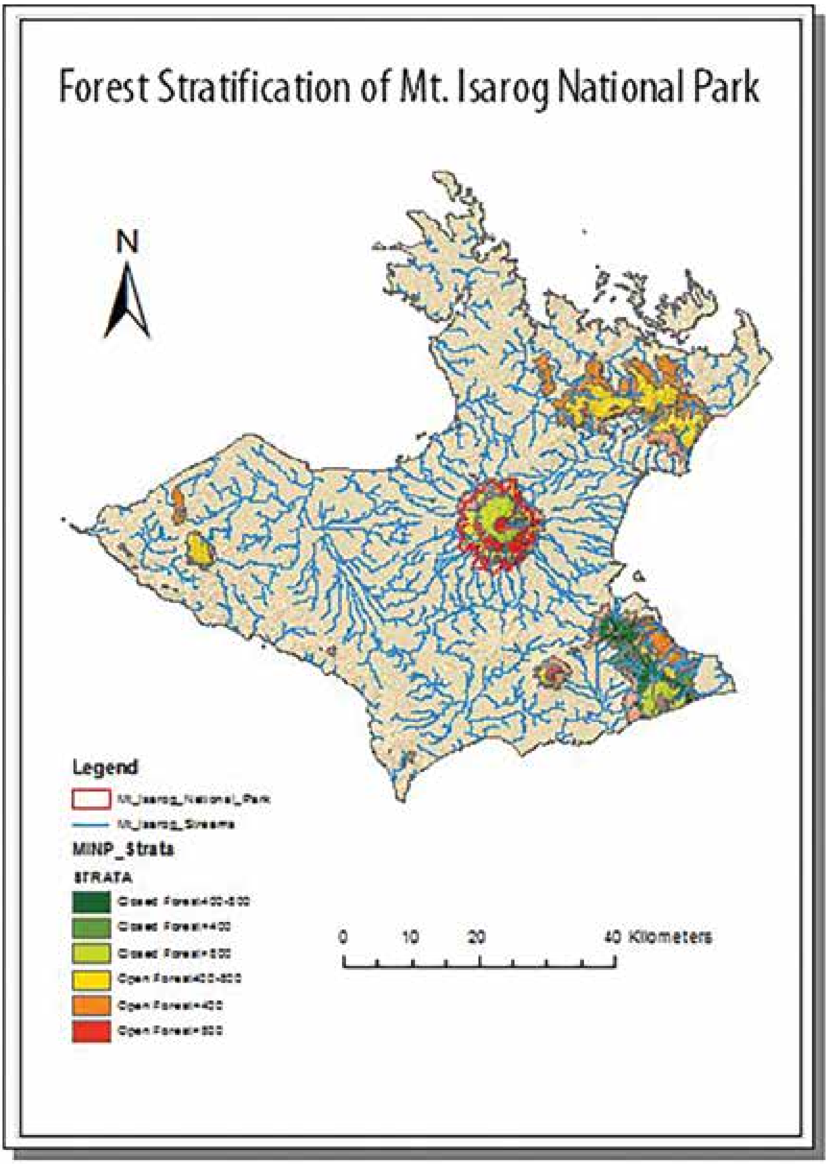


Figure 34.

select **Text** for the type and **30** for the length. Then click **OK.**

15. Right click on the **STRATA** column, select **Field Calculator**, a new window will appear. Input the following: **STRATA = [AGG14] & [ELEVATION]** Click **OK.** (Figure 31 on page 27)

16. Now open **Layer Properties** of the MINP_ STRATA, select the **Symbology >Categories >Unique Values.** Select **STRATA** on the Value Field and click **Add all Values.** Click **Apply** and **OK.** (Figure 32 on page 28)

Your Output must look like Figure 33 on page 28. You may add more variations in color of the different layers and add some effects.

17. Go to **Geoprocessing > Clip** Strata to watershed.

18. Finally, **Layout** your map and include the necessary data. (Figure 34)

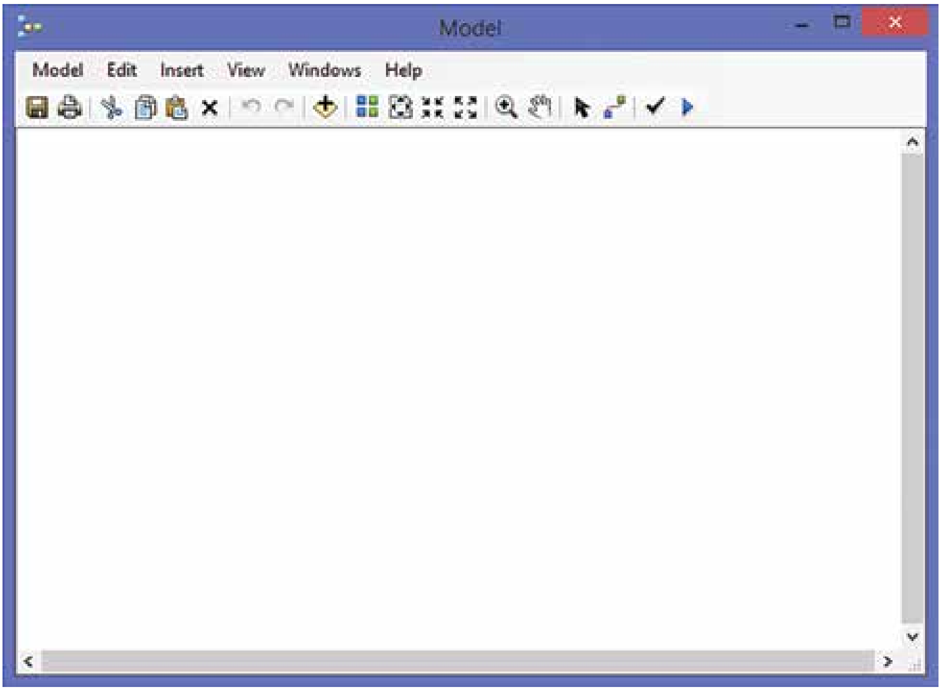


Figure 35.

3.1.3 Modeling Landslide Susceptibility Using Arcgis™ Modelbuilder

> Dataset Preparation

1. Copy the **Landslides** folder and Paste it to your **C:\CapDev_Terrestrial** directory.

2. Start **ArcMap**. Click the **Geoprocessing** menu then click on **Environments**.

3. Expand the **Workspace** and in the **Current Workspace** set it to **C:\CapDev_Terrestrial\Landslides\Isarog.gdb** while under the **Scratch Workspace**, set it to **C:\CapDev_Terrestrial\Landslides\Output.gdb**. Click **OK**.

4. Open **ArcCatalog** and navigate to the **Landslide** folder directory.

5. Double click on **Isarog.gdb** and you'll see three (3) raster datasets and four (4) feature datasets.

6. Drag and drop all seven (8) datasets to your **Table of Contents** in **ArcMap**.

7. Click **Save** and navigate to your working directory and provide a **File name** using **Landslide Susceptibility**. Click **Save**.

8. Click **Customize** then **Extensions**. Make sure **Spatial Analyst** is checked. Click **Close**.

9. To add the **Spatial Analyst** toolbar, go to **Customize > Toolbars > Spatial Analyst**.

10. Finish and **Save** your document.

> Modeling Landslide Susceptibility

1. Using **ArcCatalog**, right click on your **Landslides** folder then **New > Toolbox**.

2. Rename it to **Landslide Modeling Tools**.

3. Right click on the **Landslide Modeling Tools** and click **New > Model**.

4. An empty **ModelBuilder** session will open. (Figure 35)

5. Click on **Model** then **Model Properties**. Click

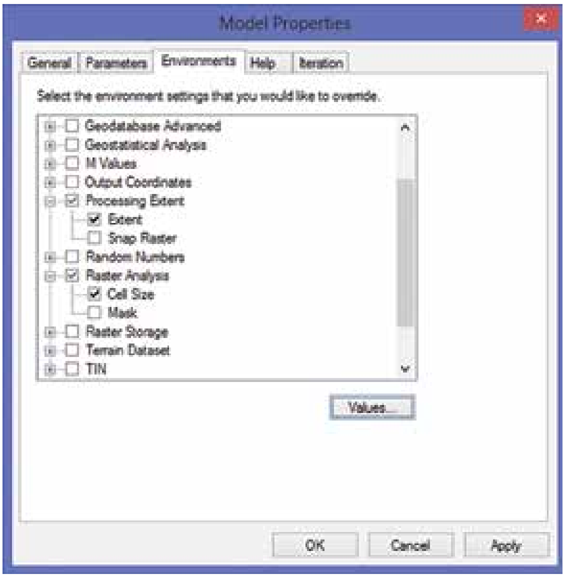


Figure 36.

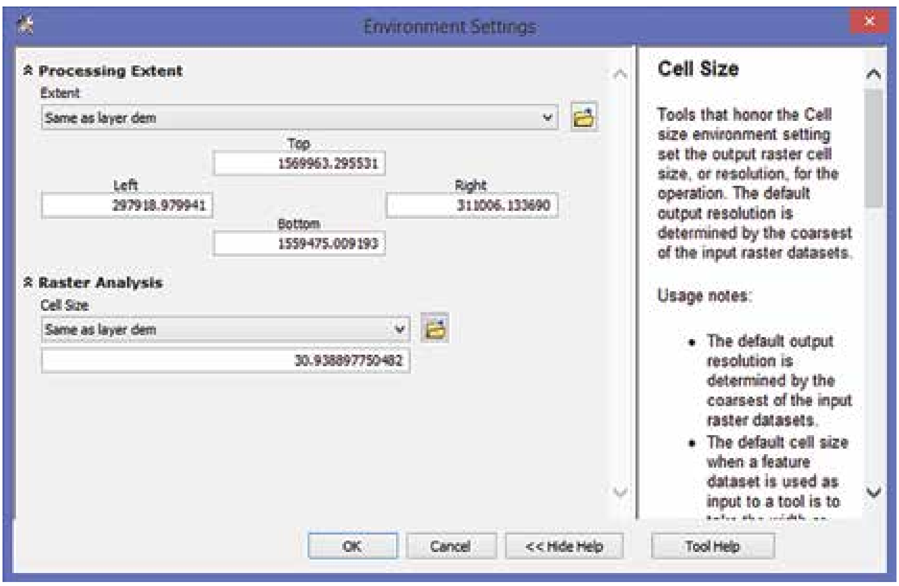


Figure 37.

the **General** tab.

6. Type **LandslideSusceptibility** in the **Name** and **Modeling landslide susceptibility** in the **Label** text box.

7. Check the **Store relative path names (instead of absolute paths)**.

8. Click on the **Environments** tab. Expand **Processing Extent** and check **Extent**.

9. Expand **Raster Analysis** and check **Cell Size**. (Figure 36)

10. Click **Values**. Set the **Extent** of **Processing Extent** to **Same as layer dem**. Also, in the **Cell Size** under **Raster Analysis**, set it to **Same as layer dem**. (Figure 37)

11. Click **OK** and click **OK** again**.** Click **Save**.

12. From the **Table of Contents**, drag the layers

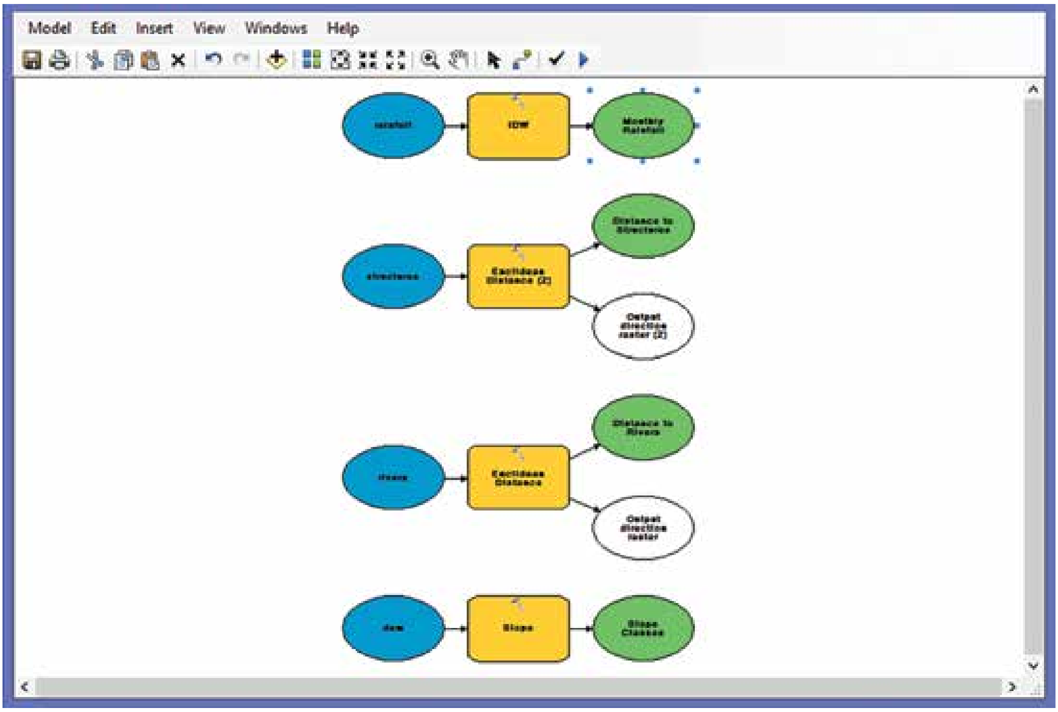


Figure 38.

rainfall, **dem**, **rivers** and **structures** to your model.

13. In the **ArcToolbox**, go to **Spatial Analyst > Interpolation** and drag **IDW** in line with the **rainfall** dataset in the model.

14. Then click and drag the **Slope** tool from **Spatial Analyst > Surface** into your model and place it in line with your **dem** data.

15. Locate the **Euclidean Distance** tool in the **Spatial Analyst > Distance** toolset.

16. Click and drag the **Euclidean Distance** tool in line with the **rivers**.

17. Repeat the previous step but this time place the **Euclidean Distance** tool in line with **structures**.

18. Click the **Connect** tool to link **rainfall** to the **IDW** tool. Select **Input point feature**.

19. Repeat this same process for **dem**, **rivers** and **structures**.

20. On the **Model** toolbar, click the **Select** tool and click the **Auto Layout** button, then click the **Full Extent** button to apply the current diagram properties. Click **Save**.

21. Double click on **IDW** tool. Set the **Z value field** to **RAINFALL**. Click **OK**.

22. Right click on the output and **Rename** it to **Monthly Rainfall**.

23. Double click on **Slope** tool. Leave the **Input raster** and **Output raster** as the default values.

24. In the **Output measurement**, choose **PERCENT_RISE**. Click **OK**.

25. Right click on the output variable (**Slope_dem1**) and **Rename** it to **Slope Classes** then click **OK**.

26. However, for the **rivers** and **structure**, leave all default parameters.

27. Then, **Rename** the output variables into **Distance to Rivers** and **Distance to Structures**.

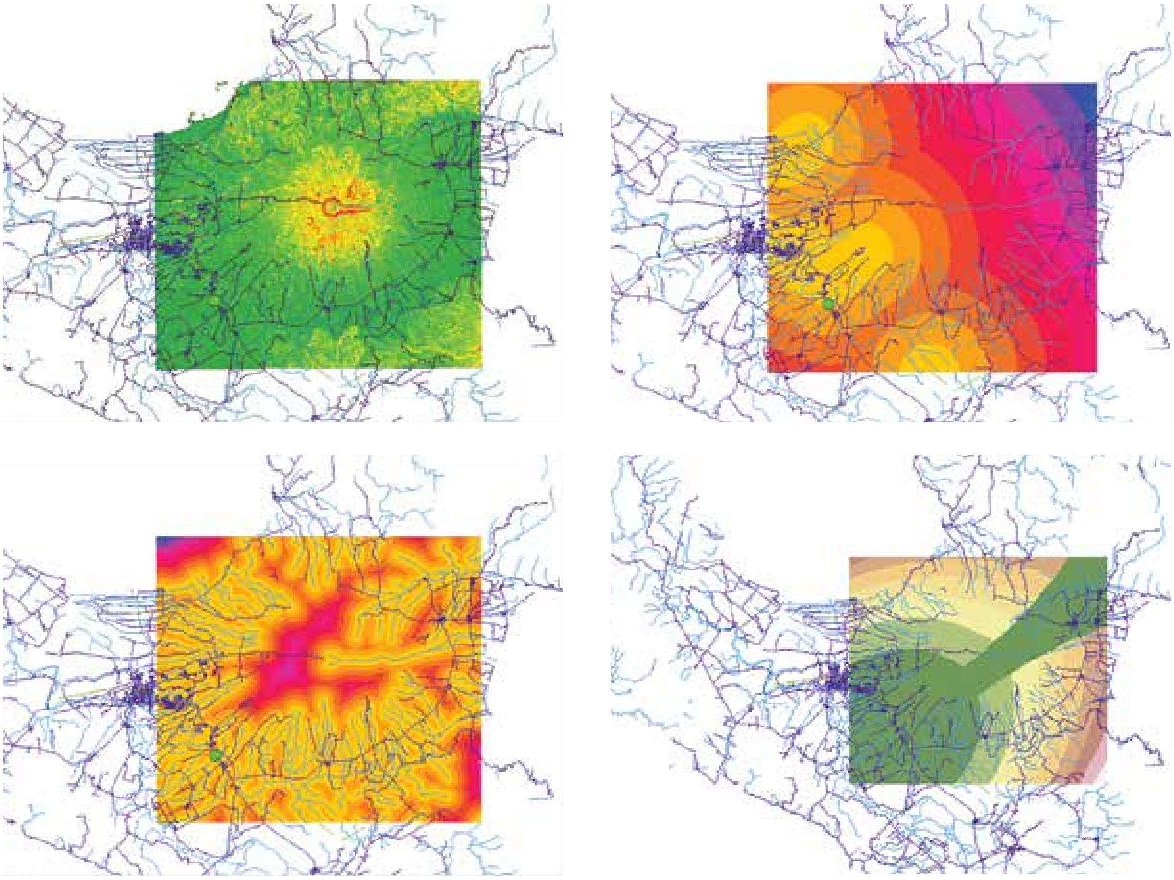


Figure 39.

28. Right click on each output variable then click on **Add To Display**.

29. Click **Run** to run the model. Click the **Auto Layout** and **Full Extent** buttons. (Figure 38 on page 32)

30. Click **Save** the model (Figure 39).

> Reclassification Process

1. Locate the **Reclassify** tool in the **Spatial Analyst Tools** toolbox **Reclass** toolset. A rating of 1 to 5 will be used in this modeling where a value of **1** indicates very low susceptibility and **5** indicates very high susceptibility.

2. Click and drag the **Reclassify** tool onto the **ModelBuilder** in line with **Monthly Rainfall** and another to **Slope Classes**. Also drag **Reclassify** tool in line with **dem**, another **Reclassify** tool in line with **Distance to Rivers** and finally, another **Reclassify** tool in **Distance to Structures**.

3. Click the **Connect** tool and connect them.

4. Click the **Select** tool, then click on **Auto Layout** then click on **Full Extent.** (Figure 40 on page 34)

5. First, open the **Reclassify** tool connected to **Slope Classes** variable.

6. From the **Reclassify** window, click on **Classify** and the **Classification** window appears.

7. Click the **Classes** drop down arrow and click **5**. Edit **Break Values** and set the thresholds to **8%**, **18%**, **30%**, **50%** and leave the last value as is (this will constitute the class **>50%**). Click **OK**.

8. Rename the output variable from the **Reclassify**

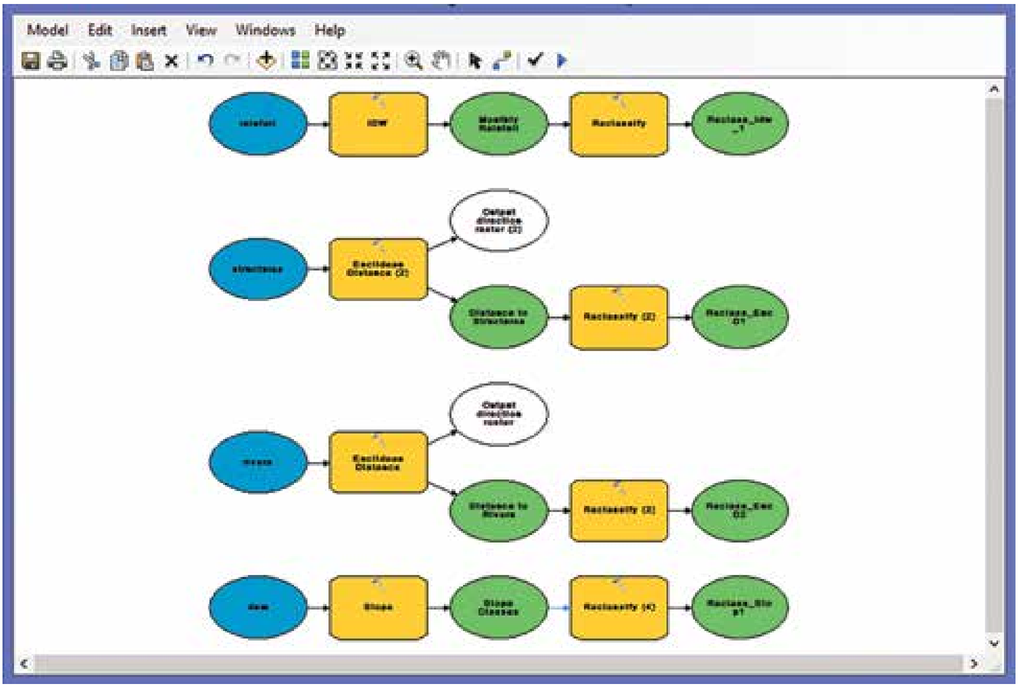


Figure 40.

tool to **Reclassed Slope**.

9. Next is to reclassify the **rainfall**. Double click on **Reclassify** tool then set the **Classification Method** to **Natural Breaks (Jenks)** and set **Classes** to **5**. Click **OK**.

10. **Rename** the output to **Reclassed Rainfall**.

11. Next is to reclassify the **dem**. Double click on the **Reclassify** tool connected to **dem**.

12. Click on **Classify** and from the **Classification Method**, choose **Natural Breaks (Jenks)** and set the **Classes** to **5**. Click **OK** then click **OK** again.

13. Rename the output variable from the **Reclassify** tool to **Reclassed Elevation**.

14. Now, open the **Reclassify** tool connected to the **Distance to Rivers** variable.

15. Click on **Classify**. Set **Classification Method** to **Natural Breaks (Jenks)** and the number of **Classes** to **5**. Click **OK**.

16. Click **Reverse New Values**. Clicking this makes it so that distances close to rivers have a higher new value since these are more susceptible to landslide. Click **OK**.

17. Rename the output variable from the **Reclassify** tool to **Reclassed Distance to Rivers**.

18. Lastly, open **Reclassify** tool connected to the **Distance to Structures** variable.

19. Click on **Classify** and set the **Classes** to **5** (regardless of classification method).

20. Edit the **Break Values** and set the thresholds to **500**, **2,000**, **5,000**, **8,000** and leave the last class as is (this will cover the distance **>8,000**). Click **OK**.

21. Click **Reverse New Values** to highlight that distances close to structures have a higher susceptibility to landslide. Click **OK**.

22. Rename the output variable to **Reclassed Distance to Structures**.

23. Right click each of the variable outputs – **Reclassed Rainfall**, **Reclassed Slope, Reclassed Elevation, Reclassed Distance to Rivers**, and **Reclassed Distance to Structures** – and click **Add**

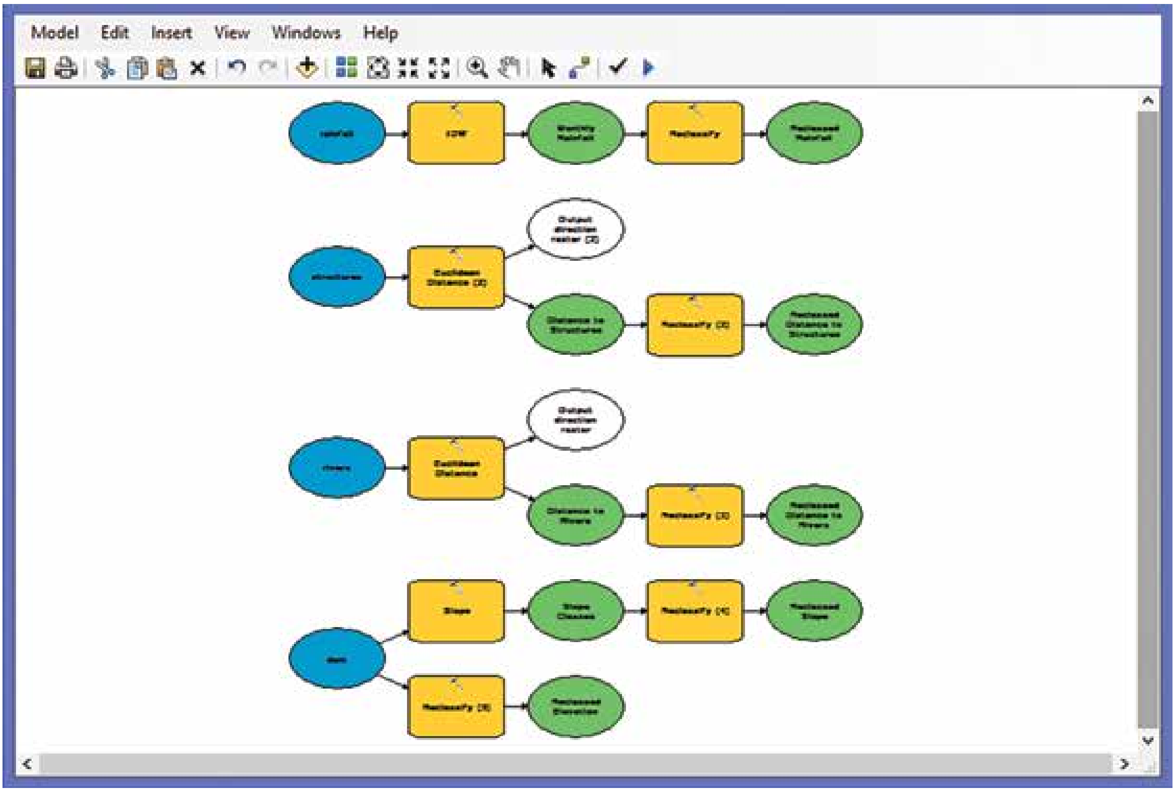


Figure 41.

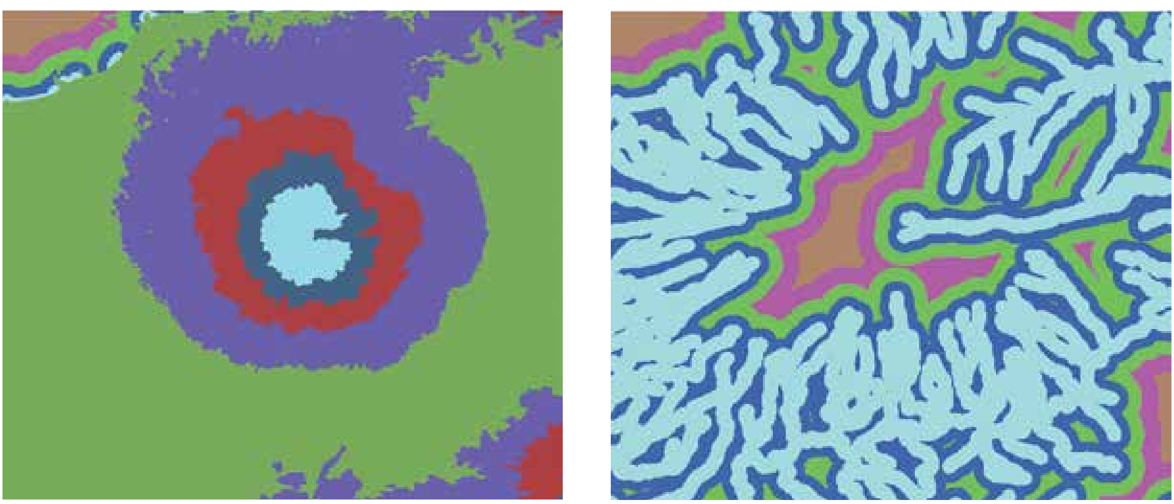


Figure 42.

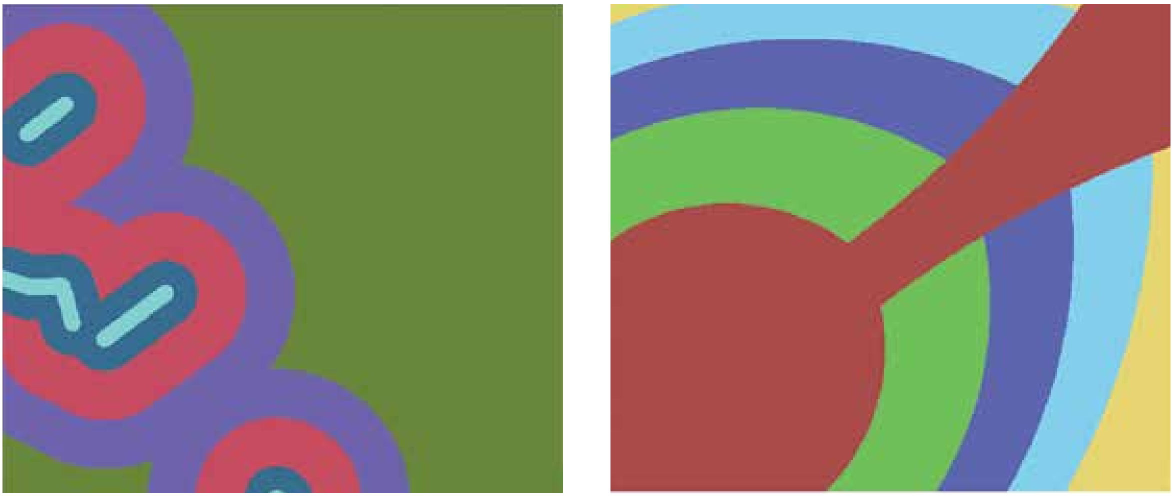


Figure 43.

