Partnership to Support Development and Implementation of Training Module on Botanical Assessment for ASEAN Member State

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Preface

Overview of the Training Module

This training module is instructional material specially prepared for ASEAN Peatland Managers and Workers. This Module covers the combined topics in Plant Collecting Techniques, Methods of Assessment of Peatland Vegetation, and Data Analysis, designed to give people a better understanding of the subject matter. Modules are presented in simple, coherent, and comprehensive language. Theories and principles are presented in the first part of the text, and the second part contains activities to exemplify discussions made in the first part.

The years of teaching experience of the authors and expertise in both fields of the senior author made it possible to come up with a text combining such ideas.

The Authors

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GENERAL OBJECTIVES OF THE TRAINING

At the end of the training sessions, the following objectives will be achieved:

1. Assessed vegetation or plants to protect and conserve valuable ecosystems in the ASEAN Region; and

2. Conceptualized Training Module on botanical assessment for the ASEAN Member State, under the framework of a regional program – i.e. Measurable Action on Haze Free Sustainable Land Management in Southeast Asia (MAHFSA), being coordinated by ASEAN Secretariat, with implementing partners – Center for International Forestry Research (CIFOR) and Global Environment Centre (GEC).

SUGGESTED TRAINING SCHEDULE

Day	Module	Lesson	Title	No. of Hours
1	1 - Basic Plant Collecting Techniques and Identification	1	Plant Collecting Techniques	1
		2	Plant Species Identification	2
	2 - Assessment of Peatland Vegetation	1	Assessment of Peatland Vegetation	3
	3 – Data Analysis			2
2	Fieldwork/ Outdoor Activities on Plant Collection and Identification, as well as Assessment of Peatland Vegetation			8

QUALITIES OF THE TRAINER

This module is better utilized by the Trainer who has the following qualifications:

1. preferably at least master’s degree holder major in Biology;
2. has satisfactory writing skills;
3. has excellent communication skills; and
4. has a passion to help the participants thrive.

INSTRUCTIONS TO THE TRAINER

BEFORE THE START OF THE TRAINING:

(1) Familiarize yourself with the content of this module.
(2) Prepare all the materials needed for the lecture and the activities in training.

WHILE DELIVERING THE LESSONS, keep in mind the following:

(1) Work with utmost SAFETY by religiously following proper protocols in doing the activities in training.
(2) Communicate properly and correctly all instructions in every activity to the participants.

AFTERCARE

(1) The trainer is responsible for the maintenance of the cleanliness and orderliness of all the materials and equipment used in training.
(2) Record all the feedback of your participants regarding this module so that the authors may make some adjustments when necessary later.
(3) Do a proper inventory and return all borrowed materials and equipment completely to their storage area.

Module 1
Basic Plant Collecting Techniques and Identification

Overview of Module 1

This Module shows the basic plant collecting protocol and plant identification procedure. The peatland managers and workers will be guided in these basic yet important preliminary activities to assess the vegetation and determine the plants that are existing and growing so they know what to protect and conserve in this fragile ecosystem.

Lesson 1 **– Plant Collecting Techniques**

Duration: 1 hour

Specific Learning Objectives

Upon completion of this module, the learners/participants will be able to:

1. know how to collect and process plant specimens in the project site;
2. increase the scientific knowledge and contribute to plant diversity conservation;
3. promote the value of plant diversity to the visitors, and
4. develop techniques for collecting plants.

Suggested Methods: lecture with powerpoint presentation and board notes

Resources

A. Supplies: whiteboard marker

B. Equipment: multimedia projector and projection screen

C. Visual Aids: slides or photos

D. Handouts: see inserts

A. Introduction

Collecting botanical/plant specimens is one of the most important activities in botanical assessment, particularly in peatland ecosystems. It is thought to be unnecessary, yet it is an essential component, especially if you do not know the identity of a plant you have come across in your sampling area. More so, if the plant species is incidentally suspected to be new to science! Hence, you have to know certain things and specific procedures normally introduced to forest managers, peatland personnel, plant enthusiasts, and students, among others.

Most plant collections are for preservation in the herbarium. A *herbarium* is an institution for the collection of dried plant specimens as contrasted to *hortorium*, which is a collection of living plant specimens. In its more than four centuries of history, the herbarium has grown up into an institution. And one may associate the term today not only with collections of dried plant specimens but with instruction, research, and extension- that is, the source of public information (Buot, 2019).

Each specimen contains valuable information such as the use of the plant, the habit, the ecology and distribution, and the taxon to where the plant belongs.

A herbarium can then be viewed as a biological data bank with numerous quantities of raw information that could be interpreted, evaluated, experimented with, synthesized, and used by the students, researchers, extension workers, and public laymen as well.

In view of the significant role played by a herbarium both in a college and in a community, it is important that we should learn its techniques.

A. Plant Collection

1. Prepare paraphernalia such as plant press, corrugated boards, old newspapers, plant labels, etc.
2. Parts of branches with flowers and fruits will be good when collecting vines, shrubs, and trees. The specimen should measure 30-40 cm in length.
3. Root system of herbaceous plants should be included in the collection whenever possible. This is especially necessary in the case of the grass family or Poaceae, for it is a good taxonomic character.
4. Fleshy underground parts should be sliced open to facilitate drying. Drying may be accomplished by sun drying or oven drying.
5. Seeds should be collected and dried too.

B. Labelling, Pressing, and Drying of Plant Specimens

1. Write pertinent information on field labels as you collect each specimen since this may change when dried. Note the color of the flowers, fruits, and surfaces of the leaves. Ethnobotanical notes may also be indicated.

2. The collection number of the specimen found in the field label refers to the number assigned by the collector to a particular specimen. A collector will assign the

number one (1) to the very first specimen he collects, # 2 to the next, and so on. If, for the first time, he collects 4 branches of *Terminalia copelandii*, he/she should assign collection number one (1) to the 4 specimens.

In cases where he collects another *Terminalia copelandii* specimen in another area, then that should be collection # 2 already. The numbering shall be consecutive throughout the active collection life of the collector.

3. The collection number should not be confused with the herbarium number. The herbarium number of the specimen affixed on the herbarium label, found ideally at the lower right-hand corner of the mounting sheet, refers to the number assigned by the herbarium curator to each specimen deposited in the herbarium. In here, no two specimens will have a similar number. Even 2 *Terminalia* specimens collected by one person in the same area at the same time will have different numbers. In other words, the herbarium number is the accession number or the control number of each deposited specimen.

4. Collected plant materials should be placed between folded newspapers together with their corresponding field labels.

5. The plant specimen should be packed tightly between a pair of herbarium pressers. If possible, each folded newspaper should be placed between cardboard or absorbent materials.

6. The herbarium pressers should be placed under the sun, in a herbarium oven or electric dryer, or in any sufficiently warm place to dry the plant materials.

7. It is advisable to replace newspapers and cardboard daily to hasten drying and, in the case of succulent species, to prevent the growth of fungal organisms.

Note:
Not all plants can be pressed using the standard method, some plants should be treated differently when drying. Fragments of bamboo, pandans, and palms with irregular shapes and thickness, are pressed and dried separately from other small parts.

Fleshy plants and underground organs such as a corm, tuber, and rhizomes of bananas and aroids must be poisoned before pressing. Make a cut of the specimens longitudinally or transversely and treat with 70% denatured alcohol or formalin/alcohol/acetic acid (FAA) solution.

C. Poisoning

1. Poisoning of plant materials is accomplished by dipping the specimens in a solution of 1 liter of denatured alcohol. Poisoned specimens are air-dried.
2. In the case of mounted specimens, poisoning may be accomplished by using an improvised brush made of cotton and a wooden stick. Dip the cotton in the poison

solution and apply it over the plant materials.

D. Mounting

1. The thoroughly dried specimens shall be mounted on a standard-size bristol board mounting sheet (11.5” x 16.5”) using Gum Arabic or glue or special tapes.
2. In the case of large specimens like gingers (*Etlingera littoralis*) and the like, it is best to fasten the mounting sheet on a thick cardboard of similar size and then sew the specimen and tie it tightly.
3. Mounted specimens should be inserted in a genus cover fold (17” x 24”).
4. If desirable or whenever practical, insert the genus in a family folder.

Note:

Bananas, aroids, and similar plant groups have delicates structure, flowers, fruits etc. They are generally and can be stored using chemical solutions in a bottle or in jars with plastic covers. This is often called “spirit materials”. The method is done by means of 70% denatured alcohol or by formalin/alcohol/acetic acid (FAA) solution. Both liquids help to harden the plant tissue and are useful for embryological and anatomical studies.