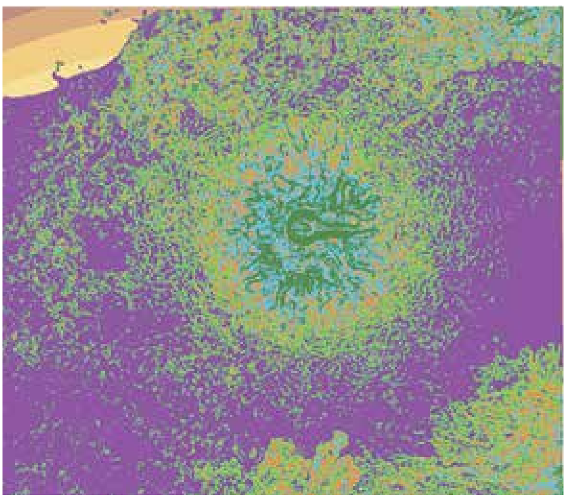


Figure 44.

To Display.

24. Click **Auto Layout** and then the **Full Extent** button. (Figure 41 on page 35)

25. Click **Run** button to execute the three **Reclassify** tools in your model.

26. Click **Save** button (Figure 42 on page 35, Figure 43 and Figure 44).

> Performing Weighted Overlay

1. You are now ready to combine the reclassified datasets with the land use and geology of the area to generate landslide susceptibility.

2. 2. Assign the inputs the following percentages of influence or relative weights of each factor. Note that these are just sample assumptions. You may refer to other literature for the weights or conduct multi-criteria analysis to generate the weights.

For this exercise, here are the relative weights:

- Reclassed Slope – 30%
- Reclassed Rainfall – 10%

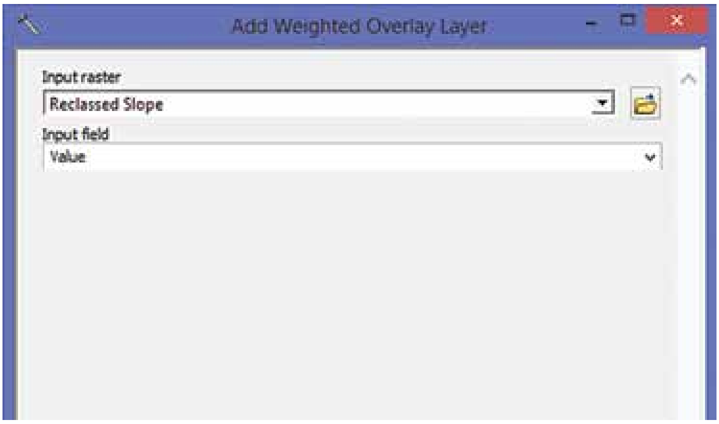


Figure 45.

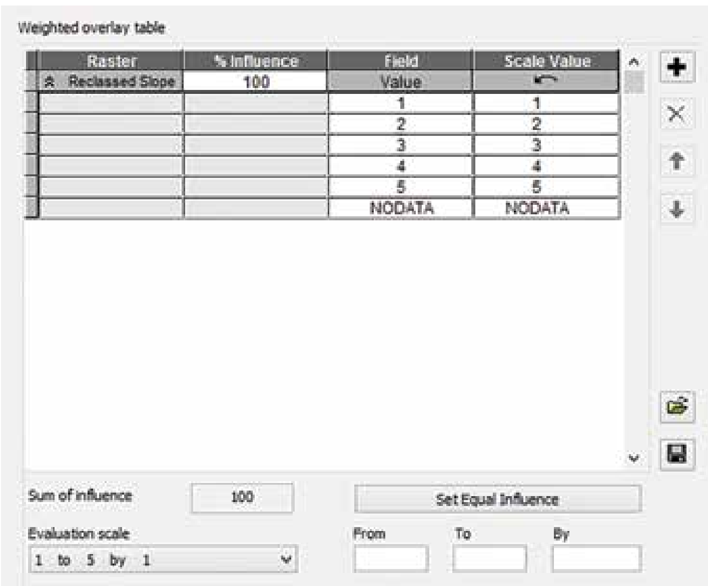


Figure 46.

- Reclassed Elevation – 10%
- Reclassed Distance to Structures – 10%
- Reclassed Distance to Rivers – 10%
- Landuse – 15%
- Geology – 15%

3. Click and drag the **Weighted Overlay** tool, located in the **Spatial Analyst** toolbox **Overlay** toolset into the **ModelBuilder**.

4. Open the **Weighted Overlay** tool. (Figure 45)

5. Type **1, 5** and **1** in the **From**, **To** and **By** text boxes. Click **Apply**.

6. Add the **Reclassed Slope** to the **Weighted Overlay** tool. Click the **Add Raster Row** button and for the **Input raster**, select **Reclassed Slope** from the drop down list and leave the **Input field** as **Value**. Click **OK**.

7. The raster is added to the **Overlay Weighted Table**. The **Field** column displays the values of the **Reclassed Slope** data. The **Scale Value** column mimics the **Field** column because the **Evaluation**

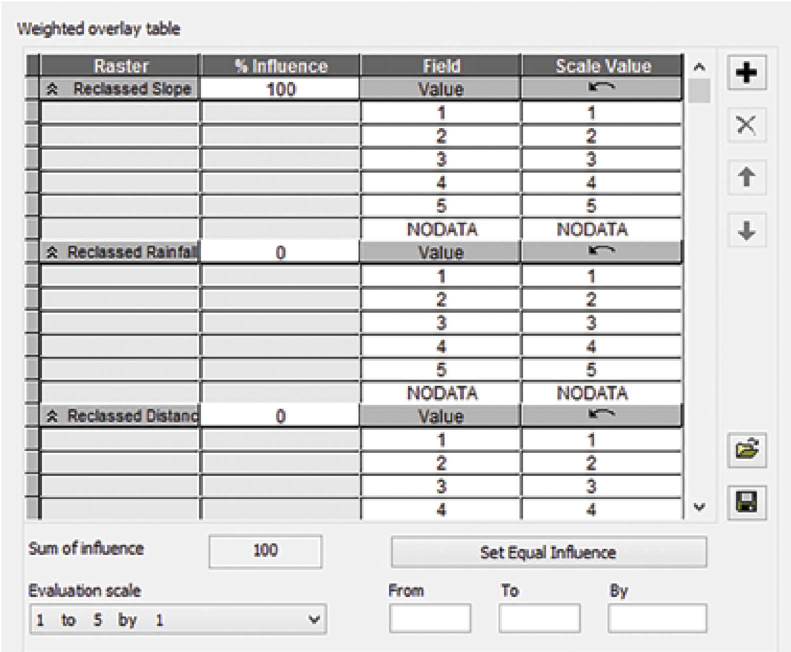


Figure 47.

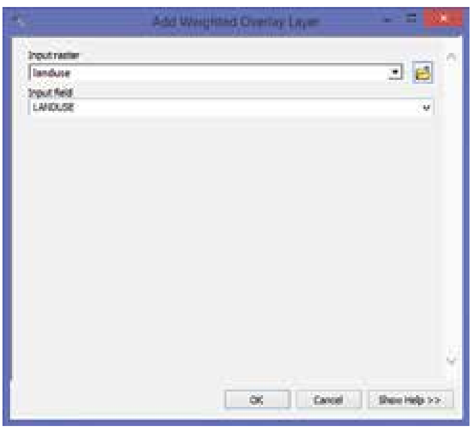


Figure 48.

Scale was set to encompass the range of values in each input raster. (Figure 46 on page 37)

8. Repeat the previous step for each of the reclassified datasets including **Reclassed Rainfall, Reclassed Elevation**, **Reclassed Distance to Rivers**, and **Reclassed Distance to Structures** (Figure 47).

9. Now add the **landuse** and **geology** layers.

10. Initially, select the **landuse** from the **Input raster** box. From the **Input field**, choose **landuse** then click **OK**. (Figure 48)

11. Change the default **Scale Values** for **landuse** following the values:

- Annual Crop – 4
- Built-up – 4
- Closed Forest – 1
- Grassland – 3

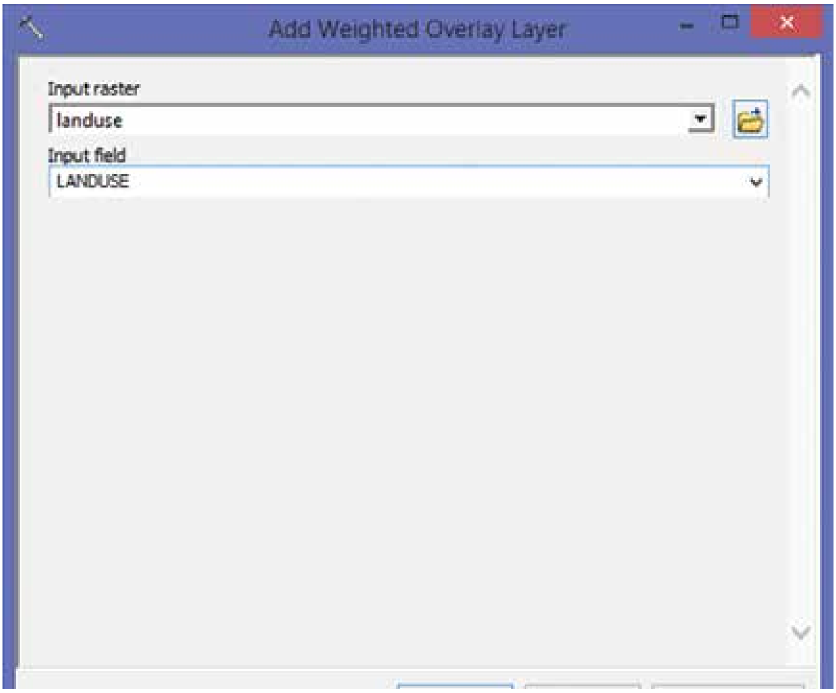


Figure 49.

- Inland Water – 3
- Open Forest – 1
- Perennial Crop – 2
- Shrubs – 3
- Wooded Grassland - 3

12. Now add the **geology** layer. From the **Input field**, select **geology** then click **OK**.

13. Change the default **Scale Values** for **geology** following the values:

- Pliocene-Quaternary – 1
- Upper Miocene-Pliocene (Igneous Rock) - 1
- Cretaceous-Paleocene - 2
- Basement Complex (Pre-Jurassic) – 2
- Recent – 5
- Lake – Restricted

14. You'll now assign a percentage of influence to each raster. This is mainly based on how much importance (or weight) each should have in the final susceptibility map.

15. In the **% Influence** column, type the percentages for each of the input rasters:(Figure 49)

- Reclassed Slope – 30%
- Reclassed Rainfall – 10%
- Reclassed Elevation – 10%
- Reclassed Distance to Rivers – 10%
- Reclassed Distance to Structures – 10%
- Landuse – 15%
- Geology – 15%

16. Click **OK**.

17. Rename the output variable of the **Weighted Overlay** to **Landslide Vulnerability**.

18. Right click and select **Add To Display**.

19. Accept the **Output raster** then click **OK**.

20. Click **Auto Layout** button then click **Full**

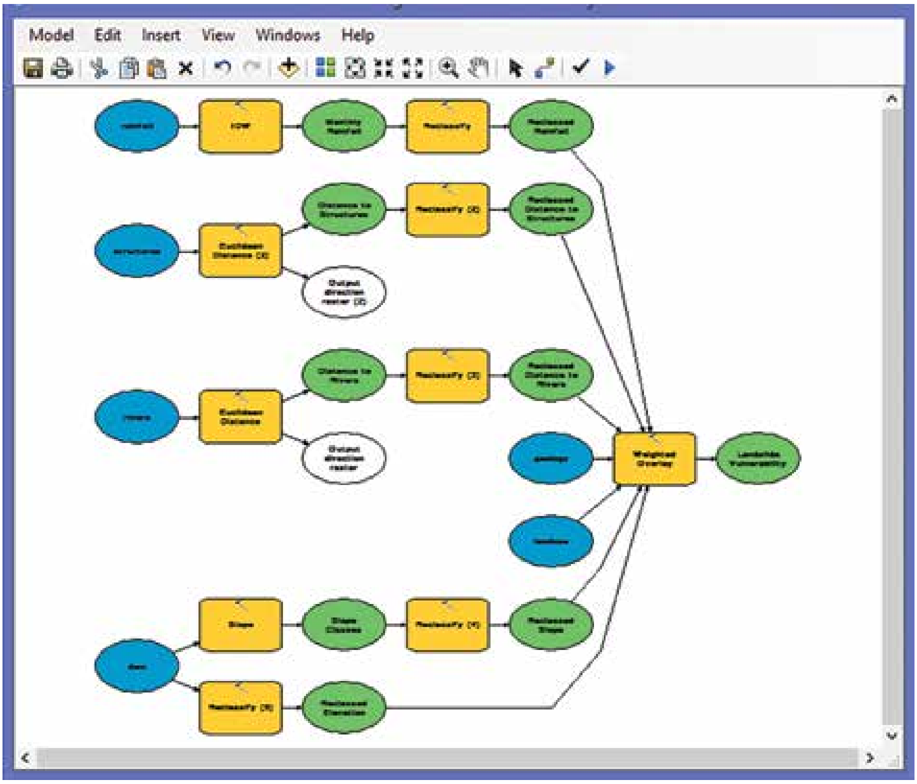


Figure 50.

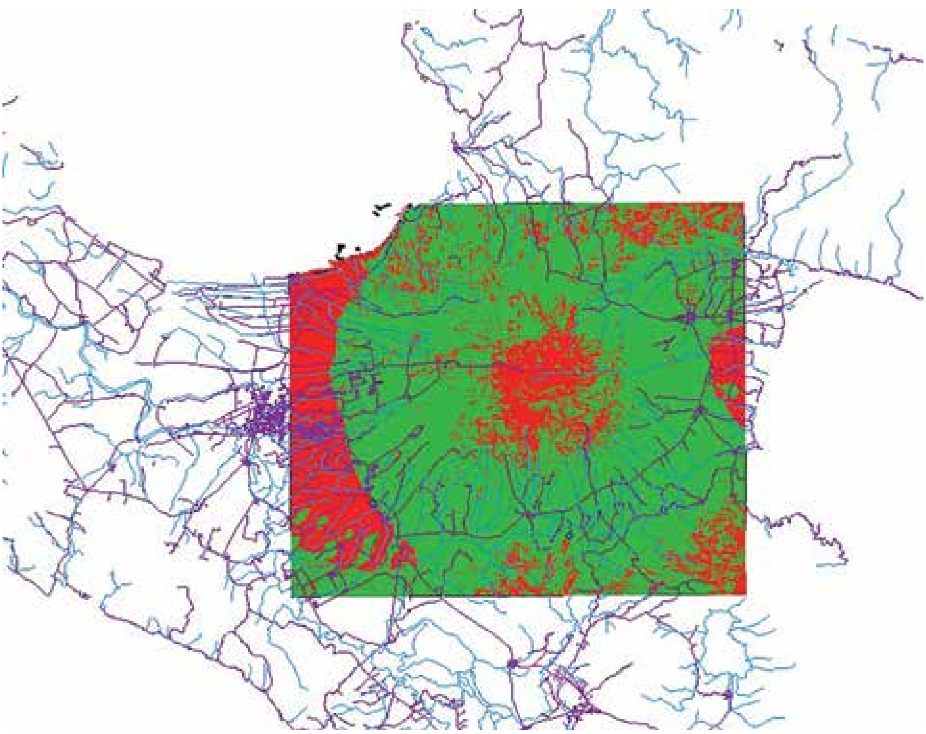


Figure 51.

Extent. The entire model is shown in Figure 50 on page 40.

21. Then, **Run** the model then **Save** the model.

22. The final model should look like Figure 51 on page 40

3.1.4 Assessment Of Watershed Functions

> Introduction

WATER CONSERVATION IS ONE OF THE VITAL ecosystem services that most protected areas (PAs) provide to communities. The water conservation function of a PA is largely dependent on watershed characteristics including land use, land cover, vegetation, soil, climate, and topography. Thus it is essential that these watershed characteristics are properly described and monitored for an accurate assessment and understanding of the state of water resources at any given time.

Watershed characterization and monitoring can be done in conjunction with or as an integral component of the PAs biodiversity assessment and monitoring.

Land use and land cover such as forests and other vegetation types are considered the most influential determinants of the state of water resources particularly volume and water quality (i.e., pH, temperature, DO, sediment concentration and TDS). Hence, these watershed characteristics, along with the climate, should form part of the minimum list of parameters that should be assessed and monitored to describe the state of water resources at any given time.

> Data Collection

Characterization of Subwatersheds

THE DRIVERS OF THE CONDITION OF WATER resources need to be characterized and then periodically monitored in conjunction with the monitoring of water quality in each of the sub-watersheds. These drivers are:

CLIMATE

Climate can be characterized by:

a. Installing weather monitoring devices (i.e., rain gauges, thermometers and wind vane) in strategic locations in the sub-watersheds.

b. Using sensor-aided automatic or recording devices for ease and efficiency of monitoring, but due to budget constraints this is not always feasible.

c. Using available climate data from PAGASA or any other agencies holding climate data gathered from weather stations in and around the sub-watersheds.

d. Installing and operating sensor-aided devices such as an automatic weather and water level station (AWLS) that usually have integrated system for monitoring streamflow, rainfall, temperature, relative humidity, solar radiation and wind can be done following the procedures that come with the package of AWLS.

CLIMATE CHARACTERIZATION

- DAILY VALUES OF RAINFALL, temperature and winds over long period of time are desirable (preferably at least 30 years).

- FOR THE BASELINE PROFILING, available secondary data from PAGASA and other agencies (e.g., SUCs, research institutions and LGUs) that maintain weather monitoring stations can be used.

- NEW VALUES OF CLIMATE DATA WILL be needed in the monitoring and assessment of the present and projected condition of water resources.

• COMPUTE DAILY AVERAGE, MONTHLY average and annual average values from the daily values.

Topography

Topography can be characterized by:

a. Using available digital slope map or elevation map and DEM from NAMRIA, BSWM, NEDA, academic and research institutions, National Power Corporation, Energy Development Corporation, USGS, Google Earth and open sources, and other government and private agencies.

b. Using tables showing the distribution of slope and elevation in various classes generated from the maps.

c. Using contour maps obtained from DENR so that elevation and slope maps and DEM can be digitized and generated using GIS.

d. Generating average slope, average elevation, total relief, maximum relief, drainage patterns, drainage density, stream density, elongation ratio and other physiographic features from the contour maps.

TOPOGRAPHY CHARACTERIZATION

THE TOPOGRAPHIC FEATURES BELOW are more or less static and are usually not subject to periodic monitoring:

- Elevation
- Slope
- Total relief
- Maximum relief
- Drainage patterns
- Drainage density
- Stream density
- Elongation ratio
- Bifurcation ratio
- Others

Soil and Geology

Soil and geology can be characterized by:

a. Using available soil and geology maps from MGB-DENR, NAMRIA or BSWM.

b. Generating tables showing the distribution of the sub-watershed areas into various soil classes and geological types.

SOIL AND GEOLOGY CHARACTERIZATION

• FOREST SOILS ARE VARIABLE AND THE causes of variability are many. Spatial variability is a function of bedrock type and parent material, climate, tree species composition and understory vegetation, disturbances (e.g., harvesting, windthrow, etc.), and forest management activities (e.g., site preparation, thinning, pruning, fertilization, vegetation management).

• ALL THE SOURCES OF SPATIAL variability must be considered to systematically sample and describe forest soil properties. This is why sampling strategies and methodologies must be selected with care.

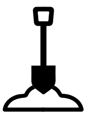
• THE APPROPRIATE SAMPLING DESIGN including the number of samples to be collected and the location of sampling should be so selected to capture the inherent variability of site characteristics particularly forest vegetation, geology and land use.

• WHERE THERE IS HIGH VARIABILITY IN site characteristics, the number of samples

Procedure For Soil Sampling For Various Analyses

1

1. The location of the sampling plots is determined by the primary objective of soil characterization. To assess the interactions of biodiversity and soil properties, collect soil samples at the established biodiversity plots within the 1 x 1 m plot and along transects where there are established biodiversity plots or where biodiversity is regularly monitored. Soil sampling should be done at least once a year and done simultaneously with biodiversity monitoring and assessment to the extent feasible.

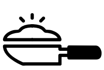


2

2. To assess the interactions of land use and land cover with soil properties, collect soil samples at each major land use and land cover types. Sub samples can be collected in various elevation and/or slope classes within a particular land use and land cover type.

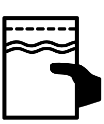
3

3. Within a particular land use or land cover type, collect composite samples along two transects at least 50 m apart. In each transect, collect composite soil samples in every 100-m elevation class.



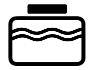
4

4. Prepare soil surface before soil collection. Carefully scrape off soil surface to be sampled to remove leaves and other organic materials o top.



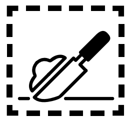
5

5. Place the scraped litter materials in a bag and bring it to the laboratory to determine fresh and oven-dry weight.



6

6. Collect core soil samples using a soil auger to a depth of 20-30 cm for bulk density and porosity determination. Carefully place the samples in a container and bring them to the laboratory without disturbing the core sample.



7

7. Collect a composite sample of approximately 1 kg each from at least five 1 m x 1 m plots (to a depth of about 10-30 cm) inside the biodiversity monitoring plots to determine the soil's chemical and physical properties (except bulk density and porosity) in the laboratory using standard protocols.

8

8. Place five 1-kg samples from a particular biodiversity plot in a bucket and mix it thoroughly before taking a 1-kg composite sample from the bucket. Bag and tag it for shipment to the nearest laboratory.

9

9. There are laboratories that require soil sample to be air dried and sieved before the composite samples are brought in for analysis:

- Air-dry the composite soil samples for about two weeks or until the soil samples are totally dried.
- Grind the soil samples into small particles and pass it through a sieve (#10 mesh) to ensure uniformity of soil particle sizes.
- Handle soil samples carefully to avoid contamination.
- Sieved soil particles should then be brought to the laboratory for analysis.

Figure 52. Procedure for Soil Sampling for Various Analyses

should proportionately increase.

• AT THE MINIMUM, THE SOIL PROPERTIES that need to be characterized include: litter, NPK content, soil organic matter content (OM), soil moisture content (SMC), pH, bulk density, porosity, and texture.

Procedure For Soil Sampling For Various Analyses

("Procedure For Soil Sampling For Various Analyses" on page 43)

Land Use and Land Cover

Land Use and Land Cover can be characterized by:

a. Using available maps from DENR (NAMRIA, MGB, and FMB) or DA (BSWM).

b. Generating tables showing the distribution of land use and land cover types in each sub-watershed through using GIS.

LAND USE AND LAND COVER CHARACTERIZATION

• LAND USE AND LAND COVER ARE dynamic sub-watershed properties that need to be monitored every 2 or 3 years using new remotely sensed data when feasible. Otherwise new land use and land cover maps can be generated by updating the old land use and land cover maps through field surveys and/or participatory mapping of the sub-watersheds involving the local communities that are familiar with the conditions of the sub-watersheds.

• A GIS TECHNICIAN SHOULD PROCESS new satellite images of sub-watersheds into land use and land cover maps.

• COMPARATIVE ASSESSMENT OF OLD and new land use and land cover maps in various time periods in the past will reveal the magnitude and direction of changes in land use and land cover that can then be correlated with stream discharge and water quality data for the same time periods.

> Streamflow Monitoring

STREAMFLOW MONITORING IS A PROCEDURE that considers the representativeness of the sample measurements of the overall condition of streamflow at the time of sampling. Hence the monitoring stations be judiciously located so that the influence of the most dominant land use and land cover can be observed.

The location of streamflow monitoring stations depends largely on the objective of monitoring:

a. If the objective is to simply know how much volume of water flows down the watershed given the combined influences of all drivers of streamflow at a particular time period, then a single monitoring station is sufficient at the outlet of the watershed.

b. If the objective is to correlate the quantity and quality of streamflow with specific individual drivers like land use, land cover, soil types or rainfall, then several monitoring stations should be established in areas that will capture the influences of the drivers of interest.

The location of the monitoring stations must be selected well to insure that only the surface water coming from watershed areas with the particular land use or land cover or any other area of interest is captured:

a. The area of interest is the area where the stormflow (i.e., surface runoff due to rainfall) portion of the streamflow is coming from.

b. Under ideal conditions, i.e. when the particular land use or any other single driver is found in one subwatershed unit, then one monitoring station at the outlet of the subwatershed will be enough.

1. Considerations in Identifying Suitable Gauging Station Sites

a. Stations should be located beside **bridges** or any similar structure that may be used as platform where the instrument for monitoring of water level and stream velocity can be mounted (in cases when AWLS is used) or launched (in cases when portable devices such as flow meters are used).

b. Straight section of about 100m upstream and downstream from the site

c. Total flow is confined to one channel at all stages, and no flow bypasses the sampling stations.

d. The **streambed** is not prone to scouring and filling and no significant aquatic plant growths that will hinder free flow of streams

e. Banks are stable, high enough to contain floods, and free of brushes that may obstruct streamflow.

f. Permanent, stable **control** that is effective at all stages. The control can either be a section or channel control or a combination of the two. A good example is a section in the channel where both banks are reinforced with concrete walls or where the channel cross section from banks to streambed are cut in solid rocks or where the entire an channel section is built with concrete structures such as weirs and flumes.

g. A **pool** upstream from the control at low stages to ensure good stage measurements (avoids high velocities and severe turbulence at high stages)

h. Gage site is far enough **upstream** of a confluence to avoid variable backwater or back flow.

i. Satisfactory conditions for measuring discharge at all stages is available, i.e. accessible all the time.

j. Free from **large rocks** and **boulders.**

k. Secured and has support of local communities and other stakeholders.

2. Measurement of Streamflow Cross-Section

a. Use meter tape or meter stick to measure the total width of the stream channel from bank to bank and take various depth measurements (at least 5 at equal intervals) across the width of the stream.

b. Plot the width and depths in a cross-section paper or using Excel. The resulting graph can be used for estimating stream discharge by multiplying it by stream velocity. The graph can also be used for determining the width of streamflow given certain depth of water.

3. Measurement of Stream Velocity

THERE ARE SEVERAL METHODS USED FOR measuring stream velocity. Streamflow velocity can be measured using either **float method** or **current or flow meter** (mechanical or digital).

Float Method

FOR THIS METHOD, THE VELOCITY IS computed as the distance travelled by a float divided by the time of the float upon travelling that distance. In equation form;

$$v = d/t$$

where:

v = velocity (m/s)

d = distance travelled by the float (m)

t = time elapsed from travelling the distance, d (seconds)

Below is a step-wise procedure for estimating float velocity:

i. Measure and mark on one streambank a certain straight distance parallel to the **centerline** of the stream

ii. Select a **suitable float** (i.e., table tennis balls or other floating objects)

NOTE

A SURFACE FLOAT WILL TRAVEL WITH A velocity of about **1.2 times** the mean velocity of the water column beneath it. A partially submerged float made from a wooden stick with a weight at its lower end (so that it floats vertically) may be used. The velocity of a float of this type will be closer to the mean velocity and a correction factor of about 1.1 is appropriate if the submerged part of the float is at one-third to one-half the water depth.

iii. Station one **observer** at each ends of the marked distance

iv. **Release** the float before the upstream end of the marked distance

v. The observer stationed at the upstream end shall **signal** to the downstream observer as soon as the float passess his station

vi. After which the downstream observer shall quickly start a stop watch and stop it when the float passes through the downstream station and records the **travel time** of the float from the upstream station to the downstream station. A blank **data sheet** is shown in "Annex 6.1. Field data sheet for estimating float velocity" on page 106.

vii. For wide streams, **several floats** can be released at uniform distance across the width of the stream.

Current or Flow Meter

IDEALLY, AN AVERAGING FLOW METER THAT automatically measures the average velocity of the streamflow by dragging the flow meter across the width of the stream from one bank to the other should be used. Flow meter measurements should be taken at 0.2 and 0.8 of the water depth if streamflow is deeper than 0.5 m, otherwise measurements are taken only at 0.6 of the total depth.

Period of Measurements

STREAMFLOW MONITORING USING FLOW meters or current meters at the identified monitoring stations should be done **weekly** during the **dry season** and using the flow meter and will be computed using the cross-section method in estimating the amount of surface water available in the watershed.

Stepwise Procedure for Measuring Stream Velocity and Discharge:

i. Measure the river **cross-section** at each monitoring stations

ii. Plot the river cross-section and **divide** it into equal strips sections

iii. Measure the **horizontal distance** b1, from reference point 0 at the top of the streambank to the point where the water meets the streambank (i.e., point 1 in Figure 53). Measure also the horizontal distance b2 from reference point 0 to vertical line 2.

iv. Measure the **channel depth** d2 at vertical line 2

$$\overline{V_t} = \frac{V_{0.2d}+V_{0.8d}}{2} \quad \text{or} \quad \overline{V_t} = 0.6\, V_{0.6d}$$

v. With a flow meter, measure the **mean velocity v2** at vertical line 2 following the steps below:

- For shallow flow (depth d of water < 50 cm), measure the velocity at 0.6d
- For deep flow (depth > 50 cm), the velocity was measured at 0.2d and 0.8d. Then compute the average velocity, *V* as:

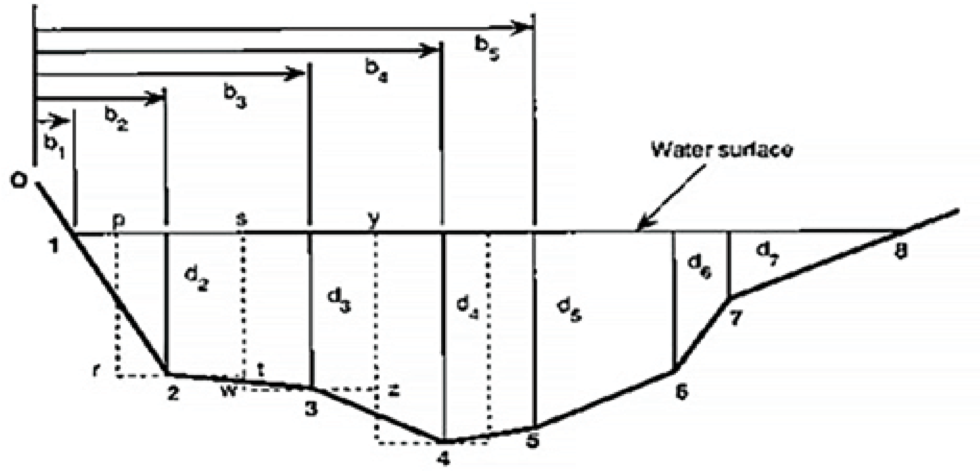


Figure 53. Stream cross-section divided into vertical sections for discharge measurement

vi. Repeat Steps iii, iv and v at all the vertical sections across the stream width.

vii. In cases where flow meter is not available, **floats** can be used for stream velocity measurement.

viii. The computation for **discharge** is based on the assumption that the average velocity measured at a vertical line is valid for a rectangle that extends half of the distance to the verticals on each side of it, as well as throughout the depth at the vertical. Thus, in Figure 53 the mean velocity would apply to a rectangle bounded by the dashed line p, r, s, t. The area of this rectangle is:

$$A2 = (b3-b1)/2 \times d2$$

and the discharge is computed as:

$$Q2 = A2 \times v2$$

where A2 is the cross-sectional area of vertical section 2; b1 and b3 are distances from point 0 to vertical line 1 and from point 0 to vertical line 3; Q2 is the discharge of vertical section 2; v2 is the average velocity at vertical section 2.

ix. Similarly, the **velocity** applies to the other vertical sections and the discharge through each section is computed as:

$$Q = A \times d \times v2$$

Total discharge (**Qt**) across the whole cross-section is computed as:

$$Qt = Q1+Q2+Q3+\ldots..Qn$$

The discharges in the small triangles at each end of the cross-section, Q1 and Qn, will be zero since the depths at points 1 and 8 are zero. If the water is shallow, the operator may wade into the stream holding the flow meter in place while measurements are being made.

> How to Develop a Rating Curve

TO FACILITATE THE ESTIMATION OF STREAM discharge, a rating curve should be developed for each monitoring station. This action aims to create an equation for estimating streamflow volume given a certain water level.

Procedure For Rating Curve Development

1. Take sufficient simultaneous measurements of streamflow velocity and the corresponding water level.

a. DRY SEASON: Only a few velocity measurements are needed since the water level does not vary so much.

b. WET SEASON: More measurements are needed to draw the relationship of velocity and water level.

- This can be done by taking velocity measurements during a strong rainfall event (i.e. during typhoons) when the level of water varies from low to maximum level.
- Velocity measurements should be taken at the beginning of the rainfall event and every so often as rainfall event progresses until the water level reaches maximum height.
- Continue measuring until the level of water recedes to its level before the rain. Safety measures must be followed in measuring velocity and water level, especially during a stormy event. A blank data sheet is shown in "Annex 6.2. Field data sheet for velocity and water level measurements" on page 107.

3. Plot the discharge (f) vs water Level (b) and draw a smooth line over the plotted points. This is the rating curve that can be used for estimating the stream discharge given water level measurement.

4. Once the rating curve has been developed, monitoring of stream discharge is reduced to the measurement of water level.

Specific Guidelines for Using Water Level Sensors

WATER LEVEL MONITORING SYSTEM (WLMS) can be installed in bridges along the stretch within the subject watershed or wherever there is any suitable permanent structure (e.g., foot bridge, electric posts) across the stream where the WLMS can be anchored.

At least one WLMS should be installed at or near the outlet of the subject watershed. Given more resources, one WLMS can be installed upstream and another one at the midstream portion of the mainstream of the watershed.

KEY STEPS IN THE INSTALLATION OF WLMS

DETERMINE THE CROSS-SECTIONAL area of the river.

MOUNT THE SENSOR OF THE INSTRUMENT perpendicular to the water surface.

INSTALL THE DEVICE NO HIGHER THAN 9 m from the bottom of the river.

ADJUST THE SOLAR PANEL TO FACE southward to fully utilize sunlight.

SET THE TRANSMISSION OF DATA INTO the server at 15-min intervals.

> Stream Water Quality Monitoring

THE PHILIPPINE CLEAN WATER ACT OF 2004 defines water quality as: *The characteristics of water that define its use and measured in terms of physical, chemical, biological, or radiological characteristics by which the acceptability of water is evaluated to classify water resources and their beneficial use.*

Water quality can be measured through laboratory analysis of samples and/or directly in the field by using water quality meters.

Laboratory Analysis of Water Samples

Goals of Water Quality Monitoring

1. To promote a better understanding of the factors that determine the characteristics of water through time.

2. To determining the best use of water, classification of water resources according to certain set of standards, assessment of the responses of water to human activities and changes in environmental

factors, and assessment of impacts of projects and programs to determine compliance with existing standards.

THE OBJECTIVES FOR MONITORING IS OFTEN an output of a participatory process involving key stakeholders. It is usually related to the common long-term vision for water and for the sustainability of human and natural systems. Once set the objectives will guide the succeeding steps below.

Delineation of the area of concern

THE AREA OF CONCERN IS DETERMINED largely based on the set objectives for water quality monitoring. The domain of monitoring could be as extensive as the whole river basin or sub-basins and could be as limited as a small catchment. Key consideration in the delineation of area of concern or study is to ensure that the flow of surface (and subsurface) runoff originating from an area that is theorized to influence water quality passes through the sampling station.

Location of Sampling and Monitoring Stations

LOCATION OF WATER SAMPLE COLLECTION IS determined by the objectives of water analysis in the same way as the objectives of streamflow measurement determine the location of streamflow monitoring. In general, water samples shall be collected in conjunction with the timing and location of streamflow measurements to facilitate correlation of stream discharge with streamflow water quality, and the correlation of water quality with land use and other key drivers of water quality.

Period and Frequency of Measurements

WATER QUALITY WITHIN THE WATERSHED IS monitored monthly at established monitoring stations during dry months and at least twice weekly during wet months. Period of water sample collection should be synchronized with the schedule of streamflow measurement. Measurements and sample collection should also be done opportunistically such as after an extreme rainfall event.

Collection of Water Samples

COLLECT WATER SAMPLES FOR LABORATORY analyses using the grab sampling technique or using a water sampler.

The laboratory where the analyses are made may require additional special collection procedures for some parameters:

a. Using appropriate markers, label each sample container with the date, time, and site number/ name.

b. Record lab sample kit number on program-specific Data Sheet, if available.

c. Collect water samples in sections of the streams that are not stirred up or disturbed. In rivers, samples should be collected while standing on edge of water or on a rock if practical. Otherwise, stand in water and reach upstream as far as possible to avoid collecting stirred up water. Telescopic dipper can be improvised using a long pole as extension of the handle of a dipper to collect water beyond the normal reach of collector.

d. Procedures recommended for hard-substrate, regular-flow streams:

   - Hold uncapped (pre-labeled) bottle upside down and submerge in water
   - Tip bottle upright and allow water to fill bottle
   - Remove bottle from water and screw on cap

e. Procedures recommended for soft-sediment, low-flow streams:

   - Use large, clean container to collect water
   - Rinse container in stream water three times
   - Collect stream water
   - Fill smaller containers with water from large

container. To ensure even mixing of sample water, gently swirl water in large container each time before water is decanted into smaller container

f. Procedures for grab water sample collection in wetlands

- Use a clean long-handled plastic dipper and wide-mouth plastic mixing jug to collect water from a standing position or from a raft or small boat
- Thoroughly rinse mixing jug and dipper three times with sample water
- Fill mixing jug using long-handled dipper to collect water from just below the surface. In well-mixed open water areas having sufficient depth, water may be collected by directly submersing the mixing jug. Avoid collecting floating organic material (i.e., algae, plant debris, thrash, etc.) by carefully clearing an opening in any surface

g. Handling of the grab samples

- Use gloves especially when collecting water samples that are likely to contain toxic constituents, pollutants and infectious bacteria
- Do not touch the inside or lip of the sample bottles or caps to avoid contamination of the water samples
- Keep the water samples inside an ice chest or as prescribed by the laboratory where the samples will be brought for analysis
- Deliver the water samples promptly to the laboratory to minimize change in the properties of water samples
- Fill out the sample custody form to ensure that the water samples are taken care of properly as it is transferred from one custodian to another

3.1.5 Onsite Monitoring and Measurements Using Water Quality Meter

THE PROPERTIES OF STREAMFLOW SUCH AS Dissolved oxygen (DO), Electrical Conductivity (EC), Salinity, pH, and temperature can be directly monitored at the monitoring stations using a multi water quality parameter meter (e.g., Hanna and Global Waters). Use the detailed instructions that come with a particular type or brand of water quality meter as your guide in actual field measurements.

Water quality meter readings can be taken in several locations:

1. Streamflow gauging stations along with streamflow measurements, particularly if float velocity is used to measure stream discharge.

2. At carefully selected points along the mainstream or tributaries if you want to determine the variation in water quality properties as influenced by elevation, land use and land cover types. Using the drainage map overlaid with land use and land cover types, identify the locations of the points in the stream where quality meter readings should be taken to insure that the surface runoff draining from an area or sub-watershed with a particular land use and land cover types of interest can be captured.

3.1.6 Data Analysis

THE VARIOUS MONITORING ACTIVITIES described above shall be used mainly to detect changes in streamflow volume and quality, and in soil properties.

a. **Trend Analysis:** May be performed to determine if there is an increasing or decreasing trends in the characteristics of streamflow and soil compared to the baseline.

b. **Cause and Effect Analysis:** May be performed to determine the factors that are likely to be the

Sampling Site Selection

MAP

Use existing maps (shape files if available) and other secondary information (PAME reports, academic studies, existing survey reports, ancestral domain management plan, PA management plan, watershed management plan, operational plan, local CLUPs, FLUPs), to have a better understanding of the different land cover types (forest land, scrubland, agricultural land, grassland, built-up area, open/barren land) and forest formations in the area.

COMPUTER

Use a computer and any available GIS software to approximate the area for each land cover type (Table 3.1 on page 49).

LAND USE

A land-use map and vegetation map can be extracted to serve as the basis for the laying-out of sampling plots/transects.

Figure 54. Sampling Site Selection

drivers of any change detected in the streamflow and soil characteristics.

SAMPLES OF SPECIFIC ANALYSES THAT MAY BE PERFORMED:

1. ASSESSMENT OF TRENDS AND changes in the condition of land use and vegetation; condition of water turbidity and soil fertility.

2. CORRELATION OF TRENDS AND changes in the condition of land use and vegetation cover with the trends and changes in the condition of water total nitrogen content.

3. CORRELATION OF CHANGES IN vegetation cover types and sediment yield of streamflow.

4. EFFECTS OF BIODIVERSITY ON SOIL organic matter content.

5. EFFECTS OF VEGETATION COVER types on soil porosity and bulk density.

6. EFFECTS OF LAND USE AND vegetation cover types on soil pH.

3.2 Floral Assessment

ACCURACY OF FLORAL ASSESSMENT IS

heavily dependent on the sampling design and intensity or the proportion of area subjected to inventory. However, it is impossible to inventory or measure the whole protected area thus it is necessary to do sampling.

- One of the biggest assumptions of any sampling technique is that the sample is representative of the whole area.
- For proper representation of the different vegetation and forest formation, sampling sites should be well stratified.
- Stratification doesn't always need to have proportionate sampling efforts for each vegetation type. A more important consideration is the ecosystem's diversity and complexity.

A General Approach for Floral Assessment is outlined below.

3.2.1 Sampling Site Selection

See "Sampling Site Selection"

3.2.2 Sampling Techniques For Each Land Cover Type

THE LAND COVER OF AN AREA DETERMINES the appropriate sampling technique to be used for floral assessment or whether the zone needs to be surveyed.

> Sampling Techniques for Different Land Cover Types

"Table 3.1 General classification of land cover types" on page 53 shows the general classification of land cover types.

Now let us discuss each one in detail.

1. Barren Land and Built-Up Area

- Not subjected to floral assessment but location and area of coverage must be noted.
- Few GPS readings can be made from strategic points on the ground to more accurately locate and plot these areas on the map.
- Expansion or reduction on the coverage of these land cover types is one of the important indicators of forest's health and status.

2. Scrubland, Grassland and Agricultural Land

- These land types are monotypic or contain less diversity, sampling in these areas can be minimal (less number of samples). However, similar with barren land and built-up areas, extent and location of these vegetation types should be marked for the purpose of monitoring reduction or expansion.
- Recommended sampling technique for areas dominated by grasses and other ground cover species is the Line Intercept Technique (LIT).
- The LIT is effective for measuring ground and canopy cover, as well as numerical abundance and frequency of trees.
- LIT provides direct measurement rather than visual estimation of cover. The technique can be easily learned and it only requires minimal equipment to apply.

HOW TO DO THE LIT

1. DETERMINE THE NUMBER AND length of transect

- The number and length of transect will depend on the extent and heterogeneity of the area.
- The map (which map?) can give us the approximate area of the ecosystem while a reconnaissance survey after examining the map will give us an idea of the heterogeneity

Table 3.1 General classification of land cover types

LAND COVER TYPE	CHARACTERIZATION/DESCRIPTION	DOMINANT PLANT SPECIES
Barren land	Land not covered by vegetation i.e. rocky areas, lahar laden areas	None
Built-up area	Land intensively use for the establishment of structures i.e. settlement, transportation and communication facilities	None
Grassland	Land area heavily dominated by grasses (Poaceae) and sedges (Cyperaceae) without any tree species growing i.e. cogonal land	Cogon (Imperata cylindrica), Talahib (Saccharum spontaneum)
Crop land	Land area devoted for rearing of livestock and production crops i.e. corn or rice plantation	Agricultural crops (corn, rice, coconut, vegetable crops)
Scrubland	Land area dominated by grass but with few scattered shrubs and/or small trees i.e. Parang vegetation, Buyo-buyo stand	Cogon, Talahib for grasses; Akleng parang, Lanete, Binayuyu, Batino, Paguringon, Bagna, Binunga, Figs, Buyo-buyo for trees
Forest land	Large tract of land (>0.5 ha) dominated by trees and other woody vegetation	Depends on the kind of forest formation (see Table 3)

of the ecosystem.

• The length of transects can vary depending on the extent and complexity of the area. The more sparse the vegetation, the longer should be the lines.

• The rule of thumb is to have a minimum 10-m transect per every hectare of the vegetation type (Mitchell & Hughes, 1995).

2. LAY OUT THE TRANSECT LINES.

• For unbiased sampling, lay out transect lines systematically.

• Establish a baseline considering the slope and topography.

• Lay-out transect lines perpendicular to the baseline at certain interval distance.

• Space transect lines far enough apart to avoid sampling overlap.

• Establish the baseline at the center of the survey area and the transect lines alternately on each side (Figure 55), for a better representation of the vegetation. This also facilitates movement during the assessment.

3. MEASURE THE INTERCEPTS

• Measure the amount of intercept for each species by recording the length of tape bisected/intercepted by each plant species (Figure 56 on page 54).

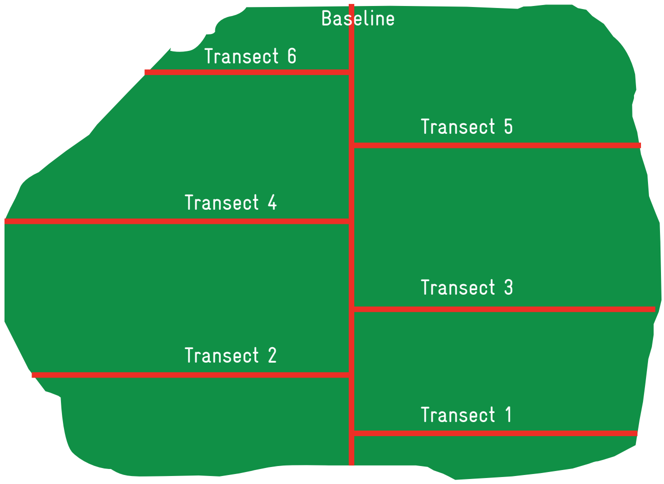


Figure 55. Transect lines established alternately from each side of the baseline. Space between transects may vary depending on preferred sampling intensity and available resources. Length of transects depends on the extent of the area.

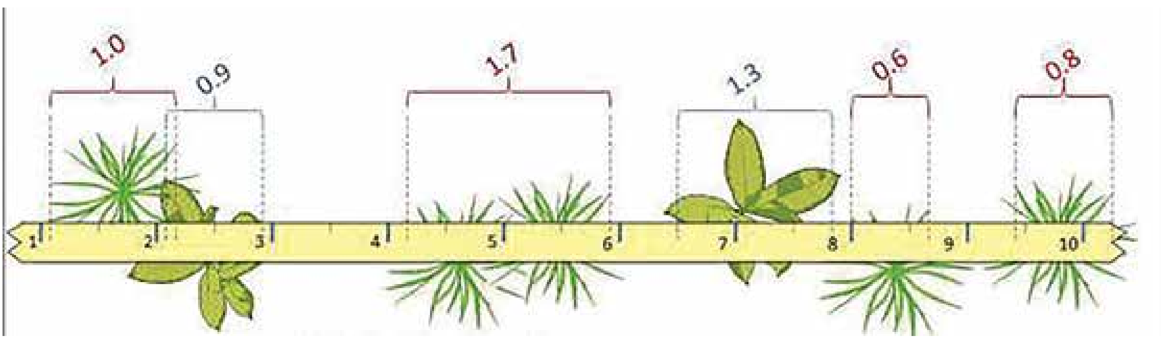


Figure 56. Measuring the intercept for each plant prior to computation of percent cover.

• This can be determined by getting the difference between the end and the start of the intercept (E-B "Annex 6.3. Field data sheet for Line Intercept Technique (LIT)" on page 108)

• When recording data, the lower canopy should not be measured if it is encompassed by a larger upper canopy, as cover overlap will result to overestimation of percentage cover.

• If a tree is intercepted in two separate branches, two measurements should be done (9a, 9b on the data sheet)

4. ASSESS THE COVER

• Calculate the percentage cover for each species by dividing the total intercept length for that species with the length of the transect lines. Species with the greater percentage cover are the dominant species on site.

$$\%\text{ Species cover} = \frac{\text{Total intercept length of species}}{\text{Length of transect lines}} \times 100$$

• Compute the percentage cover for the site

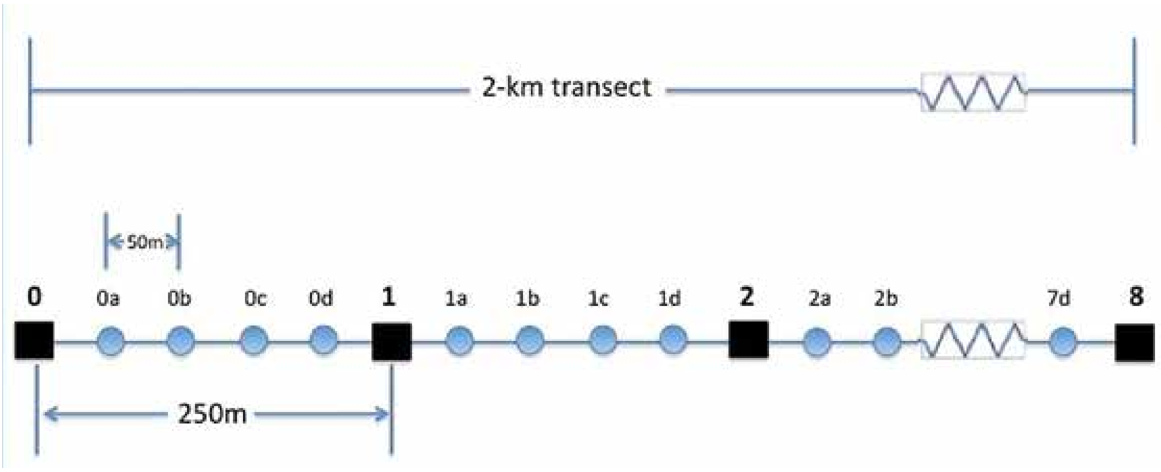


Figure 57. Transect line design, a 2-km transect where black squares represent the stations every 250m and the blue dots represent the sections every 50m

by dividing the total intercept length for all species with the total length of the transect lines.

$$\%\ \text{Site cover} = \frac{\text{Total intercept length of all species}}{\text{Length of transect lines}} \times 100$$

3. Forest Land

• The modified belt- transect method for biodiversity assessment developed by B+Wiser (2014) was further modified for the assessment of forestlands.

• The same 2-km transect will be used (Figure 57 on page 55), but quadrats, instead of circular plots, will be employed for diversity assessment. The ecosystem level assessment will be at every 50-m interval, instead of 25-m.

HOW TO DO THE BELT-TRANSECT METHOD

1. ESTABLISH THE TRANSECT LINE.

• Using a meter tape, layout the transect line along the slope of the mountain to cover different elevation gradient. In a mountain ecosystem where a lot of physical factors (i.e. climate, soil type, aspect) are the same throughout the area, elevation plays a significant role on species diversification

• The transect line does not need to be straight. It can be established along the trails for better accessibility but your quadrat should be established a few (2-5) meters from the trail. Otherwise, there will be underestimation of biodiversity if the open/disturbed part of the trail will be included in the quadrat.

• While setting-up the 2-km transect, mark every 50m section with highly visible flagging tape. Use a different color flagging tape for every 250m stations to distinguish sections from stations.

• Label the sections continuously as 0a, 0b, 0c, 0d…7d while stations should be labeled as 0, 1, 2, 3, up to 8. With this calibration, the 300m mark should be labeled 1a. Using GPS device, marked the points of the eight stations. Note the GPS accuracy level when the reading was made.

2. ASSESS THE LEVELS OF DIVERSITY.

A. Ecosystem Level Assessment (see data sheet in "Annex 6.4. Field data sheet for ecosystem level assessment" on page 109)

- Do this in every 50m section (0a, 0b, 0c, 0d..... 7d) of the transect line.

- Each section can be classified following the 12 forest formations developed by Fernando et al. (2008) ("Table 3.2 Characterization of the different forest formations in the Philippines (modified from Fernando et al. 2008)" on page 57).

- To get a better idea of the forest structure, further classify the sections based on the maturity of the stand i.e. early second growth, advanced second growth, and old growth.

- Take pictures of the site from all cardinal directions (N, E, S, W) and note the reference number of the photos.

- The complete field data sheet for ecosystem level assessment is shown in "Annex 6.4. Field data sheet for ecosystem level assessment" on page 109.

- Record observed disturbance (i.e. clearing, cutting, kaingin, presence of invasive species) from each section in the remarks column.

B. Assess species level.

- Conduct species diversity assessment at every 250m station using nested quadrat technique (Error! Not a valid bookmark self-reference..). - ??? (what is the correct statement?)

- Establish quadrats in alternating directions on the transect line (Figure 58 on page 58) to eliminate bias in the selection of sampling quadrat.

1. Upper Canopy Diversity (see data sheet in "Annex 6.5. Field data sheet for ecosystem level assessment" on page 112

2. For large woody plants whose diameter is equal or greater than 10 centimeters, measurements of diameter at breast-height (DBH), merchantable height (MH), and total height (TH) will be done inside the 20m x 20m quadrat. The observed flowering and fruiting of the individual trees as well as other tree disturbance (i.e. forking, diseased, with cut, covered by epiphytes, etc.) should be noted on the remarks column.

3. Understorey Diversity (see data sheet "Annex 6.6. Field data sheet for understory assessment" on page 113)

SMALL TREES (<10 CM DBH), POLES, saplings and shrubs inside the 5m x 5m quadrat will be identified and counted. It is important to assess the understory diversity (includes herbs, shrubs, and trees with height of ≥1m). The presence of sufficient number of saplings and young trees in a given population often determines successful regeneration. Epiphytes nesting on trees inside the 5m x 5m quadrat should be identified. Flowering and fruiting of individuals inside the quadrat must be noted under remarks.

4. Ground Cover Diversity (see data sheet in "Annex 6.7. Field data sheet for the ground cover diversity assessment" on page 114)

IDENTIFICATION AND ESTIMATION OF percentage cover of grasses and other ground cover species (vines, ferns, sedges and other

Table 3.2 Characterization of the different forest formations in the Philippines (modified from Fernando et al. 2008)

FOREST FORMATION	ELEVATION	SOIL	LOCALITIES	SOIL WATER	DOMINANT SPECIES
Tropical lowland evergreen rain forest	Lowlands to 1,200m	Zonal soils	Inland	Dry land	Dipterocarps
Tropical lower montane rain forest	(750) 1200-1500m	Zonal soils	Inland	Dry land	Pines, Tanguile, Oaks, Tree fern
Tropical upper montane rain forest	(600) 1500-3000m	Zonal soils	Inland	Dry land	Tree ferns, Medinillas, Rhododendrons
Tropical sub-alpine forest	(2400) 3,000m – tree line	Zonal soils	Inland	Dry land	Tinikaran, *Podocarpus spp.*, Rhododendrons, Medinillas
Forest over limestone	Mostly lowlands	Limestone	Inland	Dry land	Molave, Philippine teak, Bogo, Tindalo, Dipterocarps
Forest over ultramafic rocks	Mostly lowlands	Ultramafic rocks	Inland	Dry land	Mangkono, Nickel tree, *Scaevola spp.* Dillenia spp.
Beach forest	Mostly lowlands	Sandy	Coastal	Dry land	Coconut, Talisai, Bani, Dapdap, Malubago, Bitaog, Agoho
Mangrove forest	Just above sea level	Muddy clay/silt	Estuarine	Water table high at least periodically	*Rhizophora spp., Avicennia spp., Sonneratia spp.*
Peat swamp forest	Mostly lowlands	Oligotrophic peats	Fresh- water	Water table high at least periodically	*Calophyllum sp., Tristaniopsis sp.*
Freshwater swamp forest	Mostly lowlands	Eutrophic soil (rich in minerals)	Fresh- water	Water table high at least periodically	Sagu, Lanipau, Buri
Tropical semi-evergreen rain forest	Mostly lowlands	Zonal soils	Inland	Moderate annual shortage	Dipterocarps
Tropical moist deciduous forest	Mostly lowlands	Zonal soils	Inland	Marked annual shortage	Dipterocarps

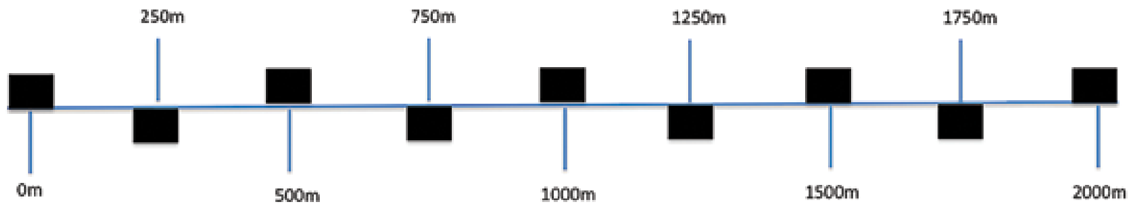


Figure 58. Quadrats layout along the 2-km transect line

erect plants <1m in height) will be done inside the 1m x 1m quadrat. Cover of forest litter and barren soil inside the quadrat is also included in the survey. The presence of any forest disturbance inside the quadrat should be noted on the remarks.

5. Number of transects to establish

THE NUMBER OF TRANSECTS TO BE established will depend on the heterogeneity of the protected area. Each forest formation should have at least one transect. But in reality, the available manpower and financial resources will be the most important factors to decide on the number of transects that the PA can assess and monitor.

4. Mangrove Forest

- A mangrove forest is a unique ecosystem with a community of trees occurring in a very define zonation pattern (Figure 59), which is dictated primarily by the type of substrate and the tolerance of the species to salinity and inundation.
- Unlike the terrestrial forestlands, the diversity in a mangrove forest is significantly lower. For instance, a particular zone can be dominated by a single species as in the case of *Rhizophora* zone. Hence, when surveying, all the mangrove zones, from seaward to landward, must be properly sampled.
- The most applicable sampling technique for mangrove forests is the belt transect method.

HOW TO DO THE BELT TRANSECT METHOD FOR MANGROVE FORESTS

- Lay out a baseline transect parallel to the shore, the length of which will depend on the extent of the mangrove forest in the study area. (Figure 60 on page 60)
- Establish transect lines perpendicular to the baseline at every 100-m interval. The length of transect lines may vary depending on the extent of the mangrove forest, but as much as possible, the transect lines should extend to the most landward zone of the mangrove forest.
- Establish a nested 10x10m quadrat at certain intervals along the transect lines depending on the extent of mangrove forests.
- For large contiguous mangrove forests

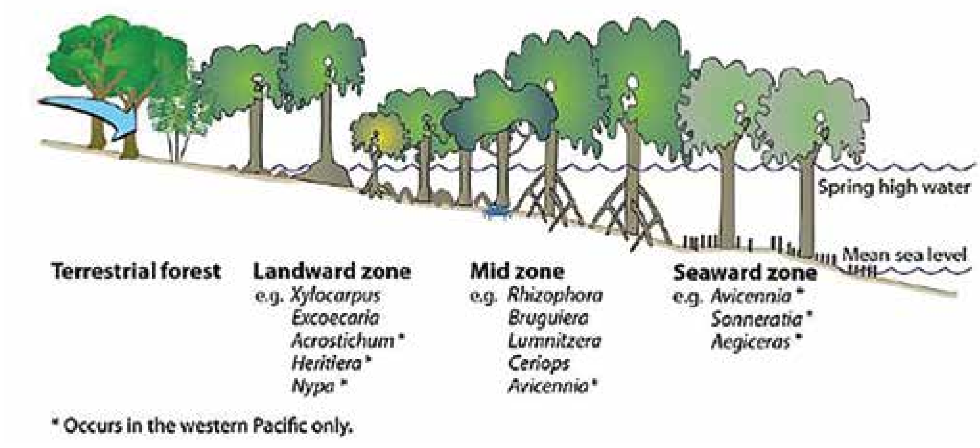


Figure 59. The three zones typical of mangrove habitats in the tropical pacific, showing the differences in mangrove species typical of each zone. (Image source: http://www. spc.int/climate-change/e- book/images/c6fig1.png)

(i.e. Palawan, Pagbilao Quezon, Calatagan Batangas, Masbate, Surigao, Dinagat islands etc.), a 100-meter interval between quadrats is suggested (Figure 60 on page 60).