To prepare 70% denatured alcohol in 100ml, add 72.92 parts of 96% commercial grade ethyl alcohol with 27.08 distilled water.

To make 100 ml FAA, add 10 ml of 40% formaldehyde and 5 ml of glacial acetic acid to 85 ml of 96% ethyl alcohol (Wormersly,1981). The dilution and volume may increase depending on the number and type of specimens.

E. Filing

1. In filing the specimens, one may follow any acceptable system of plant classification published in botany and taxonomy books.

2. However, for ease and convenience, one may devise an artificial way of filing so long as it is practical and workable. An example may be an alphabetical arrangement of the families and the genera and species within each family and genus respectively.

3. All herbarium materials should be entered and numbered in the herbarium record book and indexed before filing.

F. Handling

1. Herbarium specimens are very fragile and delicate materials; hence they should be handled with utmost care. When handling and filing, these should be carefully placed

one on top of the other, with the mounted plant material ALWAYS facing up.
2. When herbarium specimens are transported to distant places, these should be packed in boxes thick enough to protect the specimens inside.

G. Periodic Check Up

1. Periodic inspection of the specimens, (probably every 4 or 6 months) for possible damage or attack by museum pests should be done.

2. Naphthalene balls or other repellents should be used to prevent the destruction of herbarium specimens.

3. Re-poisoning may be done whenever necessary following the procedure in poisoning.

FIELD ACTIVITIES

Activity 1: Plant Sampling

A – Orientation to Plant Sampling

B – Fieldwork: Collection/field trip to the Peatland area and or any other area close to the venue

C - Exercise: plant collection, pressing, drying, mounting, and labeling of collected specimens

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Lesson 2: Plant Species Identification

Duration: 2 hours

Specific Learning Objectives

At the end of Lesson 2, the participants will be able to:

1. know plant identification and classification.
2. become familiar with basic plant physical features.
3. begin to identify plants using morphological characteristics.

Definition of Terms

Species – a group of related or similar organisms capable of breeding freely to produce fertile offspring. It is the basic unit of biological classification and hence, its use as a measure of biodiversity.

Scientific name – consists of a genus name and specific epithet. The scientific names of species are italicized. The genus name is always capitalized and is written first; the specific epithet, on the other hand, is not capitalized and is written second.

Classification – the placing of a plant (or group of plants) in groups or taxa, which are referred to in various categories according to a particular plan or sequence; e.g,, every species is classified as a member of a particular genus, every genus belongs to a particular family, etc.

Herbarium specimens - Herbarium specimens are materials used to determine the plant diversity of particular regions, as a reference for identification, and as a source of information about plant species.

Principles and Concepts in Identifying Species of Plants

1. Identifying a landscape or plant requires recognizing the plant by one or more characteristics, such as size, form, leaf shape, flower color, odor, etc., and linking that recognition with a name, either a common or so-called scientific name

2. The most common methods of identifying plants are as follows: Expert's determination. Recognition. Matching with known herbarium specimens or illustration/ photographs/ literature.

3. The location and form (shape) of the plant can also be used to provide identifying clues.

4. Leaves. The leaf shape, size and other surface characteristics of leaves are often the first features used to narrow down the possibilities when looking at an unknown plant.

5. Leaf arrangement and or phyllotaxy

6. Bark and trunk

7. Flowers, berries, and cones

8. Plant classification. The system of plant classification is essential to reduce complications or confusion in determining a plant's identity, as the use of common names can be highly inaccurate.

Method: Illustrated discussion and lecture

Materials/Equipment Needed: LCD Projector

Introduction

The plants can be identified and classified by looking at certain distinguishing morphological characteristics and external features. Some plants are closely related, which is shown by the similarity of their flower structures. These plants are placed into a specific plant family. A herbaceous example of a family that is based on the similarity of flower parts would be Asteraceae, the aster family, of which sunflowers and daisies are members. An example of a woody plant family would be Lecythidaceae, to which putat belongs.

Within each family, there are members that are more closely related than others. This relationship is demonstrated by the similarity of basic morphological traits like leaf shape or arrangement. These plants are placed in a group called a Genus. Putat belongs to the genus *Barringtonia* while swamp daisy is placed in the genus *Acmella*.