• For narrow strips of mangroves along the shore, the distance between quadrats can be as short as 50 meters or 25 meters.

• Identify and measure (DBH, MH, TH) all trees inside the 10x10m quadrat with diameter of equal or greater than 5 centimeters.

• Identify and count small trees (< 5 cm DBH), and other non-tree flora (shrubs, vines, herbs, ferns) inside the 2m x 2m quadrat. The same field data sheet for the canopy and understory of forestland can be used for mangroves.

• In the remarks column, record the observed flowering and fruiting of the individual trees and other tree disturbances.

FLORAL ASSESSMENT

• Additional collections of plant species can be made using the random meander survey – a non-systematic general collection method to account for other species occurring outside the survey plots.

• In most of the flora assessment we conducted, the number of species collected from the opportunistic survey are significantly greater than those recorded from the quadrats. With this method, there is a higher chance of encountering more species occurring in the area. However, except for presence or absence of the species, it will not give other quantitative data to determine the dominance or importance value of each species.

• Using a unique identifier, collect and tag sample specimens for each species that are difficult to identify in the field.

• These samples should be returned to base camp and processed at the end of each day of survey to preserve the specimens prior to identification at the end of the survey period.

• The Sweinfurth's method (commonly

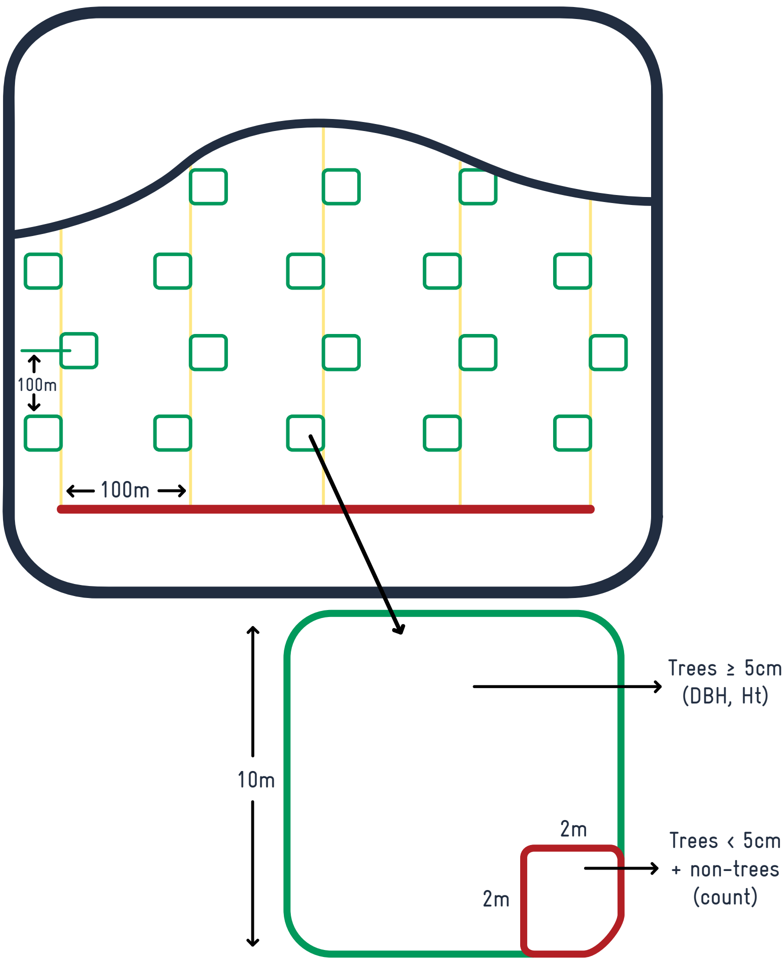


Figure 60. Belt transect method for mangrove forests

known as "wet collection" method), a standard plant collection technique, should be employed for specimens that were difficult to identify in the field.

• This method involves soaking of properly labelled specimens in ethyl alcohol to avoid rapid wilting and crumpled drying.

• Note down important information such as habitat, physiognomy, slope and aspect, and characteristics of the plants that will be lost after drying, DBH and TH.

• The specimens should be packed in polyethylene bags and sealed for further analysis in the laboratory.

• Dry all specimens collected during the survey period (either by oven or air drying) for long-term storage and systematic processing in the laboratory.

• Consult relevant literature (Philippine Journal of Science, Flora Malesiana, Flora of Manila, Enumeration of Philippine Flowering Plants, Lexicon of Philippine Plants, Blumea, Leaflets of Botany among others) for initial identifying the dried plant materials.

- For final identification, compare the dried specimens with the image database on type materials of the Philippines.

- With the proliferation of reliable taxonomic website showcasing online image database and interactive identification keys for plants (http://www. plantsystematics.org, http://www.philippineplants.org, http://www.kew. org/herbarium/keys/fm/key.html), it is important to take photos of every species encountered in the field. Identification from photographs of fresh plants is often easier than identification of dried specimens.

3.2.3 Data Analysis

> Importance Value of Species

- Tabulate and analyze all information gathered in the field to characterize floral composition of the study area. Compute the relative density, relative dominance, and relative frequency values for each species to obtain their Importance Value (IV).
- IV is a standard measurement in forest ecology to determine the rank relationships of species. Compute the IV separately for the upper canopy, understory, and ground cover species.
- Importance values will be determined using the following formulae:

Density

$$= \frac{\text{Number of individuals}}{\text{Area sampled}}$$

Relative Density

$$= \frac{\text{Density for a species}}{\text{Area sampled}} \times 100$$

Frequency

$$= \frac{\text{Number of plots where species occur}}{\text{Total number of plots sampled}}$$

Relative Frequency

$$= \frac{\text{Species frequency value}}{\text{Total frequency for all species}} \times 100$$

Dominance

$$= \frac{\text{Basal area or volume for species}}{\text{Area sampled}}$$

Relative Dominance

$$= \frac{\text{Species Dominance}}{\text{Total dominance for all species}} \times 100$$

Importante Value

= Relative Density + Relative Frequency + Relative Dominance

> Diversity Indices

- Diversity indices (Shannon, Simpson's and Evenness index) for each transect and quadrat can be generated using any available biodiversity software (i.e. PAST, MVSP, BioPro, Diversity, etc.) with the data on the number of species and abundance for each sampling quadrat.
- Shannon Index gives an estimate of species richness and distribution.
- Evenness Index tells us how evenly species and/or individuals are distributed inside a plot or quadrat.

Table 3.3 Classification scheme by Fernando et al. 1998

RELATIVE VALUES	SHANNON (H') INDEX
Very High	3.5 and above
High	3.0 – 3.49
Moderate	2.5 – 2.99
Low	2.0 – 2.49
Very Low	1.9 and below

- Simpson's Index gives the probability of getting different species when two individuals are drawn (with replacement) inside a plot. Basically, the higher the value for any of the diversity indices, the greater the species diversity in the area and vice versa.
- The classification scheme developed by Fernando et al. (1998) should be used for the interpretation of Shannon diversity index ("Table 3.3 Classification scheme by Fernando et al. 1998" on page 62).

> Endemism and ecological status

- Assess the endemism and ecological or conservation status of the different species to determine the ecological importance of the vegetation in the area.
- The geographical distribution of plant species has been very useful for assessing biodiversity values of regions, and islands.
- Species confined to a particular site should be given particular conservation management strategies, as they are more vulnerable to disturbance due to their narrow range.
- The online database, Co's Digital Flora of the Philippines (www.philippineplants.org), and other published literature (Enumeration of Philippine Flowering Plants Vol. 1-4 (Merrill 1923-26); Revised Lexicon of Philippine Trees (Rojo 1998) can be consulted to determine the places of distribution of each species.
- The conservation status of each species will be based on the most recent recommendations of the Philippine Plant Conservation Committee (PPCC) of the Protected Areas and Wildlife Bureau (PAWB), DENR officially issued as DENR Administrative Order No. 2007-01 better known as "The National List of Threatened Philippine Plants and their Categories', and the listing of threatened species by the International Union for Conservation of Nature better known as the IUCN red list.
- Some of the ecologically important species present in the protected area can be used as biodiversity indicators for the periodic monitoring.

3.3 Faunal Assessment

3.3.1 Arthropod Assessment

- The arthropod fauna, particularly the class of Insecta, is the most diverse group of organisms on earth. More than 1 million species of insects have been described and many new species are still being discovered. In the Philippines, more than 25,000 species of insects were already described despite the few numbers of insect taxonomists.
- Arthropods play an important role in the

ecosystem as decomposers, pollinators, seed dispersal agents, bio-control agents of pest and diseases and many others. Although insects offer various benefits, one should bear in mind that there are insects which are injurious or detrimental in nature.

- With the diversity of arthropods comes the variety of methods of assessing arthropod diversity and their populations.

Walker (1981) lists methods of measuring insect populations. Other techniques used in ecological studies are given by Southwood (1966) where he pointed out the usefulness of these methods in measuring the relative changes in populations rather than determining absolute numbers.

- Detected changes in population can be used to assess and plan the management strategies needed. The results from various methods, of course, depend on several factors such as the actual density or population size, numbers in a particular phase or level of activity of the animal, efficiency of sampling method and responsiveness of a particular sex and species to the traps being used, time of sampling and many others.

> Expected Outputs for Arthropod Diversity Assessment

1. Taxa composition and list of arthropods in the area.
2. Species/taxa richness, abundance and dominance
3. Different biodiversity measurements/indices
4. Possible interrelationships of arthropod and the vegetation in the area
5. Photos of different species.

The result of the assessment will also provide information on what species to be monitored (i.e., keystone species, indicator species) and where the permanent monitoring plots/transects should be established.

CHALLENGES IN ARTHROPOD DIVERSITY ASSESSMENT

- One of the main problems in dealing with arthropods is that even limited sampling can yield large numbers of specimens and an enormous diversity of species.

- Another problem is taxonomic impediment due to high proportions of undescribed arthropod taxa and the few specialists available especially in the Philippines and the lack of knowledge on species distribution, diversity and ecological roles.

- Identification of specimens can be done up to order level only, or if possible, up to family level.

- Species identification will be mostly arbitrary in nature. The PA person that will be involved in the assessment needs good knowledge and skills in identifying or categorizing the different arthropod groups/ taxa.

MATERIALS AND EQUIPMENT

- Insect net
- Collecting bottles
- Small specimen bottles
- Forceps
- Digital camera with macro setting and/or macro lens
- 80% ethyl alcohol

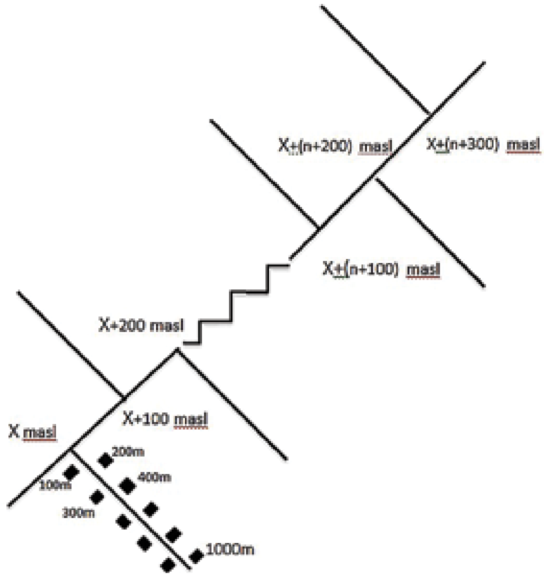


Figure 61. Hypothetical diagram of the modified transect method for assessing arthropods with alternating 1.0km sub-transects established every 100m elevation gradient along the main transect line (Note: The main transect line can be located in the topographic map of the area).

Figure 62. Illustration of insect net with collapsible handle (bottom) and collecting glass jar (above).

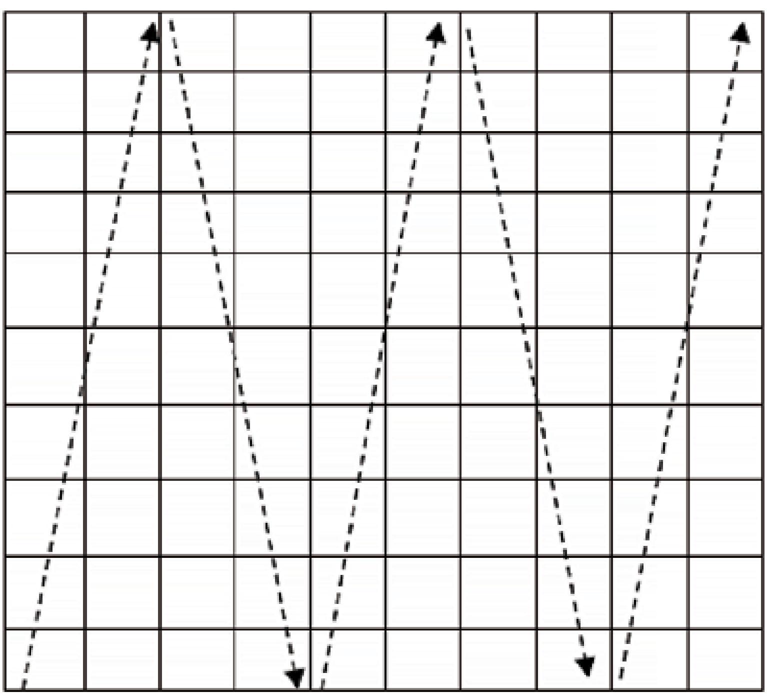


Figure 63. Diagram showing the zigzag direction of sweeping arthropods in a 20x20m sampling plot.

- Waterproof specimen tags
- Indelible pen
- GPS receiver
- Paper triangles
- Small field bag

3.3.2 Methods

> Site Selection

THE SITES AND PROCEDURE FOR SELECTING the sites for arthropod assessment will be the same as that of the flora assessment.

> Sampling Design

a. Modified transect method

Arthropod diversity assessment can be done using a transect method similar to the modified belt transect method for the flora assessment. This is similar to the method adopted by Pollard (1997) and Thomas (1983) for butterfly assessment.

a. Establish a transect line along the slope of the mountain covering different elevation gradients (Figure 61 on page 64).

b. At every 100-m elevation interval, establish a sampling transect measuring 1000m (1km) distance side by side with the flora quadrat.

c. For every sampling transect, establish 10x10m quadrats with interval of 100m alternately on the sides of the sampling transect.

d. Using an insect net (Figure 62 on page 64), make 50 sweeps (5-10 sweeps at a time) while walking along a zigzag direction within the quadrat (Figure 63 on page 64). Each sweep should follow a 180-degree motion.

e. For every 5-10 sweeps, place captured arthropods in a collecting jar (Figure 62 on page 64) with 80% ethyl alcohol. Label each jar with the date, name of the collector, name of the PA, transect line number, and sampling plot number.

f. Butterflies and other arthropods that cannot be preserved in alcohol can be placed in paper triangles. Label each paper triangle with the date, name of the collector, name of the PA, transect line number, and sampling plot number.

g. Note pertinent data and observations (e.g. habit, host plants, activity of the arthropod, etc.) in a field notebook.

h. Remove all debris of leaves and twigs from the insect net, and move on to the next sampling plot.

i. Sort and identify specimens in the base camp. For specimens that are more difficult to identify, take these to a laboratory for further examination.

NOTE

KEYS TO SPECIES IDENTIFICATION OF insects/arthropods in the Philippines are very limited, thus, identification will be done up to Order level or if possible up to Family level except for some well-studied species.

b. Opportunistic sampling

a. Hand-pick using forceps or use an insect net to collect macro-arthropods while walking along the transect line, moving from one sampling plot to the next.

b. Place specimens inside a collection jar with 80% ethyl alcohol. Label each jar as “Opportunistic Sampling” with the date, name of the collector, name of the PA, and transect line number. One jar will be assigned for each transect.

Table 3.4 Arthropod Fauna Survey Form

Observer:	Genaro I. Zapanta		Date:	October 20, 2015	
Name of PA	Mt. Isarog NP		Location:	Tigaon, Camarines Sur	
Transect No.	01		GPS Reading:	13°39'33"N	123°22'24"E
Plot No.	03		Elevation:	759 masl	
Habitat type	Young second growth		Weather:	Cloudy	

No.	Name of Taxa	Species Code	Arthropod Class	Frequency	Remarks
001	*Papilionid butterfly*	*Lep-001*	*Insecta*	*llll*	*Big; black front wings; red hindwings*
002	*Long-horned beetle (Cerambycidae)*	*Col-001*	*Insecta*	*lll*	*Small; brown; body length approx. 1-inch*
003	*Black ant*	*Hym-001*	*Insecta*	*llll – llll-*	*Nesting in rolled leaf*
004	*Hantik*	*Hym-002*	*Insecta*	*lll*	*Red body; long, curved mandible*
….					
n					

Remarks could be the following: Body size (small, medium, big, large); body color; body shape (pointed, curve, straight, etc.); distinctive markings (body stripe, body spots, unique body parts, etc), photo number, other observations.

Examples of Species Code: Dip-001; Col 001; Hym 005; Hem 008; Lep 010 – (Dip = Diptera; Col = Coleoptera; Hym = Hymenoptera; Lep = Lepidoptera)

c. Note pertinent data and observations (e.g. habit, host plants, activity of the arthropod, etc.) in a field notebook.

d. Sort and identify specimens in the base camp. For specimens that are more difficult to identify, take these to a laboratory for further examination.

> Specimen Organization and Recording

a. Place collected specimens of related species belonging to a particular Order or Family in separate collecting jars. Label each jar with the date, family or order of the specimens, name of the collector, name of the PA, transect line number, and sampling plot number.

b. Record important data in the data sheet ("Table 3.4 Arthropod Fauna Survey Form" on page 66) such as taxa name (common name, local name, order or family name), arthropod class, number of individuals caught, and possible remarks.

c. Photograph each species recorded. Ideally, use a digital camera with macro setting and/or macro lens. Note the file number of each photo in "Remarks".

> Data Analysis

DATA COLLECTED WILL BE USEFUL IN providing the arthropod species/taxa composition, abundance, density, habitat associations, arthropod-host plant interactions among others.

a. Illustrate Graphs on the relative proportions of the various taxa and their abundance.

b. Based on the samples during the assessment, derive the species accumulation curve to determine the minimum sampling effort needed. The graphs can be made using the MS-Excel program or with the use of other computer software such as STATGRAPHICS, BIOPRO or other similar programs.

c. Compute empirical measures of biodiversity based on the data particularly for the number of individuals of a specific taxon.

The two most commonly used measures of biodiversity are:

1. Species richness indices: A measure of the total number of the species in a community.

2. Heterogeneity or diversity indices: Aims to obtain a quantitative estimate of biological variability that can be used to compare biological entities, composed of direct components, in space or in time. Diversity usually implies a measure of both species number and 'equitability' (or 'evenness').

NOTE

COMPLETE INVENTORIES OF ALL species present at a certain location, is an almost unattainable goal in practical applications.

Formulae for two species richness indices:

Margalef's diversity index:

$$D_{Mg} = \frac{(S-1)}{\ln N}$$

Menhinick's diversity index:

$$D_{Mn} = \frac{S}{\sqrt{N}}$$

where N = the total number of individuals in the sample and S = the number of species recorded.

For heterogeneity measures, it is assumed that individuals are randomly sampled from an infinitely large community, and that all species are represented in the sample.

Shannon-Wiener diversity index, the most widely used diversity index is calculated using the equation:

$$H' = -\sum p_i \ln p_i$$

where p_i is the proportion of individuals found in the ith species.

Another heterogeneity measure is the Simpson's index which is given by:

$$\gamma = \sum_i p_i^2$$

where p_i is the proportion of individuals found in the ith species. This index is used for large, sampled communities which expresses the probability that any two individuals drawn at random from an infinitely large community belong to the same species.

3.3.3 Vertebrate Wildlife Assessment

SURVEY OF AMPHIBIANS, REPTILES, BIRDS, and mammals involves methods that are both time and labor-intensive. A minimum of 3 to 5 sampling days per site is required to get a more or less accurate account of the species assemblage of the area.

Sampling effort is sufficient when the species accumulation curve reaches a steady plateau or asymptote against number of sampling days. A plotted species-effort line graph determines the approximate inventory of total species assemblage in any protected area.

USEFUL TOOLS FOR ASSESSMENT

1. Brief ecological or behavioral notes derived from field observation encoded in diaries (ex. Species seen feeding on fruit or nectar to help describe diet) can help confirm ecological linkages necessary for describing the value of wildlife in supporting ecosystem services.

2. Field notes provide invaluable data on the biology or ecology of a species (ex. Breeding or nesting strategies) that may be lacking for status assessment.

3. Ethnobiological notes (ex. Local names) and human impacts (ex. Use by locals) based on interviews are equally important observations that require detailed data recording.

STAFF REQUIREMENTS AND MUST- DOS FOR WILDLIFE ASSESSMENT

ASSESSMENT OF TERRESTRIAL vertebrates is also dependent on the capacity of the Staff to follow standardized sampling methods, data recording and, basic skills in taxonomic or parataxonomic identification.

1. Staff should be knowledgeable and skilled to be able to follow taxonomic keys and field guides.

2. Staff must be able to properly conduct field data recording and collection of voucher specimens. This will then facilitate the verification of taxonomic identification through the assistance of wildlife experts.

3. Staff should have a basic understanding of statistics (for Biology) and computer-based data analysis is needed to show trends (density, diversity and endemism), support identification, and prepare recorded survey data for inter- and intra- study site comparisons of wildlife inventories between elevational or habitat gradients or across adjacent protected areas.

4. The protected area staff and other personnel assigned to conduct the field work will have to camp out near the sampling sites for the whole duration of the survey.

5. Equipment and materials must be prepared days prior to the actual fieldwork.

6. Food for the duration of the fieldwork for the whole team should be planned out.

7. Water is usually available in the field and camp sites are best set near water sources, unless potable water is not available on site then water must be out-sourced.

8. Several porters are needed in remote sampling sites, to carry the enormous load of camping gear, equipment, materials and food supplies required by the wildlife team

9. Proper pre-planning and field logistics is crucial in implementing a comprehensive wildlife assessment.

> Sampling Design

THERE ARE DIFFERENT POSSIBLE SAMPLING designs that can be implemented in PAs, depending on their size, extent of required information, time and effort available and accessibility of habitat types within the study site.

For consistency and to allow comparative analysis between different PAs, the survey of terrestrial vertebrates should be restricted to terrestrial forest ecosystems, with fairly comparable habitat types, but may vary considerably by soil type, elevational gradient, vertical stratification, climate type and biogeographic zone.

See "Coverage of Survey Plots" on page 70 for sampling designs suggested for assessment of terrestrial vertebrate fauna in PAs:

> Survey of Small PAs

A comprehensive general assessment can be completed in small PAs where only a manageable number of transects and plot/stations can be established with a suitable forest ecosystem. After doing the comprehensive survey, important plots representative of habitat type and elevation can be selected for monitoring (See "Coverage of Survey Plots" on page 70).

This transition from complete survey (wildlife assessment) to rapid sampling (wildlife monitoring) can be applied for the following protected landscapes with limited sizes and less variation in forest types, may be up to 2-3 types:

1. Forested Islands (lowland forest to coastal forest)
2. Mountain Peaks (lowland forest to mid-montane and mossy forest)
3. Unique Forest Types (lowland forest with forest over ultramafic or karst rock)

> Survey of Large PAs

RANDOMIZED SUBSET OF PLOTS CAN BE surveyed in large protected areas where access to widespread established transects and plot/stations can be a challenge to complete (See "Randomized Distribution" in "Coverage of Survey Plots" on page 70).

After doing the survey, select important plots for monitoring. This transition from randomized survey (wildlife assessment) to rapid sampling (wildlife monitoring) can be applied to large protected landscapes with less varied forest types. However, limitations in survey team capability, time and funding have pressed most PAs to implement both rapid assessment and monitoring of pre-selected plots – as common practice for previous BMS (See "Coverage of Survey Plots" on page 70).

SITE SELECTION

SAMPLING SITES FOR THE ASSESSMENT of terrestrial vertebrates should include all of the forest formations (Fernando et al. 2008) present in the PA, from Lowland Evergreen Forest to Upper Montane Forest.

- The wildlife or terrestrial vertebrate fauna component team should follow the site selection devised by the terrestrial flora group.

- The sites should cover the flora permanent plots or sampling transects within each particular forest formation. This is important to maintain uniformity in site selection between the different biological components and for integration of assessment.

- It is also crucial to target habitat types with presumably high levels of species diversity.

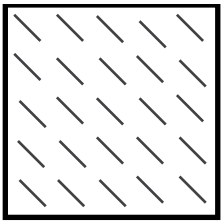
- Patterns of species diversity for herpetofauna, birds and mammals correlate variably along elevational gradients.

- For birds and bats, richness is negatively correlated with elevation.

- Small, non-volant mammals peaks at the area of transition from lower montane to mossy forest (Heaney 2001, Rickart et al. 2011).

- Reptile diversity is higher at lowland forests

Coverage of Survey Plots



Non-Randomized
Distribution

> Characteristics of Non-Randomized Distribution and Comprehensive Coverage of Survey Plots

1. Full coverage of wildlife survey plots within the study area, using a grid system, no randomized selection of plots.

2. Although non-random selection of plots may cause potential bias, full coverage of area will be done regardless of habitat type and condition.

3. Actual wildlife survey implemented on entire study area, using grid system to evenly distribute survey plots/stations, but difficult on very large PAs.

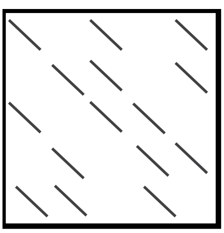
4. Due to comprehensive coverage, selection of plots within a study area using a grid system may disregard elevation, slope, and habitat condition.

5. Full coverage entails more time and effort to completely survey all plots within the grid system and represent more comprehensive data.

6. Based on analysis of survey results (species diversity/density), the "best" locations can be determined which may harbor most key indicator species.

7. From this comprehensive coverage, "best" plots with most key indicator species can be selected as sites for periodic monitoring (BMS).

8. This design represents the ideal scenario for wildlife assessment, which establishes the complete baseline info needed, with minimal statistical bias.



Randomized
Distribution

> Characteristics of Randomized Distribution and Subset Coverage of Survey Plots

1. Random selection of plots reduces bias towards "best" locations, but assumes that habitat type and condition are consistent within the study area.

2. Full coverage of wildlife survey plots within the study area, but with randomized selection of plots to be surveyed via grid system.

3. Actual wildlife survey implemented only on a proportion of the study area, thus data represents a subset of the entire site, especially on very large PAs.

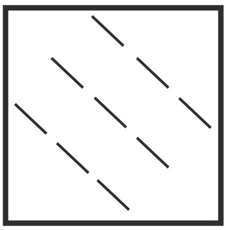
4. Due to random subset coverage, selection of plots within the study area via a grid system may disregard elevation, slope, and habitat condition.

5. Limited coverage entails less time and effort to survey plots within the grid system regardless of accessibility, but represents only a subset of data.

6. Based on analysis of survey results, fewer "best" locations can be determined from this surveyed subset, which may harbor most key indicator species.

7. From this subset" sites.

8. This design is acceptable for wildlife coverage, not all of "best" plots can be selected as sites for periodic monitoring (BMS), and potentially miss out on the "best assessment, although it establishes only a portion of the baseline info needed, it affords minimal statistical bias. This design represents the ideal scenario for wildlife assessment, which establishes the complete baseline info needed, with minimal statistical bias.



Non-Random Distribution

> Characteristics of Pre-Selected Non-Random Distribution and Subset Coverage of Survey Plots

1. Non-random and predestined selection of plots may cause bias towards "best" locations, and represent varied habitat types and condition.

2. Definitely no comprehensive coverage of wildlife survey plots within the study area, with no randomized selection of plots to be surveyed.

3. Actual wildlife survey implemented only on a proportion of the study area, thus data represents a subset of the entire site, especially on very large PAs.

4. Due to pre-selected distribution of plots within the study area, each subset of plots may represent elevational gradients and habitat types.

5. Limited coverage entails less time and effort to survey plots within the grid system, although pre-selection may be attributed to site accessibility.

6. Due to pre-selection of sites, the "best" locations (if known) can be targeted for this surveyed subset, which may harbour the most key indicator species.

7. Rapid assessment of pre-selected "best" plots can also represent sites for periodic monitoring (BMS), assuming that "best" locations are known.

8. This design is acceptable for wildlife assessment, establishing only a portion of the baseline info, but additional tests are needed for statistical bias

(Diesmos et al. 2004) while amphibians may exhibit high diversity up to lower montane forest.

• Other habitat attributes should also be considered in selecting sites such as size of the area, topography, habitat heterogeneity and presence of human-induced modifications.

• Within each PA, there are variable degrees of human impacts, thus the coverage of forests may be patchy and dependent on disturbance gradients, proximity to agricultural areas or even built-up man- made habituation.

• Establishment of transects, net lines or trap lines on selected sites will depend upon the specific habits of each taxon.

• Whenever possible, transects should be far enough from net lines or trap lines to prevent disturbances.

Herpetofauna

MOST AMPHIBIANS AND REPTILES ARE difficult to identify unless they are captured, collected, and examined in detail. Recent innovations in species delimitation such as molecular phylogenetics, modern morphometrics, and bioacoustics, facilitate persistent taxonomic changes amongst herpetofauna in the Philippines, which indicate many splits in taxa or even discovery of potential new taxa in most protected areas. Although many studies have resolved systematic relations in most herpetofauna, we need to reiterate the importance of proper and complete field recording and procurement of voucher specimens. As such, to record the diversity of herpetofauna in an area, it is ideal to capture them.

CAPTURING SPECIMENS

ATTAINING A COMPREHENSIVE RECORD of amphibians and reptiles in a sampling site involves preparing all potential methods for increasing capture rates and facilitating field observation.

- Snake hooks or clamps provide safe handling of snakes, dip nets for scooping tadpoles, and drift-nets with pit-fall traps to capture skinks.

- A wide array of field electronics afford proper photo-records (either close-up or zoomed in), GPS data and recording frog calls.

- Complete materials for preparing captured voucher specimens facilitates recording morphometrics, standardized fixation and preservation, and tissue-sampling for molecular studies.

- In some cases, tissue swabs are now included in many amphibian studies for screening wild populations for potential chytrid fungual infections.

A thorough sampling of herpetofauna ensures that the most data are recorded given the high amount of time and effort deployed during the assessment (and monitoring) period.

Materials and Equipment

FIELDWORK INVOLVES MOVING TO SEVERAL sites during the duration of the assessment. All your materials must be stowed in sturdy plastic crates with clamp-on lids. Affix a listing of the contents on each crate so any team member can easily find and return materials. Materials and equipment commonly used for processing amphibians, reptiles, birds and mammals (eg. Weighing scales, caliper, ruler, etc) are best kept in a tackle box.

MATERIALS AND EQUIPMENT

- GPS receiver with batteries and SD card

- Digital audio-recorder with unidirectional microphone

- Digital SLR Camera with macro lens and close-up speed light, and zoom-lens

- 100-m wind-up meter tape

- 30-meter drift fence (thick black trash bags, stapler, staples, bamboo sticks)

- Plastic containers (ice cream tubs or 2-liter soda bottles and large scissors)

- Trowel

- Resealable (zip-lock) plastic bags (big and small sizes)

• Large thick plastic bags and clear packaging tape

• Snake (pinning) hook with noose and snake clamp/tongs

• Thick cloth bag (small and large pillow cases)

• Reinforced insect net and durable dip nets

• Large and small lab forceps

• Large rubber bands (0.5 or 1 inch width, 2 ft length)

• Glue boards or fly paper, thumbtacks

• Dissecting set (fine tissue and bone scissors, scalpel with blade)

• Headlamps (with batteries and spare bulb, unless LED)

• Waterproof Torch or Spotlight (with batteries and spare bulb, unless LED)

• Flagging tapes/Ribbon markers

• Data Sheets (for transect counts and specimen catalogues)

• Plastic clip board, hard bound clip-binder and paper puncher for data sheets

• Indelible pen and Pencil (eraser/sharpener) and specimen tags

• Steel tape measure, steel foot ruler and thick twine (10m)

• Digital or Dial Caliper and "pesola" spring scales (100g, 300g, 1kg)

• Large sturdy specimen containers with spill-proof screw-cap lids

• 95% ethyl alcohol (3-5 liters) and paper towel

• Printed taxonomic keys, photo-guides and field handbooks

> Methods

1. Modified Strip Transect Sampling

a. Designate a 250-m strip transect in the selected sampling site. A strip transect represents an approximately straight line laid across the sampling site that can follow existing foot trails to minimize disturbance.

b. Lay out alternating 10x10-m quadrats at every 25 m. These should be 5 m perpendicular to the transect (Figure 64 on page 74). Mark each area with flagging tape.

c. Establish ten (10) quadrats per site covering an area equivalent to 1,000 m2.

d. Record the GPS coordinates of the central point from each quadrat, along with two endpoints of the transect line.

e. Take a photograph each quadrat.

f. Traverse the transect by scanning through and making searches, especially for cryptic species, in potential microhabitats (e.g. streams, pools, tree holes, burrows, underneath fallen logs, under forest-floor litter, inside leaf axils of aroids, bananas or pandan/screwpines, etc).

g. Conduct sampling at least thrice a day between 0700h to 0900h, 1100h to 1300h, and 1900h to 2100h. This ensures sampling of diurnal and nocturnal herpetofauna, including mid-day active reptiles and post-crepuscular frogs and toads.

h. Follow the auditory cues of frogs and hand-capture each individual.

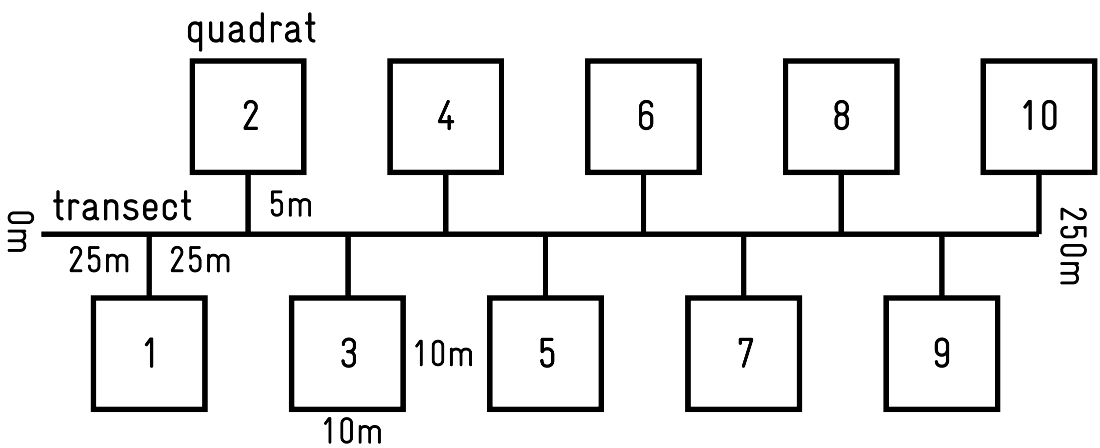


Figure 64. Diagram for modified strip transect method with alternating 100 m2 quadrats laid every 25 m along a 250 m transect line.

i. Auditory cues can also be digitally recorded and used as a reference for species identification.

j. Use bare hands and/ or forceps, snakes hooks/ tongs and even wooden sticks to capture other amphibians and reptiles.

k. Using the data sheet in "Annex 6.1. Field data sheet for estimating float velocity" on page 106, record the species, number of individuals encountered and whether they were seen, heard or captured.

l. Photograph and note the descriptions of their microhabitats and ecological or behavioral observations, if any.

2. Live-trapping with Pit-fall and Glue-board Traps

PIT-FALL TRAPS AND DRIFT FENCES ARE used to capture terrestrial amphibians, small lizards and sometimes snakes inhabiting the forest floor especially those hiding in understory or within leaf litter. Inexpensive pitfall traps that may be used are plastic containers such as small pails, deep ice cream tubs or 2-liter soda bottles.

a. Lay out pit-fall traps and glue traps across the length of the designated central strip transect in each sampling site.

b. Bury the plastic containers with the brim lower or about the same level as the ground (Figure 65). Space the traps five meters apart.

c. Cover the trap with natural roofing material such as wooden bark, stone slates or large leaves braced 1-2 inches above the ground. Record the GPS coordinates for each trap.

d. You may opt to add drift fences (Figure 65 on page 75) between traps using cut strips of black trash bags (stapled or attached with dark packaging tape) or pre-fabricated tarpaulin erected by wooden/bamboo stick. These will facilitate the movement of the animal into the pit-fall traps.

e. Alternate traps every five meters on each side of the fence. Pitfall traps may also be set without drift fences.

f. Check the traps in the morning at around 0700 h and every other hour thereafter whenever possible until 1900 h, more so if heavy rainfall occurs to avoid captured individuals from drowning or escaping.

g. Staple or tack commercially-available glue

Figure 65. Pit-fall trap buried at ground level (left); and supporting drift fence erected beside each pit-fall trap to facilitate movement towards pit entrance (right).

Figure 66. An assortment of field equipment used to facilitate capture and safe handling of herpetofauna, particularly snakes, burrowing lizards and tadpoles (L-R Snake hook, snake tongs, foldable spade, dip net)

boards or fly paper onto tree trunks or large branches every five meters to capture small arboreal herpetofauna (as well as arthropods, which may also serve as bait).

h. Check these regularly to limit predation by other wildlife or ensure retrieval of live captures which can be removed and cleaned of glue using a mixture of dishwashing fluid and cooking oil.

3. Purposive Sampling

MOST HERPETOFAUNAL SPECIES ARE HIGHLY cryptic or shy and difficult to observe, thus they require more purposive search beyond the standardized quadrat sampling and trapping arrays. Many herpetofauna are nocturnal and exceedingly difficult to observe being subfossorial (burrowing) or arboreal, making purposive observations as the common method for assessment. Species recorded using these methods will add to the overall species checklist, but may not provide computational statistical data to determine abundance or diversity.

a. Record amphibians or reptiles observed or caught outside of the strip transect sampling area (i.e. during net watching, checking mist-nets and rebaiting of traps) but within the sampling site.

b. Collect the animals by hand or with the aid of handling equipment. Protective gear such as leather gloves, large forceps, dip nets, insect nets, snake hooks, noose and tongs will aid capture and facilitate safe handling (Figure 66).

c. Use dip nets to fish-out aquatic species such as frogs and tadpoles and reinforced insect nets to sweep for arboreal species.

d. Take extra precaution in handling monitor lizards and snakes, especially venomous snakes which must be handled using snake hooks with noose or snake tongs with rubberized clamps to minimize injury.

e. Use spades and trowels to dig out burrowing reptiles and handle them with tongs or forceps, or gloved hands.

f. Use rubber bands to immobilize and capture arboreal lizards through sling- stretching bands over a stick or fingers. Use a rubber band gun to collect voucher specimens only and not for individuals intended for release (McDairmid, 2012).

4. Indices of Presence

OBSERVE FOR PHYSICAL DISTURBANCES that may be used as indices of presence of amphibians and reptiles. Species recorded using these methods will add to the species list and not provide computational statistical data, but nonetheless provide invaluable ecological and behavioral notes. Locations are properly recorded with a GPS.

a. Examples include examination of eggs (i.e., leathery eggs of snakes, calcareous eggs of geckoes), burrows (i.e., snake dens) and nests (i.e., foam nests of tree frogs, turtle's mound-nests).

b. Remains of herpetofauna can be derived from collected snake skins (Figure 67 on page 77), skeletal remains (including turtle carapace or plastron), foot prints of lizards or furrows of turtles, and even identifiable dung of frugivorous monitor lizards.

5. Ethnobiological Survey

a. Conduct ethnobiological interviews with local residents or indigenous people, especially among knowledgeable locals with proven credibility due to their persistent encounters with wildlife in the sampling site.

b. Show pictorial guides for verification of conspicuous and easily identifiable species.

c. Note other important information such as local names, personal observations of feeding habits, habitat use and breeding information as well as indigenous knowledge on how wildlife are utilized in cultural practices or folklore, traditional medicine, as food, and other socio-economic uses.

d. Discriminate information given during the interview and include only those with verifiable descriptive information or other additional evidences (i.e. animal parts used as jewelry, kept as décor, shown as hunting trophies, or as written accounts and documented in personal photographs; Figure 67).

e. Note the names of the persons interviewed, date and time of interview and locality with GPS coordinates of the area.

6. Processing of Herpetofaunal Specimens

a. Upon capture, record the detailed descriptive and quantitative external body measurements (morphometrics in millimeters) and body weight (in grams) of amphibians and reptiles on the data sheets (see "Annex 6.10. Field data sheet for modified strip transect method for herpetofauna" on page 117).

b. Take the appropriate morphometric measurements depending on specimen size and basic taxon group (frog, lizard, snake, turtle, etc.), usually noted on the standard data sheet for cataloguing voucher specimens and illustrated in Figure 68 on page 78

c. The general morphometrics taken are SVL (snout-to-vent length); head length and width at tympanum or ear opening; tail length (except

Figure 67. Evidences of herpetofauna presence such as (from L-R) remains of skin shedding of snakes, laid foam nests of tree frogs, and from ethnobiological accounts derived from interview or use of wildlife by indigenous people as adornments

anurans); forelimb and hindlimb length (except snakes, dibamid skinks and caecilians); or, carapace length and width (only for turtles).

d. Obtain more detailed measurements for specific taxa, such as width of expanded pads on digits of arboreal frogs and tibia length for frogs and toads.

e. Note the shape and size of tympanic membrane, gular fold, digital scansors, scale counts for snakes, and head scalation in both lizards and snakes for species identification, often whilst following a taxonomic key or systematic field guide.

f. Species identification are based on available published references, journal descriptions and handbooks, such as a general guide to herpetofauna by Alcala (1986); pictorial guide for amphibians by Alcala and Brown (1998); handbooks for skinks and geckoes by Brown and Alcala (1978, 1980).

g. Release all captured and identified individuals at their site of capture, unless voucher specimens are deemed necessary for collection due to unknown identity, potential new taxa or represent a new locality record.

7. Photo-Documentation

a. Before release or preservation of voucher specimens, document a representative of each captured species or each captured specimen especially those with unknown identity, potential new taxa or those that represent a new locality record.

b. Take digital photographs in color, preferably using a macro-lens with ample lighting (close-up speed light) to vividly show color differences and details of morphological characters (skin folds, scansors, head scalation, etc.).

c. Properly label photographs with corresponding date and place of capture, and information on the name of collectors, collection site, and collection method (i.e., microhabitat, pit-fall trap).

d. The same should be done for other supporting bioacoustic data like digital audio records of frog calls, voucher specimens or tissue samples collected.

e. Apart from close-ups, photo-records of microhabitats, nests or burrows, eggs or tadpoles, and even whilst in their natural environment (arboreal lizards and snakes taken with zoom lens) are also important data and which should be stored in hard drives or in properly labeled SD cards.

8. Checklist of Herpetofauna

f. Make a species listing of amphibians and reptiles in your sampling site (see “Annex 6.11. Checklist of herpetofauna” on page 118) based on the

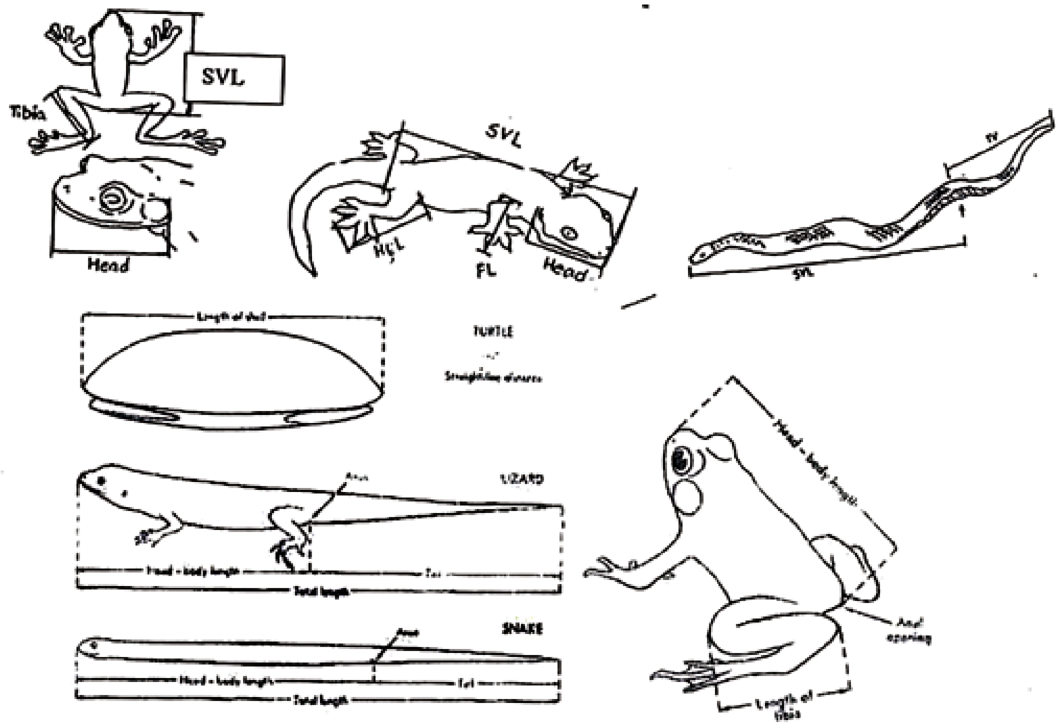


Figure 68. Basic morphometrics measured from amphibians and reptiles (adopted from Wildlife 101 Lab Manual, UP Los Baños; Gonzalez et al. 1995; and from Conant & Collins 1998).

modified strip transect count and live trapping methods, supplemented with opportunistic catching and ethnobiological interviews.

g. Digitally encode this preliminary checklist in tabular form with information on taxonomy (English name, local vernacular names, scientific name, family, order), endemism (residency status, noted as insular, regional or country endemic), population status and conservation status (based on current IUCN Red List categories, see IUCN Red List 2015 online) taken from several sources (published references or websites).

h. Remarks may include significant field notes from ethnobiological interviews, microhabitat use and breeding/feeding information.

> Data Analysis

1. Based on "Annex 6.11. Checklist of herpetofauna" on page 118, make a pie chart on distribution status, habitat association and population status of herpetofaunal species recorded, done separately for amphibians and reptiles, or done for specific taxon groups (frogs, lizards, snakes, turtles, etc.).

2. Plot a species accumulation curve using a line graph (ex. MS Excel or R platform) based on the cumulative number of species recorded against the number of sampling days.

3. Calculate density using the formula:

$$\text{Density} = \frac{\text{Total number of amphibians and reptiles recorded}}{\text{Total area of transect}}$$

4. The community diversity is mathematically calculated using the Shannon-Weiner Index

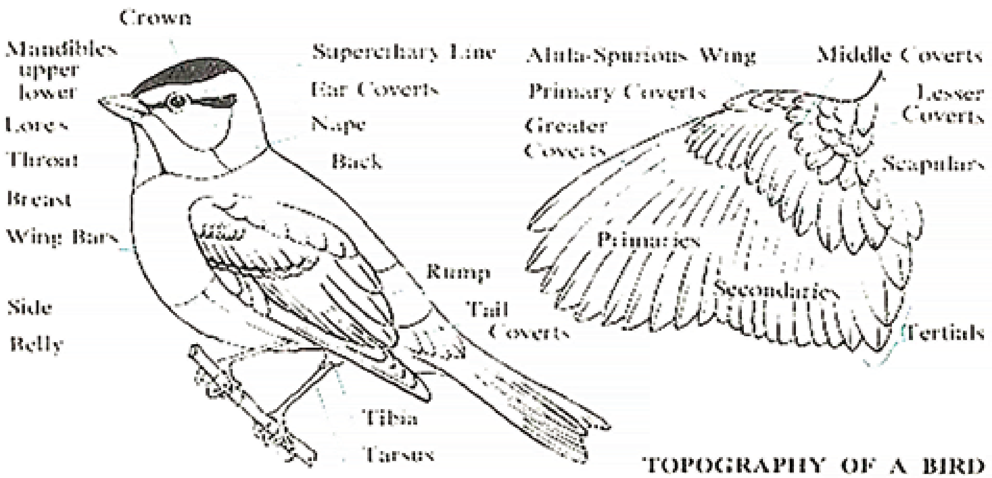


Figure 69. Avian topography showing key external parts and plumage features of a bird as exemplified by a sparrow (adopted from Reed 1928)

(Odum 1971). The value of the Shannon-Weiner index (H') is calculated using the formula:

$$H' = -\sum [n_i/N \ln n_i/N]$$

where n_i = number of individuals; N = total number of individuals.

5. The following diversity indices (parameters) are also used to determine the degree of species diversity:

i. Species Richness Index (S) - The number of species for a given area

ii. Simpson's Dominance Index (c) is computed using the formula:

$$c = \sum(n_i/N)^2$$

iii. Shannon's Evenness Index (e)

$$e = H' / H_{max},$$

$$\text{where: } H_{max} = \ln (S)$$

Birds

BIRDS CAN BE READILY STUDIED THROUGH practical means by the use of the naked eye. One can easily distinguish one species from the other based on their external characteristics (plumage patterns, color, shape of the tail, feet type and bill shape) and familiarity with external body parts through avian topography (Figure 69). This can be done with the aid of binoculars and spotting scopes. Majority of birds also produce distinct sounds and are often used to identify species.

MATERIALS AND EQUIPMENT

- Digital audio-recorder with unidirectional microphone
- Digital SLR Camera with macro lens, speed light and telephoto lens (200-400mm)
- SD cards and batteries for audio-recorder and camera
- Binoculars (preferably 7-10X magnification; 35-50 exit pupil)
- Compass
- Water-resistant field notebook
- Plastic envelopes

- 12-meter Mist nets with standard 35 mm mesh size
- Straw string/Nylon ropes
- Bolo or machete
- GPS receiver with batteries and SD card
- Transect tape measure (50–100 m)
- Resealable (zip-lock) plastic bags (big and small sizes)
- Thick cloth “bird” bags with resealable twine opening
- Thick leather gloves and disposable rubber gloves
- Dissecting set (fine tissue and bone scissors, scalpel with blade, forceps)
- Headlamps (with batteries and spare bulb, unless LED)
- Waterproof Torch or Spotlight (with batteries and spare bulb, unless LED)
- Flagging tapes/Ribbon markers
- Data Sheets (for transect counts and specimen catalogues)
- Plastic clip board, hard bound clip-binder and paper puncher for data sheets
- Indelible pen and Pencil (eraser/sharpener) and specimen tags
- Steel tape measure, steel foot ruler or “wing” ruler (1 foot and 1 meter)
- Digital or Dial Caliper and “pesola” spring scales (100g, 300g, 500g, 1kg)
- 95% ethyl alcohol (3-5 liters) and kitchen/ bathroom tissue rolls
- Thick rubber boots and waterproof overalls (for swamplands)
- Printed taxonomic keys, photo-guides and field handbooks especially the Field Guide to the Birds of the Philippines (Kennedy et al. 2000)

> Methods

1. Line Transect Count

THE PRIMARY METHOD FOR BIRD SURVEY IS the line transect count. Line transect methods can be carried as simple counts to more detailed recording of bird species, behaviour, number of individuals and elements for perpendicular distance data. Transect counts can be divided into three basic methods, depending on the purpose and need for more accurate estimation of bird populations, especially those species designated as key biological or ecological indicators. Transects may be laid out as random or non-random scattered strips across the protected area, or as pre-selected established transect routes (“Coverage of Survey Plots” on page 70).

a. Simple Line Transect Count

i. Establish a 2-km transect route traversing across eight central points marked every 250 m along a relatively straight line at relatively constant terrain, habitat type and elevation (Figure 70 on page 81). Record GPS coordinates of each central point.

ii. Traverse this route and use the data sheet provided in ”Annex 6.12. Field data sheet for simple line transect count for birds” on page 119. to record the bird species and number of individuals seen or heard within 50m either side.

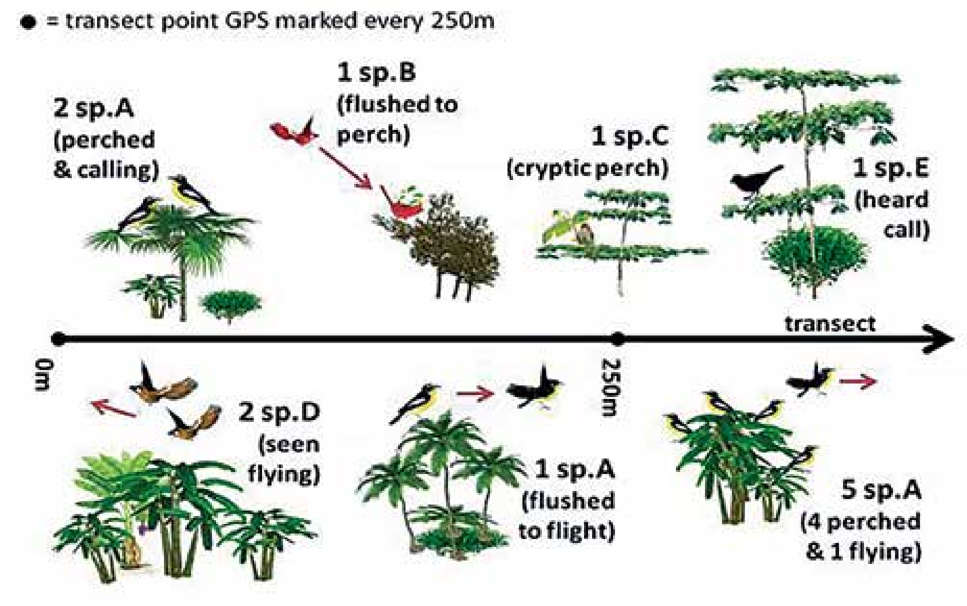


Figure 70. Diagram for simple line transect count used for recording richness and abundance of birds within a series of scattered 2-km transect routes

iii. Follow a travel period of about 1 hour per km or 2 hours per 2-km transect.

iv. Use binoculars and field guides (Kennedy et al. 2000, Fisher & Hicks 2008) to aid species identification.

v. If available, use a Digital SLR camera with telephoto lens for photo- documentation and a Digital audio-recorder for recording bird calls.

vi. Species not validated on site can be confirmed based on recordings of calls, compared with the on-line database, Xeno Canto Asia (www.xento-canto.org) and photographs compared with on-line databases, namely the Internet Bird Collection for photos/videos(www.ibc.lynxeds.com), Oriental Bird Club (www.orientalbirdimages.org) and the Wild Bird Club of the Philippines (www.birdwatch.ph).

vii. Record the type of encounter in terms of activity (if individual was perched or flying), vertical stratum of encounter (canopy, mid-canopy, and ground), and type of contact (heard, seen or both) on the transect sheet (see "Annex 6.12. Field data sheet for simple line transect count for birds" on page 119).

viii. More observation time may be given to mixed feeding flocks to ascertain identities of individuals. Each transect route is passed through twice, early morning and late afternoon usually coinciding with the foraging activity of birds. Data arising from these counts can used for estimating indices for diversity.

b. Perpendicular Distance Method

ADDITIONAL DATA IS REQUIRED FOR estimating population density of birds at the study site, through distance sampling, wherein the perpendicular distance of each encounter from the transect is recorded alongside number of individuals and species.

i. Establish a 2-km transect route traversing across eight central points marked every 250 m (Figure 71 on page 82). Record the GPS coordinates of each central point.