Members of a plant genus are again subdivided, according to their similar morphological characteristics, into a grouping called a species. For example, each different type of catmon and marigold belongs to a different species (see list below).

The BINOMIAL PLANT CLASSIFICATION SYSTEM, which we have just described, gives each plant a scientific name using the genus and species.

Examples of scientific names:

Scientific Name	**Common Name**
Dillenia indica L.	Indian catmon
Dillenia philippinensis Rolfe	Philippine catmon
Tagetes erecta L.	African Marigold
Tagetes patula L.	French Marigold

When botanists group plants, they use flower parts as their primary guide because the flower is the least affected by growing conditions. In this activity, we will be looking at leaf characteristics to help us identify plants because they are more likely to be available to you.

Introductory Lecture Outline

A. Plant Nomenclature
- 1. Binomial classification system
  - a. two Latin names
    - -genus
    - -species
  - b. cultivars and varieties - -
  - c. importance

B. Morphological Characteristics
- 1. Plant type
- a. Woody
  - 1. deciduous
  - 2. evergreen
- b. Herbaceous
  - 1. annual
  - 2. perennial
  - 3. biennial

- 2. Leaf type (we will study this in detail in the field)

- 3. Fruit type
  - a. samara
  - b. pome
  - c. nut-like
  - d. cone
  - e. acorn (nut)

4. Flowers are borne on structures called inflorescences, which are a collection of individual flowers arranged in a specific order or way.
    a. spike (a catkin is a type of spike ex. pussywillow)
    b. raceme
    c. corymb
    d. umbel
    e. cyme
    f. panicle
    g. solitary
    h. head

5. Other characteristics

PLANT MORPHOLOGY

In order to successfully identify woody plants, it is necessary for an individual to have a keen awareness (working knowledge) of taxonomic terminology and concise mental pictures of leaf, bud, stem, flower, and fruit morphology.

LEAF MORPHOLOGY

ANGIOSPERM LEAF TYPES

Simple Leaf Pinnately Compound Leaf

The position of the bud determines whether the leaf is simple or compound. In the case of a single leaf, the bud is found in the axil of the leaf and stem. If the bud is located in the axil of a structure containing more than one leaf, it is termed compound. Compound leaves may have from three to 1500 leaflets. e.g *Archidendron* with four to 14 pairs having thousand leaflets.

OTHER TYPES OF COMPOUND LEAVES

Palmately Compound

ARRANGEMENT OF LEAVES

Many vegetative keys employ the arrangement of leaves and buds as a basis for separation. The use of the four categories allows him/her to categorize plants into groups and assists in eliminating many plants from consideration in the process of positive identification.

TYPES OF VENATION

Pinnate. The leaf has a prominent central vein (often termed the midrib) that extends from the base, where the petiole attaches to the blade, to the apex of the leaf. If the interveinal areas were removed, the overall effect would be that of a fishbone. Pinnate venation occurs in the leaves of many plant types. The neem tree (*Azadirachta*) is the classic example.

Palmate. There are several main veins, all of the approximately equal in size which extend from the base of the leaf to the apex of the lobe or margin of the leaf. e.g orchid tree (*Bauhinia purpurea*)

LEAF SHAPES (ovate, lanceolate, cordate, elliptical, spatulate, obovate, oblanceolate, obcordate, oblong, linear, peltate, cuneate, reniform, hastate, etc.)

LEAF BASES (cuneate, acute, rounded, cordate, oblique, sagitate, hastate, truncate, auriculate, etc.)

LEAF MARGINS (entire, serrate, serrulate, doubly-serrate, dentate, crenate, incised, sinuate, etc.)

LEAF APICES (undulate, lobed, mucronate, cuspidate, acuminate, acute, obtuse, truncate, emarginate, obcordate, et.). Using the information on the previous pages describe each of these leaves.