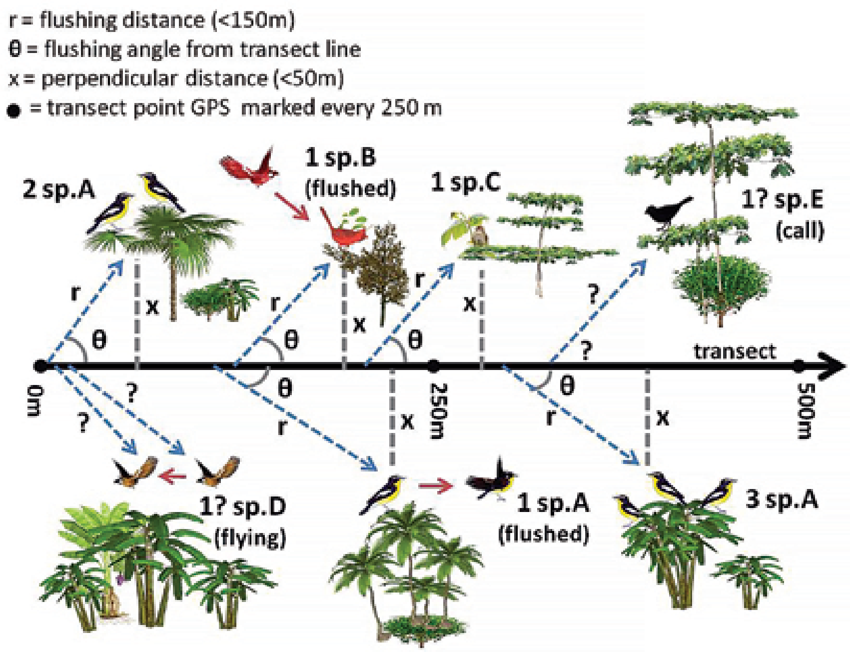


Figure 71. Diagram for perpendicular distance transect count used for recording richness and calculating density of birds within scattered 2-km transect routes.

ii. Traverse this route and use the data sheet provided in "Annex 6.13. Field data sheet for perpendicular distance method for birds" on page 120 to record bird

iii. Using a compass, estimate and record the flushing angle of each sighting whenever possible.

iv. Continue walking towards the next point or until the end of transect line, allowing brief stops to ensure proper counts and identification and for estimation of flushing distance and angle.

v. To minimize bias, birds in constant flight during the observation period are not recorded due to lack of fixed flushing distance and angle, and birds heard but not seen are not recorded due lack of known flushing distance and angle.

vi. Any bird recorded during the distance sampling period but not qualified (flying or heard) are still recorded for inclusion in the checklist, but not included in the analysis for population density.

vii. Counts can be done on all bird encounters or limited only to selected species of interests, especially potential key indicator species.

viii. Counts are also limited within 50m on either side of transect.

c. Modified Variable Circular Plot Method

THE PERPENDICULAR DISTANCE IS THE commonly used method for distance sampling. However, in study sites where transect lines are not available, then counts of birds can be done within fixed circular plots. In circular plot counts, the flushing or radial distance (r), the estimated distance (in meters) between the observer at the central point of a circular plot and the bird observed at perch or point prior to being flushed into flight, or from a perch where a flying bird alighted is equivalent to the value of "x", used for distance sampling, and is usually <50 m. This method allows the observer to properly observe, identify and record the birds seen within each plot unhampered by challenges of observation when walking in rough terrain or

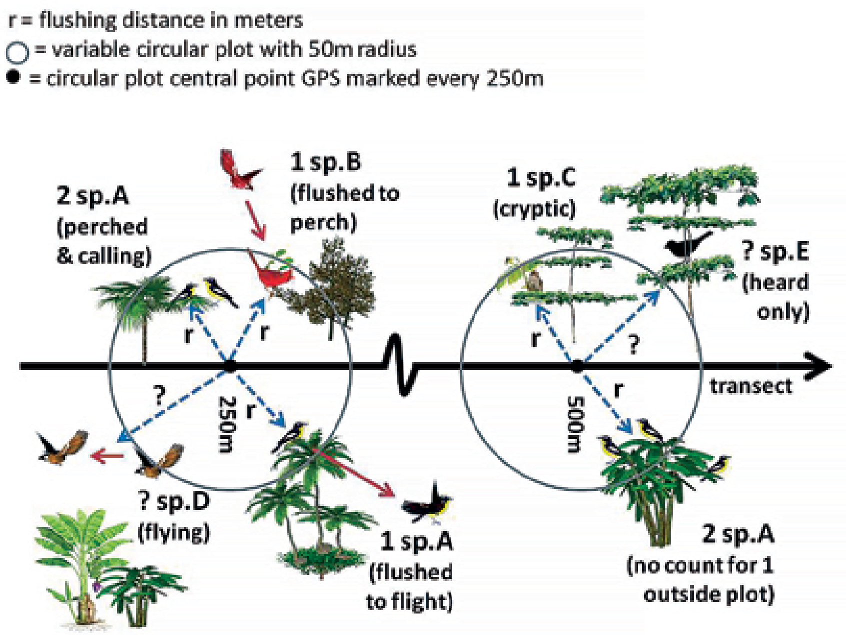


Figure 72. Diagram for modified variable circular plot count used for recording richness and calculating density of birds within scattered 2-km transect routes

thick vegetation. Here, we combine the variable circular plot method with line transect.

i. Establish a 2-km transect route traversing across eight central points marked every 250 m ("Coverage of Survey Plots" on page 70). Record the GPS coordinates of each central point.

ii. Traverse this route and stop for a period of 10 minutes at each point.

iii. Use the data sheet provided in "Annex 6.14 Field data sheet for modified variable circular plot method for birds" on page 121 to record the bird species, number of individuals seen and the radial distance of each sighting within a 50-m radius from each point (Figure 72).

iv. Using a compass, estimate and record the flushing direction of each sighting whenever possible.

v. To minimize bias, birds in constant flight during the observation period are not recorded due to lack of fixed flushing distance and angle, and birds heard but not seen are not recorded due lack of known flushing distance and angle.

vi. Any bird recorded during the distance sampling period but not qualified (flying or heard) are still recorded for inclusion in the checklist, but not included in the analysis for population density.

vii. After 10 minutes, continue walking towards the next point.

viii. Counts can be done on every point (set every 250 m) or every other central point along the 2-km transect line, which can extend further.

ix. Alternatively, individual plots can be established in special sites not delineated by transect points such as small patches of forest habitat, mountain peaks and small islets, where transect routes are non-existent.

d. Distance Sampling

THE VALUE OF "X" IS CALCULATED THROUGH

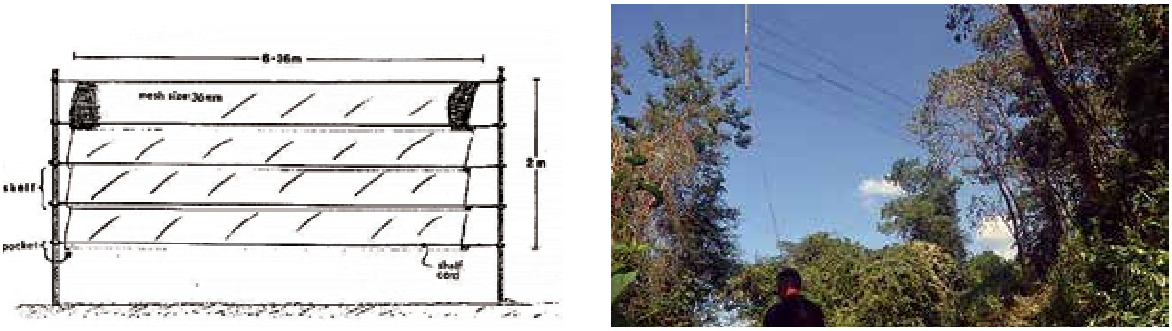


Figure 73. Standard mist net deployed on the ground up to catch understorey birds or set up across gaps in the emergent trees to catch canopy birds (falcoproject.edu)

the formula x=r*sinθ. Values of "x" and n=number of individuals of species are used to calculate for density (D) using the open access software program DISTANCE (www.distancesampling. org) truncated through a model-based analysis using the Akaike Information Criterion (AIC).

i. Depending on the area of the sampling site, establish several transect routes (10-30) across the survey period. A total of eight circular points per 2-km transect multiplied by the number of transect counts, amounts to 80-240 point count datasets per study site.

ii. Ideally, transects should be traversed only once per sampling period, but given the limitation of area, it can be traversed more than once but at different sampling days.

iii. Both the perpendicular distance method and variable circular plot method are used in distance sampling for a more accurate estimation of bird populations, especially those species designated as key biological or ecological indicators that requires periodic monitoring.

2. Setting of Mist Nets

a. To record cryptic, less vocal and nocturnal species of birds, 12-meter long mist nets are set along possible flyways and feeding trees. Mist nets are nylon nets with 35mm sized mesh, set in 3-4 rungs with loose pockets to allow capture.

b. Use a pulley system in the forest canopy or deploy the nets near the ground using poles to catch understory birds (Figure 73).

c. Set nets individually or in a series depending on the sampling site.

d. Although trimming of branches of trees reaching the nets may be done, avoid unnecessary clearing of vegetation in the area.

e. Check the mist nets for periodically for possible netted individuals, ideally every hour from 0530 to 2200 h.

f. Nets are opened for 24 hours for at least three days and two nights.

g. Carefully retrieve the birds and place them individually in cloth bags to minimize stress and injury.

h. Hang the cloth bags in cool shaded area of the basecamp prior to processing

3. Indices of Presence

a. Observe for physical disturbances that may be used as evidence for the presence of birds such as remnants of feathers, skeletal remains, eggs and egg shells, nests, footprints on soft mud/

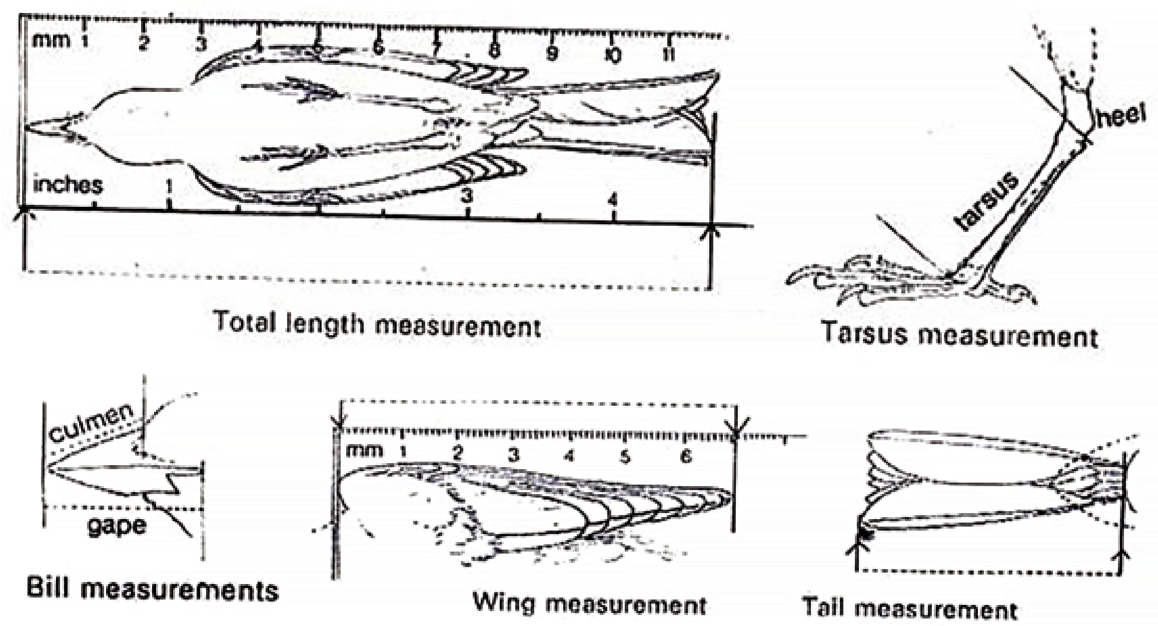


Figure 74. Standard biometric measurements for birds (adopted from the Field Guide to Birds of Southeast Asia, by King et al. 1975)

sand, feeding forays (thrush's anvil with smashed snails), owl pellets and cavity nest middens.

b. Record the locality and GPS coordinates of each evidence.

c. Species recorded using this method will add to the species list but not computational statistical data. Nonetheless, it provides invaluable ecological and behavioral notes.

4. Ethnobiological Survey

a. Conduct ethnobiological interviews with local residents or indigenous people, especially among knowledgeable locals with proven credibility due to their persistent encounters with wildlife in the sampling site.

b. Show pictorial guides for verification of conspicuous and easily identifiable species (e.g. raptors, hornbills, pigeons, parrots, etc.).

c. Note other important information such as local names, personal observations of feeding habits, habitat use and breeding information provided by these local residents, as well as indigenous knowledge on how wildlife are utilized in cultural practices or folklore, traditional medicine and as food and raw materials (socio- economic uses).

d. Discriminate information given during the interview and include only those with verifiable descriptive information or other additional evidences (i.e. animal parts used as jewelry, kept as decor, shown as hunting trophies, or as written accounts and documented in personal photographs).

e. Note the names of the persons interviewed, date and time of interview and locality with GPS coordinates of the area.

5. Processing of Bird Specimens

a. Take standard biometric measurements (Figure 74). These include total length (TL), tail-vent length (TV), body weight (WT), wing cord

(WC), bill or culmen (B) length, width of gape (G), and tarsus length (T).

b. Record measurements in the data sheet shown in "Annex 6.15 Field data sheet for bird mistnetting" on page 122.

c. Photograph representatives of species captured and then release at site of capture.

d. Prior to release, additional data can be derived from the captured birds, including blood sampling (for disease screening and DNA studies), ectoparasite collection, evaluation for molting, fat deposition and breeding condition.

e. Tissue samples can be stored without freezing in >95% ethyl alcohol or best kept in Nunc tubes with isotonic solution (i.e., EDTA-based Queen's solution) and kept frozen within a field-based cryogenic tank with liquid nitrogen.

f. Parasites collected can also be storage in these Nunc tubes with ethyl alcohol, properly labelled and documented (GPS coordinates, host species, date, locality, photos, etc.).

6. Photo-Documentation

a. Prior to release or preservation of voucher specimens, be sure to properly document a representative of each captured species or each captured specimen especially those with unknown identity, potential new taxa or those that represent a new locality record.

b. Take digital photographs in color, preferably using a macro-lens with ample lighting (close-up speed light) to vividly show color differences and details of morphological characters and soft parts (skin iris, and tarsus color, etc.).

c. Properly label photographs with corresponding date and place of capture, and information on collectors and collection site/method (i.e., mist nets).

d. The same should be done for other supporting bioacoustic data like digital audio records of bird calls, voucher specimens or tissue samples.

e. Apart from close-ups, photographs of nests, eggs and even photo-records taken whilst in natural environment (with zoom lens) are also important data, which should be stored in hard drives or in properly labeled SD cards.

7. Checklist of Avifauna

f. Make a species listing of birds in your sampling site (see "Annex 6.16 Checklist of avifauna" on page 123) based on the modified line transect counts and mist-netting methods, supplemented with evidence of presence (nest, feathers, etc.) and ethnobiological interviews.

g. Digitally encode this preliminary checklist in tabular form with information on taxonomy (English name, local vernacular names, scientific name, family, order), endemism (residency status, noted as insular, regional or country endemic), population status and conservation status (based on current IUCN Red List categories, see IUCN Red List 2015 online) taken from several sources (published references or websites).

h. Remarks may include significant field notes from ethnobiological interviews, microhabitat use and breeding/feeding information.

> Data Analysis

a. Based on "Annex 6.16 Checklist of avifauna" on page 123, make a pie chart on habitat association (vertical stratification and/or feeding guilds), species composition (taxon groups/bird families), distribution or residency status and population status of avifaunal species recorded.

b. Adequacy of sampling can be based on sampling effort by plotting a species effort curve using MS Excel or R platform, with the cumulative number of species recorded plotted against the number of sampling days.

c. Netting success, or the proportion/percentage of captures per species or for all species, can be calculated from the total net-days accumulated using mist-netting methods per sampling site.

d. Each mist-net (regardless of size or length) kept open for a day, during daylight at about 12-14 hours (or kept open the entire day and night) is counted as one net-day.

e. To compute for netting success by species, the total number of bird species is divided by the total number of net-days, multiplied by 100.

f. To compute for netting success by captures regardless of species, the total number of bird captures is divided by the total number of net-days, multiplied by 100.

g. For species with high capture rates, this can also be calculated from total number of individuals netted per species divided by the total net-days, multiplied by 100.

h. Diversity and relative abundance can be calculated from the number of individuals sampled per species using the modified line transect method (see transect data analysis, ("Annex 6.17 Data sheet for computation of species diversity indices" on page 124) and estimated population density using distance sampling (see preceding section).

i. Transect Data Analysis

Bird community diversity indices are calculated from a formula that takes into account both species richness and the relative abundance of each species in the community. Relative abundance refers to the number of individuals of a given species divided by the total number of all species encountered (see "Annex 6.17 Data sheet for computation of species diversity indices" on page 124). The community diversity is calculated using the Shannon-Weiner Index (H') using the formula:

$$H' = -\sum [n_i/N \ln n_i/N]$$

where: n_i = number of individuals; N = total number of individuals

The following diversity indices (parameters) are also used to determine the degree of species diversity:

i. Species Richness Index (S) – The number of species for a given area

ii. Simpson's Dominance Index (c) is computed using the formula: $c = \sum(n_i/N)^2$

iii. Shannon's Evenness Index (e) $e = H' / H_{max}$

iv. where: $H_{max} = \ln (S)$

Mammals

THE SIZE AND HABIT OF MAMMALS DICTATE the methods and approaches that are used for assessment and monitoring. Mammals can be categorized as small, medium and large. Small non-volant mammals generally refer to those with adult weights of less than 1 kg which include most rodents and shrews. They can be easily caught in commercially available live traps. Most volant mammals (bats) are also small and are commonly surveyed by the use of mist nets. Medium-sized mammals are those with adult weights of up to 20 kg and include civets, cloud rats, leopard cats, etc., or those that require larger traps. Large mammals include the more conspicuous pigs, deer, macaques, etc. Medium to large mammals are rarely trapped during surveys but their presence can be detected through indices such as foot prints, scats, or through ethnobiological interviews

MATERIALS AND EQUIPMENT

- Water-resistant field notebook
- Plastic envelopes
- 12-meter Mist nets with standard 35 mm mesh size, and crochet hook

- Poles and Straw string/Nylon ropes
- Bolo or machete
- GPS receiver with batteries and SD card
- Resealable (zip-lock) plastic bags and safety pins
- Thick cloth “bird” bags with resealable twine opening
- Thick leather gloves and disposable rubber gloves
- Dissecting set (fine tissue and bone scissors, scalpel with blade, forceps)
- Headlamps (with batteries and spare bulb, unless LED)
- Waterproof torch or spotlight (with batteries and spare bulb, unless LED)
- 100 cage traps (large and medium)
- Coconut-peanut butter bait and/or live earthworms
- Flagging tapes/Ribbon markers
- Permanent marker pens
- Data sheets (for transect counts and specimen catalogues)
- Plastic clip board, hard bound clip-binder and paper puncher for data sheets
- Indelible pen and Pencil (eraser/sharpener) and specimen tags
- Digital or dial caliper and “pesola” spring scales
- Digital audio-recorder with unidirectional microphone and bat detector
- Digital SLR Camera with macro lens, speed light and telephoto lens (200-400mm)
- SD cards and batteries for audio-recorder and camera
- 95% ethyl alcohol (3-5 liters) and kitchen/ bathroom tissue rolls
- Printed taxonomic keys, photo-guides and field handbooks especially the Key to Bats of the Philippines (Ingle et al. 1998)

> Methods

1. Volant Mammals (Bats)

A COMBINATION OF CAPTURE METHODS— harp traps, a tunnel trap, and mist nets— have proven to be effective in successfully recording the bat assemblage of an area (Sedlock 2011). Fruit bats are nocturnal species and can only be identified upon close examination. Thus, they are captured using mist nets. During biodiversity assessments, the usual practice is to use the same mist nets used for catching birds. They are usually left open at least until 2200 h or until the next morning but are closed during rainy weather conditions.

Most insectivorous bats are able to detect and evade mist nets due to their ability to echolocate. However, some may still be caught during net watching. The use of a harp trap and tunnel trap (Sedlock 2001) is necessary to record insect bat assemblage.

a. Mist-Netting

Two groups of bats, the fruit-eating (frugivorous) and insect-eating (in-sectivorous) bats, may be recorded through mist nets (Figure 75 on page 89).

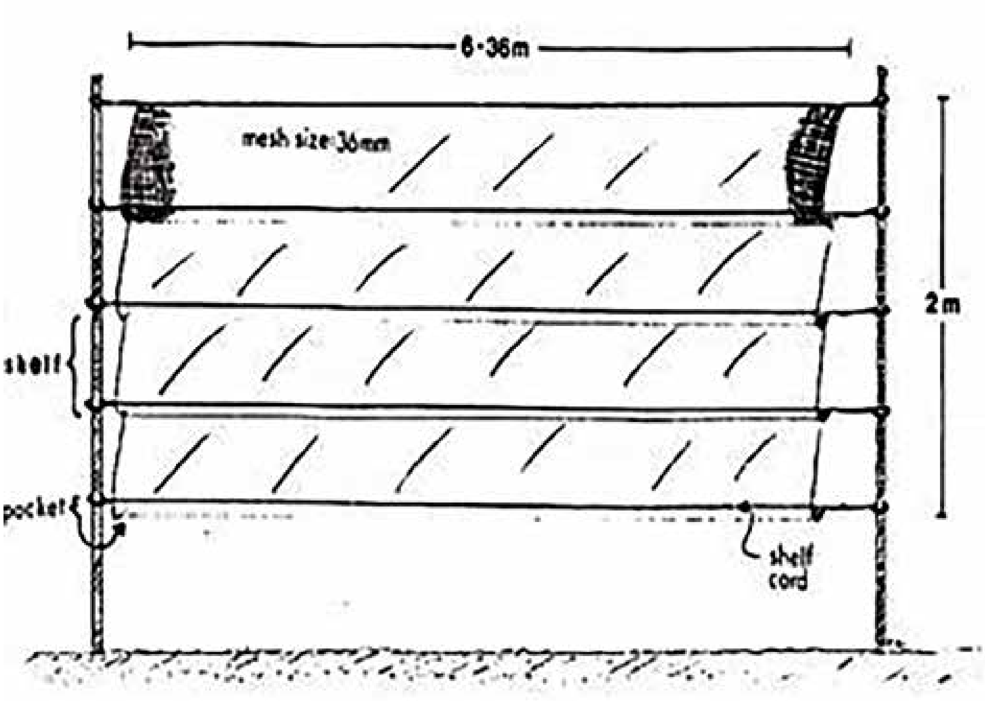


Figure 75. Mist-netting used for capturing bats

i. Follow mist net set-up instructions ("Setting of Mist Nets" on page 84).

ii. Conduct net-watching during the activity peak of insectivorous bats (about 1730-1930 h).

iii. As you are positioned on the end of a net, regularly monitor for netted insectivorous bats by flashing light along the nets.

iv. Quickly remove netted bats before they can chew the nets and escape.

v. From 1930-2200 h, check the nets every hour. Regular checking of netted bats prevents them from being too entangled and prevents the net from being chewed upon and broken. This also wards off potential predators.

vi. It is recommended that field workers wear gloves when removing netted bats. You may use a crochet hook to disentangle parts of the net that have clung tightly onto the bat.

vii. Place the captured bats individually in cloth bags to minimize stress. Nets may or may not be left open thereafter. If so, check the nets at dawn.

b. Processing of Bat Specimens

i. Identify species based on the field guide by Ingle and Heaney (1992).

ii. Using the data sheet in "Annex 6.18 Field data sheet for bat mistnetting" on page 125, record the species, number of individuals captured, sex, and approximate age (adult, sub-adult or juvenile as determined by examining digit joint ossification of bat wings).

iii. Record standard biometric measurements (Figure 76 on page 90) such as head-to- body length (HBL), tail length (TL), ear length (EL), forearm length (FA), hindfoot length (HF) and body weight.

iv. Release all individuals captured.

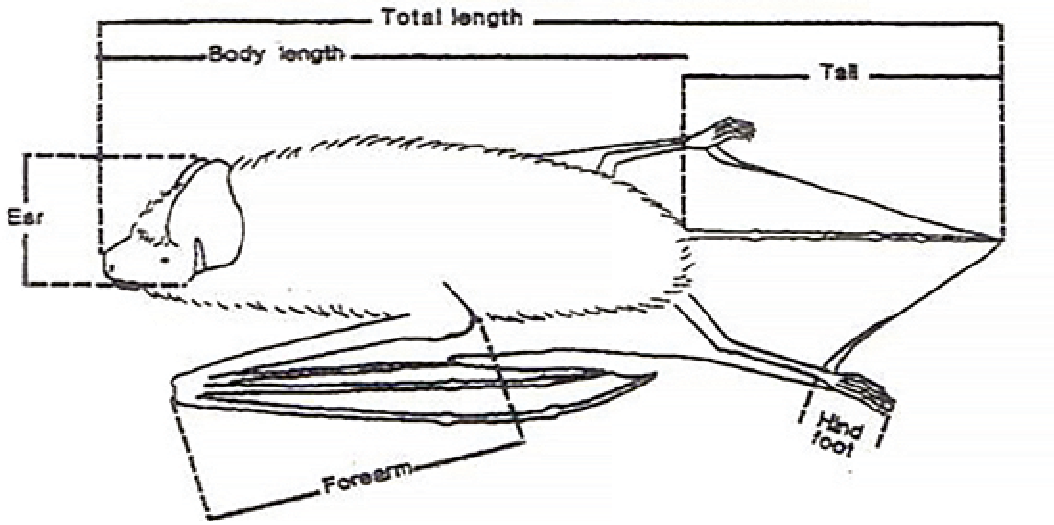


Figure 76. Standard biometric measurements taken for bats (adopted from Ingle et al. 1998).

Figure 77. Some traps used to capture small non-volant mammals, including steel mesh cage traps, Sherman's foldable aluminum traps (both live traps) and the lethal Victor snap trap.

2. Small Non-volant Mammals

a. Live Trapping

MOST SMALL NON-VOLANT MAMMALS ARE recorded through a combination of snap traps, cage traps and Sherman live traps (Heaney et al. 1989). Pitfall traps Fossorial and arboreal species have been recorded and thus ground and above-ground trapping are done.

i. To prepare bait, thinly slice the coconut meat, fry until brown and coat generously with peanut butter.

ii. If used, live earthworms can be attached onto small safety pins.

iii. For trapping on the ground surface, bait the traps (Figure 77) with coconut or earthworm and position them 5 to 10 m apart under root tangles, in front of burrow entrances, along runways, and beside or on top of fallen logs.

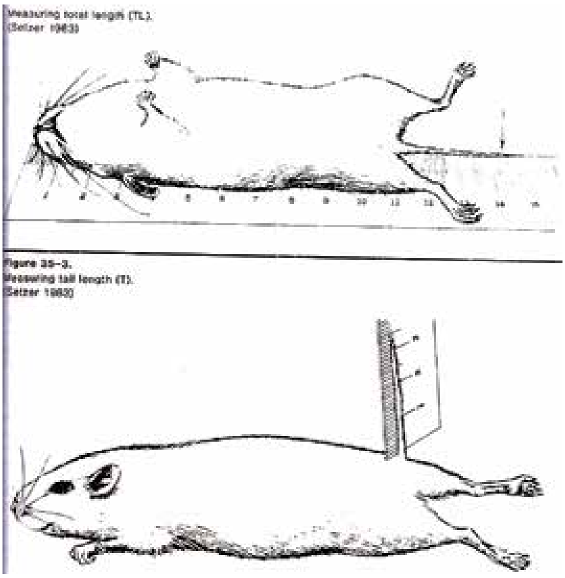


Figure 78. Standard biometric measurements taken for small non-volant mammals (adopted from a manual on mammalogy, DeBlase et al. 1990).

iv. For aboveground trapping, bait the traps with coconut and tie them onto horizontal branches of trees.

v. In areas of dense vegetation, it is easy to lose track of traps. To easily locate them, tie numbered flagging tapes above or near where traps are placed.

vi. Retrieve captures early in the morning (c. a. 0700 h) and replace bait in the late afternoon (c.a. 1700 h). Maintain all trap lines for 3 days.

vii. Plot a species effort curve for each sampling locality. This is the best indicator of the completeness of sampling for species richness of small mammals in a PA where pre-existing information is limited or absent.

b. Processing of Small Non-Volant Mammal Specimens

i. Identify species based on references such as Heaney (1998).

ii. Using the data sheet in "Annex 6.19 Field data sheet for small non-volant mammal trapping" on page 126, record the species, number of individuals captured, sex, and approximate age (adult, sub-adult or juvenile as determined by examining external genitalia).

iii. Record standard biometric measurements (Figure 78) such as head-to- body length (HBL), tail length (TL), ear length (EL), hindfoot length (HF) and body weight.

iv. Release all individuals captured except for commensal or introduced rats which are collected.

3. Medium to Large Mammals

a. Conduct ethnobiological interviews with local residents or indigenous people, especially among knowledgeable locals with proven credibility due to their persistent encounters with wildlife in the sampling site.

b. Show pictorial guides for verification of conspicuous and easily identifiable species (e.g. cloud rats, civets, wild pigs, deer, macaques etc.).

c. Note other important information such as local names, personal observations of feeding habits, habitat use and breeding information provided by these local residents, as well as indigenous knowledge on how wildlife are utilized in cultural practices or folklore, traditional medicine and as food and raw materials (socio- economic uses).

d. Discriminate information given during the interview and include only those with verifiable descriptive information or other additional evidences (i.e. animal parts used as jewelry, kept as decor, shown as hunting trophies, or as written accounts and documented in personal photographs).

e. Note the names of the persons interviewed, date and time of interview and locality with GPS coordinates of the area.

f. Presence based on indices (e.g. foot prints, wallowing area, scats, bone remains, etc.) can also be noted and considered as evidences of presence.

4. Photo-Documentation

a. Prior to release or preservation of voucher specimens, be sure to properly document a representative of each captured species or each captured specimen especially those with unknown identity, potential new taxa or those that represent a new locality record.

b. Take digital photographs in color, preferably using a macro-lens with ample lighting (close-up speed light) to vividly show color differences and details of morphological characters (fur color and pattern, hindfoot, etc.).

c. Properly label photographs with corresponding date and place of capture, and information on collectors and collection site/method (i.e., mist nets).

d. The same should be done for other supporting bioacoustic data like digital audio records of bird calls, voucher specimens or tissue samples.

e. Apart from close-ups, take photo-records of site of capture or burrows which are also important data and which should be stored in hard drives or in properly labeled SD cards.

5. Checklist of Mammals

a. Make a species listing of mammals in your sampling site (see "Annex 6.20 Checklist of mammalian fauna" on page 127) based on mist-netting, trapping and ethnobiological interview.

b. Digitally encode this preliminary checklist in tabular form with information on taxonomy (English name, local vernacular names, scientific name, family, order), endemism (residency status, noted as insular, regional or country endemic), population status and conservation status (based on current IUCN Red List categories, see IUCN Red List 2015 online) taken from several sources (published references or websites).

c. Remarks may include significant field notes from ethnobiological interviews and breeding/ feeding information.

> Data Analysis

1. Create a pie chart on habitat association (vertical stratification and/or feeding strategy), species composition (taxa/mammalian families), distribution or residency status and population status of mammalian species recorded based on"Annex 6.20 Checklist of mammalian fauna" on page 127.

2. Plot a species accumulation curve using MS Excel or R platform, with the cumulative number of species recorded plotted against the number of sampling days.

3. Netting success, or the proportion/percentage of captures per species or for all species, can be calculated from the total net-days accumulated using mist-netting methods per sampling site.

   i. Each mist-net (regardless of size or length) kept open each night, for about 12- 14 hours is counted as one net-night.

   ii. To compute for netting success by species, divide the total number of bat species by the total number of net-nights, multiplied by 100.

   iii. To compute for netting success by captures regardless of species, divide the total number of bat captures by the total number of net-nights, multiplied by 100.

   iv. For species with high capture rates, this can also be calculated from total number of individuals netted per species divided by the total net-nights, multiplied by 100.

5. Trapping success, or the proportion (or percentage) of captures per species or for all species, can be calculated from the total trap-days accumulated using various trapping methods per sampling site.

6. Each trap (regardless of size or type) kept open each night, for about 12-14 hours is counted as one trap-night.

7. To compute for trapping success by species, divide the total number of small mammal species by the total number of trap-nights, multiplied by 100.

8. To compute for trapping success by captures regardless of species, divide the total number of captures by the total number of trap-nights, multiplied by 100.

9. For species with high capture rates, this can also be calculated from total number of individuals caught per species divided by the total trap-nights, multiplied by 100.

4. Integrated Assessment and Database Management

4.1 Intergrated Assessment

A PRINCIPAL COMPONENT ANALYSIS CAN BE used to determine the correlation of the different components of the ecosystem. We can easily associate the dominant species with the forest formation if the PA was able to cover different forest formations in their assessment.

- If the PA decides to rehabilitate a degraded limestone forest, the dominant species found in the assessment, in this kind of forest should be used as planting materials.
- In conducting an assisted natural forest regeneration in an under-stocked forest, seedlings from other areas of the same formation can be used to augment the natural regenerants in the area.
- If a critically endangered species was found to exclusively thrive in a particular forest formation, the conservation strategies should focus on the protection of that forest formation.
- Data on soil analysis from each quadrat can be used to determine the soil-species interaction.
- Knowledge on the interactions of species with the physical parameters can guide the stakeholders to better PA management.
- Principal component analysis is a function available in the same software (PAST, MVSP, BioPro, Diversity, etc.) that can be used in the computation of biodiversity index.
- Assessment and monitoring data from the different PA's can be pooled and analyzed at different levesl (by forest formation, by PA, by province, by region, national), to

have a better understanding of the different terrestrial ecosystems in the country.

Considering the limitations of the PAs to cover a larger assessment and monitoring area, a network of PA's must be established to facilitate information exchange by developing a user-friendly database to share information from different assessment and monitoring sites across the country.

FAUNAL SPECIES INDICATORS

AMONG FAUNAL SPECIES, NOTE THE threatened endemic, bioindicator, foundation, keystone, and flagship species.

1. Threatened Endemic: ???

2. Bioindicator Species: Being sensitive to physical changes, can give an early warning that a habitat is suffering.

3. Foundation Species: Those that affect the physical environment by creating or maintaining a habitat that supports other species, such as how woodpeckers create tree holes.

4. Keystone Species: Predators, herbivores, and pollinators that play a unique and crucial role in the way an ecosystem functions by maintaining the structure and integrity of the community.

5. Flagship Species: Popular, charismatic species used as the focus of conservation campaigns to capture the imagination of the public and stimulate conservation awareness and action, such as the Philippine eagle, the national bird of the Philippines.

4.2 Database Management

DATABASE IS AN INTEGRATED SET OF DATA of a particular object, and in GIS, this is known as Geodatabase, which is simply a collection of geographic datasets with a comprehensive information model that can represent and manage geographic information. These are usually implemented as tables containing different feature classes, datasets, and attributes.

Advanced database management system (DBMS) is a software application that is designed to organize efficient and effective storage and access of data.

- It can include rules for managing spatial integrity and tools in addressing numerous spatial relationships.
- Three main types of DMBS in GIS:

i. Relational (RDMBS)

ii. Object (ODMBS)

iii. Object-relational (ORDMBS)

Geodatabase design starts with the identification of thematic layers that make up the system or landscape. This is then followed by describing each layer in terms of their visual representations, expected use, data sources and resolution levels.

In protected areas, DMBS can be implemented through a grid system at varying levels of management units.

- Each grid can be designed depending on the kind of information that needs to be developed over time.
- A more detailed scheme may be used for the permanent biodiversity monitoring areas since these would entail more frequent measurements and require more thorough information to be stored.

IN A NUTSHELL

THE GEODATABASE SHOULD BE designed with utmost consideration on security, reliability, integrity, high performance and provide concurrency to users.

THE ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI) STEPS FOR A GENERAL GIS DATABASE DESIGN PROCESS

1. Identify the information products that will be created and managed with GIS.

2. Identify the key data themes based on information requirements.

3. Specify the scale ranges and the spatial representations of each data theme at each scale.

4. Decompose each representation into one or more geographic datasets.

5. Define the tabular database structure and behavior for descriptive attributes.

6. Define the spatial behavior, spatial relationships and integrity rules for the datasets.

7. Propose a geodatabase design.

8. Design editing workflows and map display properties.

9. Assign responsibilities for building and maintaining each data layer.

10. Build a working prototype. Review and refine the design.

11. Document the database design.

> Datasets Defined

GEOGRAPHIC Datasets: Can be represented as feature classes or as raster-base datasets.

FEATURE Class: A single collection of homogenous themes such as land cover types, road networks, sampling locations, transects, stream networks, and the like.

RASTER Datasets: Used to represent continuous surfaces such as elevation, slope, aspect, and hillshade. Also used to handle remotely-sensed imagery, aerial photography, and other gridded datasets.

While these datasets can be used independently, it is important that data themes are collected in line with the other information layers so that fundamental spatial behavior and relationships are maintained and consistent between related GIS themes.

For example: Collection of hydrologic information about watersheds and river basins should be in agreement with the drainage network. This means that streams and rivers should fit within the watershed as well as to the surface terrain of the area.

Once the system is developed, data access and retrieval is relatively simple in GIS. This approach normally employs the structured or Standard Query Language (SQL) to create, modify, and query tables and data elements using different relational functions and operators. This allows both spatial and non-spatial information stored in a geodatabase to be easily accessed, and it can also be utilized to integrate information from other geodatabases.

5. Biodiversity Monitoring

5.1 Physical Monitoring

5.1.1 Land Use and Land Cover Change Analysis Using ArcGIS™

1. Open **ArcMap**. Add the **MMFR2003** and **MMFR2010** shapefiles. Open the **Attribute Table** of each shapefile to determine the different land cover types in Mount Makiling Forest Reserve (MMFR) and its surrounding environment.

2. Go to **Geoprocessing** menu and select **Union**, and the Union window will appear.

3. From this window, add **MMFR2003** and **MMFR2010** from the **Input Features**, and set the **Output Feature Class** to **MMFR_Union**. Click **OK**. The Union function computes a geometric union of the input features. All features and their attributes will be written to the output feature class.

4. Open the **Attribute Table**. These data provide an idea of the changes made during the two time periods. These information are essential as well in identifying spatial changes in the area. Close the attribute table.

5. To demonstrate, go to the **Selection** menu and click on **Select By Attributes**. For instance, you want to determine areas that were formerly forests in 2003 but in 2010 have become grassland.

6. From the **Select By Attributes**, select the **MMFR_Union** from the **Layer**. First double click on **"LC2003"**, then **"="**, click **Get Unique Values**. Double click on **"Forest"** then click on **AND** then select **"LC2010" = "Grassland"**. This should be the SQL command in the box - **"LC2003" = 'Forest' AND "LC2010" = 'Grassland'**. Click **OK**. The highlighted portion on the map shows the areas that are converted from forest into grassland areas.

7. To remove the selected areas, just click on the **Clear Selected Features**.

8. Now try multiple changes from one land cover to other land cover types. For example, identify annual crop and grassland areas in 2003 that were converted into forest in 2010.

9. Again go to **Geoprocessing>Select By Attributes**. Input this SQL commands to generate the scenario - **("LC2003" = 'Annual Crop' OR "LC2003" = 'Grassland') AND "LC2010" = 'Forest'** then click **OK**.

10. To get a summary of the changes made from the two periods, go to **ArcToolbox>Analysis Tools>Statistics>Tabulate Intersection**. In the **Input Zone Features** choose **MMFR2003** and the **Zone Fields** to **LC2003**. In the **Input Class Features** select **MMFR2010** and **Class Fields** to **LC2010**. Lastly in the **Output Units**, select **Hectares** then click **OK**. This creates a table that summarizes the areas and percentages of changes that happened from one time period to another. You can also export the file to Excel and generate bar or line graphs.

5.1.2 Establishment of a Permanent Biodiversity Monitoring Area ArcGIS™

1. Take the coordinates (e.g. latitude and longitude) of the tying point or corner monument of the permanent biodiversity monitoring area using a GPS unit, preferably a survey-grade equipment or device.

2. The tying point of the permanent biodiversity monitoring area in Mount Makiling Forest Reserve (MMFR) is **121.219497^0 longitude** and **14.132028^0 latitude**.

3. First open **ArcMap**. Click **ArcCatalog** and navigate where you want to create a new shapefile. Create your working folder where you will save all your work.

4. Right click on that folder, choose **New>Shapefile** and the **Create New Shapefile** box will appear. Type **'Tying Point'** under **Name**, **Feature Type** is **Point** then click on **Edit** to define the coordinate system.

5. In the **Spatial Reference Properties** window, click on **Geographic Coordinate System>World>WGS 1984**. Click **OK** then another **OK**.

6. Click the **Editor** in the **Editor Toolbar** and choose **Start Editing**.

7. Click on **Editor** again then choose **Editing Windows>Create Features**.

8. Now you can create the location of the tying point. Right click anywhere in the map window, click on the **Absolute X,Y**.

9. Under **Long**, encode **121.219497^0** and under **Lat**, type **14.132028**^{0}. Then click the **Enter** key. Then click on **Editor** drop down list and choose **Stop Editing**. If prompted to save, just click on **Yes**.

10. Now you need to project the shapefile into UTM. Click on **ArcToolbox**, then look for **Data Management Tools>Projections and Transformations>Project**.

11. In the **Project** window, choose **"Tying Point"** in the **Input Dataset or Feature Class**.

12. For the **Output Dataset or Feature Class**, navigate to your folder and type **"Tying Point UTM"** under **Name** then click on **Save**.

13. In the **Output Coordinate System**, choose **Projected Coordinate Systems>UTM>WGS 1984>Northern Hemisphere>WGS 1984 UTM Zone 51N** then click **OK**. Again, click on **OK**.

14. In the **Insert** menu, click on **Insert Data Frame** to create a new working window. Add the **Tying Point UTM** shapefile.

15. Right click on the **Tying Point UTM** and select the **Open Attribute Table**.

16. In the **Table Options**, choose **Add Field**. Type **X** under **Name** and choose **Double** in the **Type**. Under **Field Properties**, type **15** on **Precision** and **2** on **Scale**. Then click **OK**.

17. Repeat the previous step then type **Y** under **Name** and follow the same default properties as that of **X**.

18. In the table, right click on **X** then choose **Calculate Geometry**. In the new window, choose the **X Coordinate of Point** in the **Property** box, then the **Use coordinate system of the data source** should be selected under the **Coordinate System**. **Units** should be in **Meters (m)** then click **OK**. Do the same process for the **Y** field.

19. When done, the **X** field should have a value of **307,804.92** and the **Y** field has a value of **1,563,057.36**.

20. In the **Editor** dropdown list, choose **Start Editing**. Then click on **Editor** dropdown list again then choose the **Editing Windows>Create Features**.

21. In the **Create Features** window, select the **Point at end of line** from the **Construction Tools**. Then click on the tying point first then right click anywhere and choose **Direction/Length**. Type **S 55 W** and **10** then right click and choose **Finish Sketch**. These correspond to the bearing and size of the plots, respectively.

22. Now click on **Editor** and choose **Stop Editing**. Click on **Yes** to save the edits.

23. Open the **Attribute Table** and update the coordinates (X and Y) for both records. The other record has now a coordinate of **307,796.72** and **1,563,051.62**.

24. Now to create grids for PBMA, go to **ArcToolbox** and navigate on **Data Management Tools>Feature Class>Create Fishnet**.

25. In the pop-up window, navigate to your folder and create an **Output Feature Class** with a name **Grids**. In the **Fishnet Origin Coordinate**, type **307,804.92** (X) and **1,563,057.36** (Y) - this is the coordinate of the tying point.

26. In the **Y-Axis Coordinate**, type **307,796.72** for **X** and **1,563,051.62** for **Y** – this is the coordinate of the other record in the attribute table.

27. In the **Cell Size Width** and **Cell Size Height**, type **10**. In the **Number of Rows**, type **10** while in the **Number of Columns**, type **3** only.

28. Click on **Environments** then on **Output Coordinates** and under the **Output Coordinate System**, set it to **Same as Tying Point UTM**.

29. Click **OK**. The results show a plot with **30 grids** and their **center points**. You can encode the **ID** of the center points depending on the coding system your will use. This coding system will be utilized in developing your database system as well.

30. Generate the **X** and **Y** coordinates of the **Grids_label** using **Calculate Geometry**. Again these can be used as references in your system.

31. Export this table using **Table Options>Export**. Navigate to your working folder and save the file as **Grid Coordinates** and use **Text File** as its format (you may want to change the format to **.csv** before saving the file). Open the exported file using Excel.

32. Once you have collected the primary data in the permanent plot, you may now generate a database. You will use the **PBMASamples.xls** for this part to demonstrate how to generate the locations of individual trees. Save the file as **.csv** and open it on **ArcMap**.

33. Open the PBMASamples.csv in ArcMap. Go to **ArcToolbox>Data Management Tools>Features>Bearing Distance to Line.**

34. From the pop-up window, set the **Input Table** to **PBMASamples.csv**. Set the **Output Feature Class** and name it **Samples**.

35. Set the **X Field** to **X**, **Y Field** to **Y**, **Distance Field** to **Distance**, **Bearing Field to Azimuth**, **ID** to **Tree** and **Spatial Reference** to **WGS 1984 UTM Zone 51N**. Click **OK**.

36. Now convert the feature to individual points. Go to **ArcToolbox>Data Management Tools>Features>Feature Vertices to Points**.

37. From the new window, select the **Samples** from the **Input Features** and set the **Output Feature Class** and name it **Trees**. In the **Point Type**, select **END** then click **OK**. The results are the relative location of individual trees in the permanent biodiversity monitoring area.

38. Now join the other information of the database from the **Geodatabase.csv** to the points generated. Open the **Attribute Table** of **Trees** then go to **Table Options>Join and Relates> Join**. From the **Join Data** window, select **TREE** from **Choose the field in this layer that the join will be based on**, then select **Geodatabase.csv** from the **Choose the table to join to this layer, or load the table from disk**. Lastly, select **TREE** from the **Choose the field in the table to base the join on**. Click **OK**.

39. Right click on **Tree** and choose on **Data>Data Export** and save the new shapefile as **Trees Geodatabase**. Add the exported shapefile and explore its attribute table.

5.2 Floral Monitoring

5.2.1 Species and Site Selection

- The species and area to be monitored will basically depend on the results of the initial assessment. A set of criteria will be developed on how to locate the permanent monitoring plots including the presence of important/ indicator species, vegetation type, and accessibility of the area.

- After the initial assessment, conduct consultation with stakeholders to determine which among the identified ecologically and economically important species in the area is the indicator species for monitoring.
- The number and location of monitoring plot/s will primarily depend on the distribution of the identified indicator species.
- The transect lines used for floral assessment can be the same transects used for the periodic monitoring. This will give us sufficient information on the periodic changes at the ecosystem level.
- Because Philippine forests are very heterogeneous, a larger area and number of monitoring plots are required within each PA to better capture its diversity and complexity and to approximate vegetation changes within a higher level of precision.
- In light of existing permanent forest monitoring plots (UPLB, UPD, LTER) and the recent BMB's initiative to establish 2-ha permanent monitoring plots in a number of selected PAs in the country, it is better to adopt the area as well, for standardization of the national biodiversity monitoring.
- The replication of monitoring area will be based on vegetation/forest types. Ideally, each forest formation type containing indicator species should have at least one permanent monitoring plot.
- For a start, each PA should have at least one 2-ha permanent forest monitoring plot selected based on the agreed species indicators.

5.2.2 Permanent Monitoring Plot Establishment

- Establish a 2-ha permanent plot following the international protocol established by Long Term Ecological Research (LTER) Network for the establishment of permanent field plots.
- The plot must be regular (100m x 200m or 80m x 250m) for easy boundary delineation. A geodatabase will be developed to facilitate data storage and retrieval of the permanent plot. There will be two phases of geodatabase development for the permanent plot:

a. Gridding and monument marking

b. Building up of biodiversity information in the area using GIS

- The entire plot will be divided into 200 grids where each grid has a dimension of 10m x 10m.
- Monument markers will be driven in every corner and center of each grid. These corners should be geocoded for easy identification in the field and as future reference for efficient encoding of data.

DATA COLLECTION

- Determine the floristic taxa, composition, and structure from the gridded and geo-based 2-ha permanent plot.
- Assign a unique permanent identification tag/number for each live tree of measurable size within the plot (Figure 79 on page 100).
- Tag, measure, and record all trees with ≥1cm diameter.
- Take the different attributes such as diameter at breast height (dbh) (Figure 80 on page 100), merchantable height (MH) and total height (TH) from each tree using

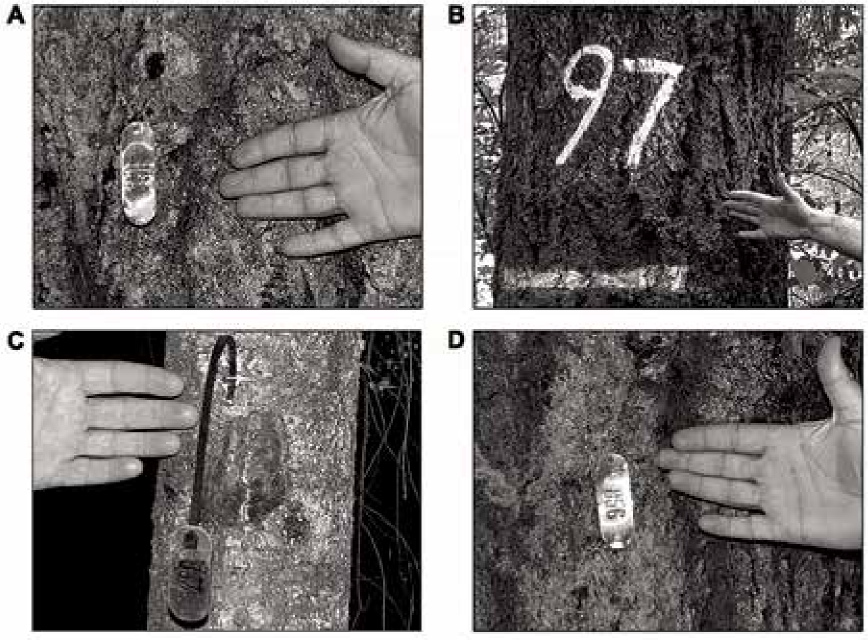


Figure 79. Methods of attaching tree tags: (a) nails, (b) painted numbers after smoothing bark, (c) plastic barlocks stapled to tree, (d) tags stapled directly to thick bark plates (after Curtis & Marshall 2005).

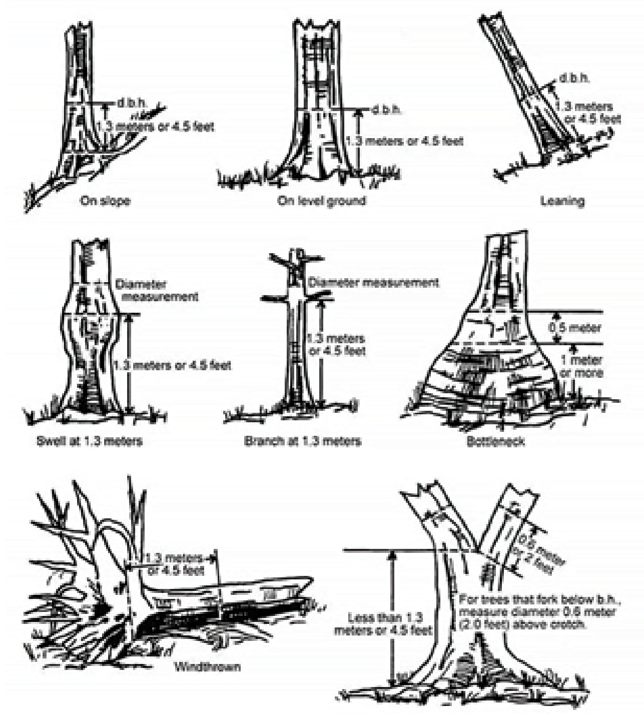


Figure 80. Measurement points for measuring diameter at breast height (DBH) of trees in various situations (after Curtis & Marshall 2005).

Table 5.1 Field data sheet for the floristic survey of permanent monitoring post

QUADRAT NO.	TREE NO.	SPECIES	SCIENTIFIC NAME	FAMILY NAME	DBH (CM)	MH (M)	TH (M)	BEARING	DISTANCE (M)
1	1	Anonggo	*Turpinia ovalifolia*	Staphyleaceae	18	4.2	10.3	N 67° E	4.2
1	2	Magabuyo	*Celtis luzonica*	Cannabaceae	21.1	7.4	20.5	N 67° E	3.9
1	3	Magabuyo	*Celtis luzonica*	Cannabaceae	2.2		2.9	S 84° E	4.45
1	4	Magabuyo	*Celtis luzonica*	Cannabaceae	1.3		3	S 72° E	4.5
1	5	Balobo	*Diplodiscus paniculatus*	Malvaceae	45	11.5	18	S 84° E	4.35
1	6	Sanglai	*Ahernia glandulosa*	Flacourtiaceae	11.9	3.2	7.6	S 68° E	4.65
1	7	Apanang	*Mallotus cumingii*	Euphorbiaceae	3.9		3.7	S 71° E	5.3
1	8	Lago	*Prunus grisea*	Rosaceae	13.6	5.2	10.1	S 62° E	5.75
1	9	Apanang	*Mallotus cumingii*	Euphorbiaceae	12	5.4	12.2	S 50° E	5
1	10	Sanglai	*Ahernia glandulosa*	Flacourtiaceae	1.75		2.1	S 47° E	5.05

appropriate instruments.

• For smaller diameter trees (< 10cm dbh), measure only diameter and total height.

• To plot the location of each tree on a map, distance and bearing of each tree from the center of each 10m x 10m plot will be taken and recorded using meter tape and compass ("Table 5.1 Field data sheet for the floristic survey of permanent monitoring post").

• Collect voucher specimens for identification, authentication, and herbarium collection.

• Tag each specimen using proper coding prior to storage.

• Photo-document all activities and process and store floristic data in GIS database for interpretation, analysis, and management purposes.

5.2.3 Frequency of Monitoring

• Monitor plant growth (DBH, MH, TH) should be done every 5 years after the baseline survey.

• Depending on availability and activity of the PA staff (patrolling works, ecotourism trekking, etc.), chronicle the basic information such as flowering, fruiting, clearing, cutting and other disturbances on a monthly basis. In cases of catastrophic events (i.e. strong typhoons, volcanic eruptions, etc.), assessment should be done immediately after.

5.2.4 Access and Retrieval

• Once all inventories are done and properly encoded into GIS format, these will comprise the entire geo-database of each PA.

• From this dataset, you can easily query and filter information that is useful in locating species with significant conservation status, estimation of above ground biomass and carbon, monitoring of growth and development of resources, rapid assessment during a disaster or pest outbreaks, and many others.

- Develop an interactive GIS map of the plot for easier information access, and to guide the stakeholders for the scientific management of the PA.
- With these permanent monitoring plots, all PAs must be encouraged to join the Long Term Ecological Research (LTER) network to share information that may be gathered and to better understand environmental change across the globe.

5.3 Faunal Monitoring

5.3.1 Arthropod Monitoring

HUMAN ACTIVITIES AND INTERVENTIONS coupled with changing climate threatens the biological resources in an area oftentimes with deleterious effects. According to Noss (1999), biota in a particular ecosystem or habitat are suffering from two main processes:

1. Simplification, where structurally rich native forests are converted to simplified secondary stands or plantations.

2. Fragmentation, where large tracts of native forest are converted to small and separated patches delimited by terrain that is hostile to many species and poses barriers to movement.

Based on the initial arthropod diversity assessment, you should determine the ecologically important species-group and area to be monitored.

The highly possible species group to be monitored would be the butterflies and the dragonflies, which are usually affected by the disturbances in the habitats due to various factors, both anthropogenic and environmental. Consult several references on butterflies and dragonflies for the identification of these species.

> Site Selection

Same as flora module ("Species and Site Selection" on page 98)

> Materials and Equipment

See "Materials and Equipment" on page 87

> Data Collection

There are two options to choose from for the monitoring of arthropod diversity:

Transect walk

THIS IS USED TO DETERMINE AND MONITOR the diversity and species richness of the selected species-group or taxa.

i. Establish a 2-km transect line with an imaginary width of 20 meters (10 meters on both sides) within a vegetation type. The number of transect lines depend on the size of the PA and the types of vegetation. The location of the sampling transects for arthropod monitoring should be adjacent to or pass along flora monitoring plots.

ii. During the transect walk, capture, count, record and photograph any arthropod species encountered. Use a field guide/reference collection for the identification of species. Label each jar with the date, name of the collector, name of the PA, and transect line number.

iii. For species that could not be identified visually or through photos, collect and preserve 2-3 sample individuals as voucher specimens for proper identification. Label each jar with the date, name of the collector, name of the PA, and transect line number.

iv. Photograph each species recorded. Ideally, use a digital camera with macro setting and/or macro lens. Note the file number of each photo.

v. Conduct transect walks twice a year based on seasonal climatic conditions (wet and dry seasons).

Use of 2-hectare permanent monitoring plots

i. Walk within the permanent plot along a zigzag path (Figure 6.3) to count and record the species or species group being monitored.

ii. Collect and preserve voucher specimens of species to be identified. Label each jar with the date, name of the collector, name of the PA, and permanent plot number.

iii. Photograph each species recorded. Ideally, use a digital camera with macro setting and/or macro lens. Note the file number of each photo.

Data Sheets

OBSERVATIONS AND OTHER PERTINENT DATA gathered during the monitoring activities will be entered into the data sheet ("Annex 6.9. Field data sheet for arthropod survey and monitoring" on page 116) that was also used in the assessment activity.

a. Time and frequency of measurement

- Monitoring of selected arthropod taxa should be done every 3 to 5 years after the baseline survey. In the event of calamities such as typhoons, volcanic eruptions, and others, assessment activity should be done immediately after (i.e., usually one or two weeks after).
- For every monitoring activity, the data should be encoded into a GIS formatted data base information system for a particular PA. Arthropod monitoring data will form part of the interactive GIS map that will be developed for easy information access by the stakeholders for better management of the PA.

b. Manpower requirement

- Regular arthropod monitoring requires only two personnel, one technical person and one guide or field assistant.

5.3.2 Vertebrate Wildlife Monitoring

- Conduct semi-annual monitoring representing the Wet and Dry Seasons (depending on locality as listed under Coronas Classification) usually coinciding also with the migratory and non-migratory season of birds, respectively.
- Monitoring should also be done after catastrophic events such as super typhoons, forest fires, volcanic eruptions, etc.
- Use the same methods used for wildlife assessment for monitoring various terrestrial vertebrates, although these can be simplified to a reduced sampling period.
- Live- trapping can be forgone for herpetofauna, thus concentrating on the modified strip transect method.
- Distance sampling and mist-netting can be optional for birds and limiting the essential transect data counts using modified line transect method to determine trends in bird species diversity and relative abundance.
- For mammals, mist-netting and cage-trapping are still the essential methods for survey.
- A summary of methods for assessment and monitoring of terrestrial vertebrates are shown in "Table 5.2 Summary of vertebrate wildlife survey methods of assessment and monitoring" on page 104

CRITERIA FOR SPECIES REPRESENTATION

FOR POTENTIAL INDICATOR SPECIES PER

Table 5.2 Summary of vertebrate wildlife survey methods of assessment and monitoring

TERRESTRIAL VERTEBRATE GROUP	FAUNAL ASSESSMENT METHODS	WILDLIFE MONITORING METHODS	POTENTIAL FOREST INDICATOR SPECIES
Amphibians	Modified strip transect Pit-fall and glue trapping Opportunistic sampling Evidences/animal remains Ethnobiological accounts	Modified strip transect Evidences and animal remains	Fanged frogs, Litter toads, Forest/Cliff frogs, Caecilians, Stream frogs, Barbourula
Reptiles	Modified strip transect Pit-fall and glue trapping Opportunistic sampling Evidences/animal remains Ethnobiological accounts	Modified strip transect Evidences and animal remains	Dragons, Sailfins, Monitor lizards, Cave geckoes, Litter skinks Cobras, Mountain snakes, Tree skinks
Birds	Modified line transect Distance sampling Mist-netting Evidences/animal remains Ethnobiological accounts	Modified line transect Mist-netting (optional with bats) Evidences and animal remains	Forest eagles/hawks, Hornbills, Parrots, Woodpeckers, Owls, Babblers/White-eyes, Monarchs, Kingfisher
Volant Mammals/ Bats	Mist-netting Tunnel trapping Evidences/animal remains Ethnobiological accounts	Mist-netting Evidences and animal remains	Flying foxes, Harpy fruit bat, Nectar bats, Ghost bat, Harpy bat,
Non-volant Small Mammals	Cage/Snap trapping Evidences/animal remains Ethnobiological accounts	Cage trapping Evidences and animal remains	Cloud rats, Forest rats/mice, Shrew rats/mice, Squirrels, Porcupine
Medium to Large Mammals	Modified line transect Opportunistic sampling Evidences/animal remains Ethnobiological accounts	Evidences and animal remains Ethnobiological accounts	Civets, Leopard cat, Deer, Warty Pigs, Tamaraw, Pangolin, Otter, Colugo, Pantot

sampling site, a thorough survey will reveal significant species that best represent the uniqueness of the protected area assessed, which may fall under the following criteria:

1. Island or regional endemic and forest dependent, threatened or otherwise, usually with high potential for being a flagship species or ethno-cultural value.

2. Philippine endemic will national concern, often with threatened status and recognized indicator species for biological diversity.

3. Keystone species, endemic or not, threatened or not but invaluable for providing ecosystem services.

› Data Analysis

a. Software

FOR DATA ANALYSIS, THE MOST BASIC AND easily available program is the Microsoft EXCEL, which can do computations and graphs. Other computer software that can be used for data that can be derived particularly in relation to statistical analysis include the Multivariate Statistical Package (MVSP), STATGRAPHICS, and other downloadable software.

b. Analysis Methods

- Similar to analysis of data for assessment, the monitoring data will used to describe species composition, abundance and distribution in the area. Evaluated these based on the conditions of the area and the possible changes that may occur prior to actual monitoring activity.
- Describe habitat relationships and host plant-insect interactions to develop conservation and management strategies.
- Obtain species richness and heterogeneity measures to determine the trend in the diversity changes of the indicator species or species-group.
- For species richness measures, compute the Margalef Index and Menhenick Index.
- For heterogeneity measures, obtain the Shannon-Wiener and Simpson's Index.
- Construct relevant graphs to indicate fluctuation and trend of diversity changes.
- For the wildlife monitoring data, add results of each monitoring survey for herpetofauna, avifauna, and mammal checklist to make a cumulative species listing.
- Note new records for the area. Compare species composition in terms of residency status, habitat association and conservation status between Wet and Dry Season sampling.
- Plot the trends in Species Diversity Indices (species richness, abundance, Species Diversity Index, Dominance and Evenness indices) during the monitoring surveys.

Annex 6.1. Field data sheet for estimating float velocity

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

DATE	TIME	LOCATION	DISTANCE TRAVELLED (M)	TRAVEL TIME (S)	FLOAT VELOCITY (M/S)

Annex 6.2. Field data sheet for velocity and water level measurements

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

DATE	TIME	LOCATION	WATER LEVEL (M)	WIDTH (M)	CROSS-SECTIONAL AREA (M^2)	VELOCITY (M/SEC)	DISCHARGE (M^3/SEC)

Annex 6.3. Field data sheet for Line Intercept Technique (LIT)

Protected Area:				Date:		Time:
Plot No.	Quadrat No.	Vegetation Type:		Observer(s):		
		Weather:				
	Transect No.	Elevation: masl				
		GPS Unit:				
Transect Coordinates						Transect Length: m
Starting Point:	N E		Endpoint:	N E		
NO.	SPECIES	VOUCHER NO.	B (DM)	E (DM)	INTERCEPT (E-B)	REMARKS
001						
002						
003						
004						
005						
006						
007						
008						
009						
010						
011						
012						
013						
014						
015						
016						
017						
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024						
025						
026						
027						
028						
029						
030						
031						
032						
033						
034						
035						

Annex 6.4. Field data sheet for ecosystem level assessment (Sheet 1 of 3)

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation:
masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

SECTION	FOREST FORMATION	STAND MATURITY	PHOTO NUMBERS	REMARKS
0.0 - 0.1				
0.1 - 0.2				
0.2 - 0.3				
0.3 - 0.4				
0.4 - 0.5				
0.5 - 0.6				
0.6 - 0.7				
0.7 - 0.8				
0.8 - 0.9				
0.9 - 1.0				
1.0 - 1.1				
1.1 - 1.2				
1.2 - 1.3				
1.3 - 1.4				
1.4 - 1.5				
1.5 - 1.6				
1.6 - 1.7				
1.7 - 1.8				
1.8 - 1.9				
1.9 - 2.0				
2.0 – 2.1				
2.1 - 2.2				
2.2 - 2.3				
2.3 - 2.4				
2.4 - 2.5				
2.5 - 2.6				
2.6 - 2.7				
2.7 - 2.8				
2.8 - 2.9				
2.9 - 3.0				
3.0 - 3.1				
3.1 - 3.2				
3.2 - 3.3				
3.3 - 3.4				
3.4 - 3.5				
3.5 - 3.6				

Annex 6.4. Field data sheet for ecosystem level assessment (Sheet 2 of 3)

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation:
masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

SECTION	FOREST FORMATION	STAND MATURITY	PHOTO NUMBERS	REMARKS
3.6 - 3.7				
3.7 - 3.8				
3.8 - 3.9				
3.9 - 4.0				
4.0 - 4.1				
4.1 - 4.2				
4.2 - 4.3				
4.3 - 4.4				
4.4 - 4.5				
4.5 - 4.6				
4.6 - 4.7				
4.7 - 4.8				
4.8 - 4.9				
4.9 - 5.0				
5.0 - 5.1				
5.1 - 5.2				
5.2 - 5.3				
5.3 - 5.4				
5.4 - 5.5				
5.5 - 5.6				
5.6 - 5.7				
5.7 - 5.8				
5.8 - 5.9				
5.9 - 6.0				
6.0 - 6.1				
6.1 - 6.2				
6.2 - 6.3				
6.3 - 6.4				
6.4 - 6.5				
6.5 - 6.6				
6.6 - 6.7				
6.7 - 6.8				
6.8 - 6.9				
6.9 - 7.0				
7.0 - 7.1				
7.1 - 7.2				

Annex 6.4. Field data sheet for ecosystem level assessment (Sheet 3 of 3)

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates: N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation:
masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

SECTION	FOREST FORMATION	STAND MATURITY	PHOTO NUMBERS	REMARKS
7.2 - 7.3				
7.3 - 7.4				
7.4 - 7.5				
7.5 - 7.6				
7.6 - 7.7				
7.7 - 7.8				
7.8 - 7.9				
7.9 - 8.0				

Annex 6.5. Field data sheet for ecosystem level assessment

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

NO.	SPECIES	VOUCHER NO	DBH	MH	TH	REMARKS
001						
002						
003						
004						
005						
006						
007						
008						
009						
010						
011						
012						
013						
014						
015						
016						
017						
018						
019						
020						
021						
022						
023						
024						
025						
026						
027						
028						
029						
030						
031						
032						
033						
034						
035						
036						

Annex 6.6. Field data sheet for understory assessment

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates: N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

NO.	SPECIES	VOUCHER NO.	COUNT	EPIPHYTES	REMARKS
001					
002					
003					
004					
005					
006					
007					
008					
009					
010					
011					
012					
013					
014					
015					
016					
017					
018					
019					
020					
021					
022					
023					
024					
025					
026					
027					
028					
029					
030					
031					
032					
033					
034					
035					
036					

Annex 6.7. Field data sheet for the ground cover diversity assessment

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

SPECIES	VOUCHER NO	% COVER	REMARKS

Annex 6.8. Field data sheet for permanent monitoring plot

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates: N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

NO.	SPECIES CODE	DBH (CM)	TH (M)	MH (M)	BEARING	DISTANCE (M)	REMARKS
001							
002							
003							
004							
005							
006							
007							
008							
009							
010							
011							
012							
013							
014							
015							
016							
017							
018							
019							
020							
021							
022							
023							
024							
025							
026							
027							
028							
029							
030							
031							
032							
033							
034							
035							
036							

Annex 6.9. Field data sheet for arthropod survey and monitoring

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

NO.	NAME OF TAXA	SPECIES CODE	ARTHROPOD CLASS	FREQUENCY	REMARKS*
001					
002					
003					
004					
005					
006					
007					
008					
009					
010					
011					
012					
013					
014					
015					
016					
017					
018					
019					
020					
021					
022					
023					
024					
025					
026					
027					
028					
029					
030					
031					
032					
033					

* Remarks may include: Body size (small, medium, big, large); body color; body shape (pointed, curve, straight, etc.); distinctive markings (body stripe, body spots, unique body parts, etc), photo number, other observations

Annex 6.10. Field data sheet for modified strip transect method for herpetofauna

Protected Area:			Date:	Time:
Plot No.	Quadrat No.	Vegetation Type:	Observer(s):	
		Weather:		
	Transect No.	Elevation: masl		
		GPS Unit:		

Transect Coordinates				Transect Length: m
Starting Point:	N E	Endpoint:	N E	

NO.	SPECIES	HEARD AND/OR SEEN	FREQ	SAMPLE MEASUREMENTS* (IN MM)					REMARKS
				SVL	TL	HL	FL	WT	
001									
002									
003									
004									
005									
006									
007									
008									
009									
010									
011									
012									
013									
014									
015									
016									
017									
018									
019									
020									
021									
022									
023									
024									
025									
026									
027									
028									
029									
030									
031									
032									
033									
034									
035									

* SVL - Snout-to-vent length, TL - Tail length, HL - Head length, HL - Hindfoot length, FL - Forefoot length, Wt - Body weight (in grams)

Annex 6.11. Checklist of herpetofauna

<table>
<tr><td colspan="3">Protected Area:</td><td colspan="5">Date:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates: N
E</td><td colspan="5">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="5">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="5">Weather:</td></tr>
</table>

<table>
<tr><td rowspan="3">NO.</td><td>CLASS</td><td rowspan="3">DISTRI-BUTION STATUS</td><td rowspan="3">RECOR-DING METHOD</td><td rowspan="3">HABITAT ASSOCIA-TION</td><td colspan="3" rowspan="2">POPULATION STATUS</td></tr>
<tr><td>ORDER</td></tr>
<tr><td>SPECIES</td><td>IUCN</td><td>CITES</td><td>PWA</td></tr>
<tr><td>001</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>002</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>003</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>004</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>005</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>006</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>007</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>008</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>009</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>010</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>011</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>012</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>013</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>014</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>015</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>016</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>017</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>018</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>019</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>020</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>021</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>022</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>023</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>024</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>025</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>026</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>027</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>028</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>029</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>030</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>031</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>032</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>033</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>034</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>035</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>036</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>037</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>038</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>039</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Annex 6.12. Field data sheet for simple line transect count for birds

Protected Area:			Date:	Time:
Plot No.	Quadrat No.	Vegetation Type:	Observer(s):	
		Weather:		
	Transect No.	Elevation: masl		
		GPS Unit:		

Transect Coordinates				Transect Length: m
Starting Point:	N E	Endpoint:	N E	

NO.	SPECIES	HEARD AND/OR SEEN	FREQ	REMARKS
001				
002				
003				
004				
005				
006				
007				
008				
009				
010				
011				
012				
013				
014				
015				
016				
017				
018				
019				
020				
021				
022				
023				
024				
025				
026				
027				
028				
029				
030				
031				
032				
033				
034				
035				
036				
037				
038				

Annex 6.13. Field data sheet for perpendicular distance method for birds

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="4">Plot No.</td><td rowspan="2">Quadrat No.</td><td>Vegetation Type:</td><td colspan="2" rowspan="4">Observer(s):</td></tr>
<tr><td>Weather:</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td></tr>
<tr><td>GPS Unit:</td></tr>
</table>

<table>
<tr><td colspan="4">Transect Coordinates</td><td rowspan="2">Transect Length:
m</td></tr>
<tr><td>Starting Point:</td><td>N
E</td><td>Endpoint:</td><td>N
E</td></tr>
</table>

NO.	SPECIES	FREQ	PERPENDICULAR DISTANCE	FLUSHING DISTANCE	FLUSHING ANGLE	REMARKS
001						
002						
003						
004						
005						
006						
007						
008						
009						
010						
011						
012						
013						
014						
015						
016						
017						
018						
019						
020						
021						
022						
023						
024						
025						
026						
027						
028						
029						
030						
031						
032						
033						
034						
035						

Annex 6.14 Field data sheet for modified variable circular plot method for birds

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="4">Plot No.</td><td rowspan="2">Quadrat No.</td><td>Vegetation Type:</td><td colspan="2" rowspan="4">Observer(s):</td></tr>
<tr><td>Weather:</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td></tr>
<tr><td>GPS Unit:</td></tr>
</table>

<table>
<tr><td colspan="4">Transect Coordinates</td><td rowspan="2">Transect Length: m</td></tr>
<tr><td>Starting Point:</td><td>N
E</td><td>Endpoint:</td><td>N
E</td></tr>
</table>

NO.	SPECIES	FREQ	RADIAL DISTANCE	FLUSHING DIRECTION	REMARKS
001					
002					
003					
004					
005					
006					
007					
008					
009					
010					
011					
012					
013					
014					
015					
016					
017					
018					
019					
020					
021					
022					
023					
024					
025					
026					
027					
028					
029					
030					
031					
032					
033					
034					
035					

Annex 6.15 Field data sheet for bird mistnetting

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot
No.</td><td>Quadrat
No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect
No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

NO.	SPECIES	SEX	FREQ	SAMPLE MEASUREMENTS* (IN MM)							REMARKS
				TL	TV	WC	B	G	T	WT	
001											
002											
003											
004											
005											
006											
007											
008											
009											
010											
011											
012											
013											
014											
015											
016											
017											
018											
019											
020											
021											
022											
023											
024											
025											
026											
027											
028											
029											
030											
031											
032											
033											
034											
035											
036											
037											

* Legend: TL - Total length, TV - Tail-vent length, WC - Wing cord, B - Bill or culmen length, G - Width of gape, T - Tarsus length, Wt - Body weight (in grams)

Annex 6.16 Checklist of avifauna

Protected Area:			Date:
Plot No.	Quadrat No.	Coordinates: N E	Observer(s):
	Transect No.	Elevation: masl	Vegetation Type:
		GPS Unit:	Weather:

NO.	CLASS ORDER SPECIES	DISTRIBUTION STATUS	RECORDING METHOD	HABITAT ASSOCIATION	POPULATION STATUS		
					IUCN	CITES	PWA
001							
002							
003							
004							
005							
006							
007							
008							
009							
010							
011							
012							
013							
014							
015							
016							
017							
018							
019							
020							
021							
022							
023							
024							
025							
026							
027							
028							
029							
030							
031							
032							
033							
034							
035							
036							
037							
038							
039							

Annex 6.17 Data sheet for computation of species diversity indices

Protected Area:			Date:
Plot No.	Quadrat No.	Coordinates: N E	Observer(s):
	Transect No.	Elevation: masl	Vegetation Type:
		GPS Unit:	Weather:

NO.	SPECIES	TRANSECT OR NETTING	FREQ (NI)	RF (NI/N)	PDI (RF)2	LN(NI/N)	PSDI (RF * LN(NI/N))
001							
002							
003							
004							
005							
006							
007							
008							
009							
010							
011							
012							
013							
014							
015							
016							
017							
018							
019							
020							
021							
022							
023							
024							
025							
026							
027							
028							
029							
030							
031							
032							

N = ($\sum$ ni):	SRI = Total number of species:	Hmax (ln(SRI)):
SDI ($\sum$PDI):	SWDI (-$\sum$ PDSI):	SEI (SWDI/Hmax):

* Legend: RF - Relative Frequency, PDI - Proportional Dominance Index, PSDI - Proportional Species Diversity Index, SRI - Species Richness Index, SDI - Simpson's Dominance Index, SWDI - Shannon-Weiner Diversity Index, SEI - Shannon's Evenness Index

Annex 6.18 Field data sheet for bat mistnetting

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

NO.	SPECIES	SEX	AGE	FREQ	SAMPLE MEASUREMENTS* (IN MM)						REMARKS
					HBL	TL	EL	FL	HL	WT	
001											
002											
003											
004											
005											
006											
007											
008											
009											
010											
011											
012											
013											
014											
015											
016											
017											
018											
019											
020											
021											
022											
023											
024											
025											
026											
027											
028											
029											
030											
031											
032											
033											
034											

* Legend: HBL - Head-to-body length, TL - Tail length, EL - Ear length, FA - Forearm length, HL - Hindfoot length, Wt - Body weight (in grams)

Annex 6.19 Field data sheet for small non-volant mammal trapping

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td><td>Time:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates:
N
E</td><td colspan="2">Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td colspan="2">Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td colspan="2">Weather:</td></tr>
</table>

NO.	SPECIES	SEX	AGE	FREQ	SAMPLE MEASUREMENTS* (IN MM)					REMARKS
					HBL	TL	EL	HL	WT	
001										
002										
003										
004										
005										
006										
007										
008										
009										
010										
011										
012										
013										
014										
015										
016										
017										
018										
019										
020										
021										
022										
023										
024										
025										
026										
027										
028										
029										
030										
031										
032										
033										
034										

* Legend: HBL - Head-to-body length, TL - Tail length, EL - Ear length, HL - Hindfoot length, Wt - Weight in grams

Annex 6.20 Checklist of mammalian fauna

<table>
<tr><td colspan="3">Protected Area:</td><td>Date:</td></tr>
<tr><td rowspan="3">Plot No.</td><td>Quadrat No.</td><td>Coordinates: N
E</td><td>Observer(s):</td></tr>
<tr><td rowspan="2">Transect No.</td><td>Elevation: masl</td><td>Vegetation Type:</td></tr>
<tr><td>GPS Unit:</td><td>Weather:</td></tr>
</table>

<table>
<tr><td rowspan="3">NO.</td><td>CLASS</td><td rowspan="3">DISTRIBUTION STATUS</td><td rowspan="3">RECORDING METHOD</td><td rowspan="3">HABITAT ASSOCIATION</td><td colspan="3">POPULATION STATUS</td></tr>
<tr><td>ORDER</td><td rowspan="2">IUCN</td><td rowspan="2">CITES</td><td rowspan="2">PWA</td></tr>
<tr><td>SPECIES</td></tr>
<tr><td>001</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>002</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>003</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>004</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>005</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>006</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>007</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>010</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>017</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>018</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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Table 2.1. Parameters for Watershed and Ecosystem Level Monitoring

KEY ACTIVITY	KEY OUTPUT	SECONDARY DATA NEEDED	PARAMETERS TO BE MONITORED	MONITORING INSTRUMENT(S)	FREQUENCY OF MONITORING	LOCATION
Topographical and Geological Profiling	Topographic and geological profile (i.e., slope, elevation, DEM, soil, geology), including physically constrained areas (i.e., steep slope, saline, acidic, ultramafic and waterlogged soil)	Topographic maps, DEM, soil and geology maps and soil erosion maps from NAMRIA, BSWM, MGB, old reports, plans, CLUPs, FLUPs, PPFPs, other plans	Soil moisture	Digital soil moisture meter	Continuous	Permanent biodiversity monitoring area in each watershed
			Soil temperature			
			Hydraulic conductivity	Hydraulic conductivity meter	Periodic	
			Infiltration Rate	Automatic infiltrometer	Periodic	
			Texture	Sample Analysis	Yearly	
			Bulk density			
			NPK			
			pH			
			OM			
			Soil erosion	Run-off/ erosion plots	Continuous	
Climate Trend Analysis and Projection	Current and projected climate (i.e., daily, monthly and annual averages of rainfall and temperature, and extreme rains and temperature, typhoons)	Climate daily values from 1971- 2015 including tropical storms and typhoons, projected daily climate values for 2020 ad 2050, for at least 3 PAGASA stations within and around the PA	Rainfall	Automated weather station	Continuous	Up, mid and downstream of each watershed
			Air temperature			
			RH			
			Wind			
			Solar radiation			

KEY ACTIVITY	KEY OUTPUT	SECONDARY DATA NEEDED	PARAMETERS TO BE MONITORED	MONITORING INSTRUMENT(S)	FREQUENCY OF MONITORING	LOCATION
Vulnerability and Risk Assessment to Climate Change and Other Natural Hazards	Risks and vulnerability maps showing places, people, communities, farms, forests, habitats that are vulnerable or at risk (i.e., to typhoons, extreme rains and temperature, floods, landslide, droughts, earthquakes, volcanic activity)	Same as above including, historical record of damages due to typhoons, floods, landslides, droughts, earthquakes, volcanic eruptions from LGUs, OCD, NDRRMC, PSA, DENR	Risks and vulnerability maps; Climate data (see above); Perceptions of the local stakeholders on risks and vulnerabilities to climate change and related hazards	Secondary data, GIS mapping, limited surveys	Every 3 to 5 years	Each watershed
Population Trend Analysis and Projection	To be done by the socio-economic team	To be done by the socio- economic team	Current and projected population	Secondary data, limited surveys		By Barangay, Municipality/ City, Province
Socio-Economic Profiling	To be done by the socio-economic team	To be done by the socio- economic team	Population	Secondary data, limited surveys		By Barangay, Municipality/ City, Province
			Age profile			
			Gender profile			
			Educational profile			
			Income profiles			
			Sources of livelihoods			
Land Use and Land Cover Change Analysis	Rates of change in land use and land cover, major drivers of land use and land cover change, current and projected lands needed for various uses	Land use and land cover maps for 1988, 1990, 2003 and 2010; legal land classification map; land tenure map (i.e., CBFMA, PCBRMA, CADT/CALC, IFMA, etc.), SAFDZ, NPAAD; population and population density maps; poverty incidence maps	Old growth forests	Remote sensing; field validation	At least every 2 years or after every typhoon	Each watershed
			Second growth forests			
			Agroforestry			
			Cultivated (lowland, upland, irrigated, rainfed)			
			Settlement/ residential areas			
			Industrial and commercial			
			Built up areas			

KEY ACTIVITY	KEY OUTPUT	SECONDARY DATA NEEDED	PARAMETERS TO BE MONITORED	MONITORING INSTRUMENT(S)	FREQUENCY OF MONITORING	LOCATION
Floral Biodiversity Assessment	Species population estimates, biodiversity indices, species- species interactions/ associations, species-habitat interactions/ associations, ethnobiological values, etc.	Land use and land cover maps for 1988, 1990, 2003 and 2010; topo maps, PA boundary map, secondary data from published and unpublished scientific papers and research results, old plans, EIS, other documents	Species Composition	Remote sensing and field surveys	Every 3-5 years; after every typhoon	2-km transect (assessment phase); 2-ha permanent plot (monitoring phase)
			Species Coverage			
			Species Density			
			Species Diversity			
			Pests and pathogens			
Faunal Biodiversity Assessment	Species population estimates, biodiversity indices, species- species interactions/ associations, species-habitat interactions/ associations, ethnobiological values, etc.	Land use and land cover maps for 1988, 1990, 2003 and 2010; topo maps, PA boundary map, secondary data from published and unpublished scientific papers and research results, old plans, EIS, other documents	Species Composition	Field surveys	Once per season	2-km transect
			Species Distribution			
			Species Diversity			
			Species Population			
			Pests and pathogens			
Water Resources Assessment	Streamflow estimates (i.e., total flow, maximum flows, low flows, water quality (i.e., sediment yield, temperature, pH, total dissolved solids, etc)	Watershed and subwatershed maps, PA boundary map, political boundary map, stream network maps, rainfall map and rainfall data (i.e., historical data from 1971-2015 and projected daily climate values for 2020 and 2050 for at least 3 PAGASA stations within and around the PA; historical streamflow data for at least the past 30 years from DPWH-BRS); location of open dumpsites, land fills, piggery and poultry, agricultural farms, mining operations, other sources of solid wastes and wastewater from LGUs; List of water users (i.e., domestic, agricultural, commercial and industrial from local water districts and other local water service providers)	Water level	Automated water level sensor	Continuous	Mid or downstream in each watershed
			Flow velocity	Flow meter	Weekly during rainy season; monthly during dry season	8 points along the mainstream or major tributaries of each watershed
			pH	Sensors and multi parameter water quality meters	Weekly during rainy season; monthly during dry season; and every 30 min during storms	
			Temperature			
			Total dissolved solids			
			Conductivity			
			Turbidity			
			Dissolved oxygen			
			Nitrogen	Sample Analysis	Monthly	
			Phosphates			
			Sediment yield	Grab sampling/ analysis	Weekly during rainy season; monthly during dry season	

Table 2.1. Parameters for Watershed and Ecosystem Level Monitoring (cont.)

KEY ACTIVITY	KEY OUTPUT	SECONDARY DATA NEEDED	PARAMETERS TO BE MONITORED	MONITORING INSTRUMENT(S)	FREQUENCY OF MONITORING	LOCATION
Watershed/ Ecosystem Services Valuation	Value of and benefits from ecosystem services	To be done by the socio-economic team				
Description of Current Policies	Facilitating and constraining policies using secondary information, KIIs	To be done by the socio-economic team				
Description of Current Institutions (Actors, Roles, Skills)	Institutional strengths and weaknesses using KIIs, FGDs, surveys and secondary information	To be done by the socio-economic team				
Land Capability and Land Suitability Assessment	Non-negotiable protection areas	To be done by the socio-economic team				
Identification of Strengths, Weaknesses, Opportunities and Threats in the Watershed and Watershed Management	Production areas (areas suitable for agriculture, settlement, industrial, commercial and other intensive uses SWOT analysis, problem tree analysis and other methods	To be done by the socio-economic team				

Table 2.2 Sample Line-Item Budget (LIB) for Biodiversity Assessment and Monitoring (Duration: 1 Year)

QUANTITY	ITEM	TOTAL
I. SUPPLIES AND MATERIALS		
3 units	First aid kit	3,000.00
20 pcs	1-liter PET bottles (for water samples)	2,000.00
4 pcs	2-gallon bucket with cover	200.00
5 kilos	Empty aluminum cans (for making tree tags)	300.00
2 pcs	Plier-type single-hole puncher (for making tree tags)	200.00
5 boxes	1/8 x 1/2-inch bling rivet nails	1,000.00
10 packs	060-type nylon thread	200.00
200 meters	8-mm nylon rope	400.00
4 bottles	1-liter denatured alcohol	600.00
100 pcs	4x6-inch polyethylene bags (for soil samples)	1,000.00
100 pcs	9x12-inch polyethylene bags (for herbarium samples)	1,000.00
100 pcs	11x16-inch resealable plastic bags	600.00
100 pcs	9x13-inch resealable plastic bags	400.00
100 pcs	5x7-inch resealable plastic bags	200.00
2 pcs	Pruning shears	300.00
2 pcs	Pole cutter	1,000.00
2 pcs	10-meter diameter tape	10,000.00
60 pcs	12x4x4-inch box traps (rat traps)	20,000.00
20 pcs	12-meter mist nets (35-mm mesh)	75,000.00
10 pcs	Insect nets	2,000.00
100 pcs	9x7-inch cloth bags (bird bags)	3,000.00
10 pcs	250-mL glass jars	200.00
1 box	Medium-sized disposable latex gloves	300.00
2 units	Dissecting kit (scalpel, scissors, large forceps, fine forceps, magnifying glass, and pins)	500.00
1 unit	300-gram precision hanging scale ("Pesola weighing scale")	6,000.00
1 unit	500-gram precision hanging scale ("Pesola weighing scale")	6,000.00
1 unit	1000-gram precision hanging scale ("Pesola weighing scale")	6,000.00
4 pcs	150-mm vernier caliper	400.00
2 pcs	150-mm dial caliper	3,000.00
4 pcs	12-inch flexible clear plastic ruler	100.00
4 pcs	100-cm measuring tape	200.00
2 units	100-meter open reel measuring tape	2,000.00
4 pcs	Magnetic north compass	400.00
4 packs	Extra-large trash bags	1,000.00
4 pcs	Headlamps	3,000.00
2 pcs	Solar/battery/hand-crank camping lantern	1,000.00
12 pcs	AAA rechargeable batteries (for head lamps)	1,500.00
12 pcs	AAA rechargeable batteries (for lanterns and GPS)	1,500.00
4 pcs	Jungle bolo with cover	1,500.00
4 pcs	Hand trowel	400.00

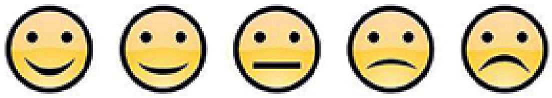
Table 2.2 cont. Sample Line-Item Budget (LIB) for Biodiversity Assessment and Monitoring (Duration: 1 Year)

QUANTITY	ITEM	TOTAL
4 units	30-liter plastic utility box with handle	1,500.00
5 rolls	Plastic twine/straw	200.00
1 box	Thick rubber band	200.00
5 rolls	1-inch satin ribbon (assorted neon colors for use as markers)	500.00
4 pcs	1-inch masking tape	100.00
4 pcs	2-inch packaging tape	200.00
4 pcs	Long plastic clipboard	300.00
10 pcs	Black fine tip permanent marker	200.00
4 sets	Miscellaneous supplies (ballpens, pencils, paper, scissors, etc.)	2,000.00
SUB-TOTAL		162,600.00
II. MAINTENANCE AND OPERATING EXPENSES		
	Training Expenses (Venue, catering, learning materials, etc.)	100,000.00
	Professional/Contractual Services (field labor, consultancy services, laboratory analysis services, etc.)	500,000.00
	Insurance Expenses (Personal accident insurance for the team)	2,000.00
	Food Expenses	50,000.00
	Communication Expenses	20,000.00
	Local Transportation Expenses	100,000.00
	Equipment Repair and Maintenance Expenses	20,000.00
	Utilities	50,000.00
SUB-TOTAL		842,000.00
III. EQUIPMENT OUTLAY		
1 unit	Laptop computer with accessories	50,000.00
1 unit	Soil Sample Collection Kit (15-cm soil corer, soil auger, soil sieve set and digital weighing balance with accessories)	50,000.00
1 unit	Soil Permeability Test Kit (hydraulic conductivity meter and infiltrometer with accessories)	50,000.00
1 unit	Laser rangefinder with accessories	50,000.00
1 unit	Microclimate sensors with accessories	175,000.00
1 unit	Automatic water level system with accessories	200,000.00
1 unit	Multiparameter Water Quality Meter with accessories	250,000.00
1 unit	Flow meter with accessories	150,000.00
1 unit	DSLR Camera with GPS and Tripod (EOS 700D Kit EF-S 18-135mm)	30,000.00
2 units	GPS with camera	60,000.00
SUB-TOTAL		1,065,000.00
TOTAL		2,069,600.00

Table 2.3 Sample Post-Training Evaluation Form

Using the following rating scale

5 - Excellent	3 - Satisfactory
4 - Very Good	2 - Unsatisfactory
1 - Very Unsatisfactory	



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Please evaluate the conduct of the training (check box)

PART I. What is your overall rating of the course? _____

PART II. Timeliness/Appropriateness of service delivery _____

PART III. Course Management (Rate from 5 to 1 using scale above)

ITEM	RATING	REMARKS
1. Achievement of course objectives		
2. Relevance of course contents		
3. Balance between theory and practice		
4. Provision of information to participants		
5. Organization and flow of course sessions		
6. Performance of resource persons		
7. Arrangements of accommodation		
8. Transport Service		
9. Training room and facilities		
10. Efficiency of course schedule		
11. Punctuality/promptness in starting and ending sessions		
12. Effectiveness of handouts, visuals, audiovisuals and training materials in facilitating and reinforcing learning		
13. Effectiveness of teaching methods used		
14. Relevance of field work		
15. Usefulness of course outputs/projects		

Other Comments/Suggestions:

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