PLANT IDENTIFICATION KEY

A. Woody Plants

#1 Name
Plant type____________Leaf arrangement________Leaf type________________
Leaf margin___________tip_____________shape___________Fruit type ______
Other characteristics:

#2 Name
Plant type____________Leaf arrangement________Leaf type________________
Leaf margin___________tip_____________shape_____________Fruit type _____
Other characteristics:

#3 Name
Plant type____________Leaf arrangement______________Leaf type________________ Leaf margin___________ tip_____________

shape____________Fruit type_____________Other characteristics:

#4 Name
Plant type____________Leaf arrangement______________Leaf type________________ Leaf margin___________ tip_____________

shape Fruit type_____________Other characteristics:

#5 Name

Plant type_____________Leaf arrangement_______________Leaf type_________________ Leaf margin___________ tip_____________

shape_____________Fruit type_____________Other characteristics:

#6 Name
Plant type_____________Leaf arrangement_______________Leaf type_________________ Leaf margin___________ tip_____________

shape_____________Fruit type_____________Other characteristics:

#7 Name
Plant type_____________Leaf arrangement_______________Leaf type_________________ Leaf margin___________ tip_____________

shape_____________Fruit type_____________Other characteristics:

#8 Name
Plant type_____________Leaf arrangement_______________Leaf type_________________ Leaf margin___________ tip_____________

shape_____________Fruit type_____________Other characteristics:

#9 Name
Plant type_____________Leaf arrangement_______________Leaf type_________________ Leaf margin___________ tip_____________

shape_____________Fruit type_____________Other characteristics:

B. Herbaceous Plants

#1 Name
Plant type _______________________
arrangement_______________________________
margin____________________tip____________________
shape___________________Flower characteristics: Other characteristics:

#2 Name
Plant type_______________________
arrangement_______________________________
margin____________________tip____________________
shape___________________Flower characteristics: Other characteristics:

#3 Name
Plant type_______________________

arrangement_ _______
margin_ _______
tip_ _______
shape_ _______
Flower characteristics:
Other characteristics:

#4

Name
Plant type_______________________
arrangement______________________________ Leaf
Leaf

Leaf
Leaf

Leaf
Leaf

Leaf
Leaf

margin____________________tip___________________
shape__________________Flower characteristics: Other characteristics:

#5 Name
Plant type______________________Leaf arrangement______________________________ Leaf margin____________________tip___________________
shape__________________Flower characteristics: Other characteristics:

TEST YOUR KNOWLEDGE

Activity 1 WORKSHEET

1. What are three identifying characteristics of a dicot? Give an example.

2. What are three identifying characteristics of a monocot? Give an example.

3. What are the differences between annual and perennial plants? Give an example of each.

4. Why are scientific nomenclature and plant classification important?

5. Explain the differences between deciduous and evergreen trees.

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Module 2
Assessment of Peatland Vegetation

Overview of Module 2

This Module presents some methods, sampling techniques, and computations to assess the vegetation. The output in this first part will become the basis for monitoring each peatland.

Lesson 1: Assessment of Peatland Ecosystem

Duration: 3 hours

Specific Learning Objectives

Upon completion of this module, the participants will be able to:
1. understand the special role of peatland in maintaining biodiversity.
2. understand the biodiversity values of peatlands that demand special consideration in conservation strategies and land use planning.
3. explain how peatland/s become vulnerable to human activities.

Suggested Methods: lecture with ppt. presentation and board notes

A. Supplies: whiteboard marker

B. Equipment: multimedia projector and projection screen

C. Visual Aids: slides or photos

D. Handouts: see inserts

A. Introduction

According to Buot, Jr. (2019), the use of appropriate methods and tools for the students or researchers to get the exact data like abundance, density, frequency, and other parameters of a species is very important. This part of the manual will introduce to the peatland managers, workers, and researchers the ecological techniques that are useful in monitoring biodiversity of forest ecosystems, particularly the important watersheds, peatlands, natural parks, and protected areas nationwide.

B. Lesson Proper/Course Methodology

In the report of Parish, Sirin, Lee, & Silvius (2007), they stated that peatlands are wetland ecosystems thatise characterized by the accumulation of organic matter called "peat" which derives from dead and decaying plant material under high water saturation conditions. The report also included the need for peatland assessment in contribution to international decision-making processes relating to global problems such as biodiversity conservation, climate change, desertification, pollution, poverty, and health.

The following are sampling techniques for areas dominated by grasses and other ground cover species:

B.1 **Point Center Quarter Method** *(Buot, Jr., 2019)*

This is a plotless method of sampling used especially in forest ecosystem Mueller-Dombois and Ellenberg 1974).

1. Lay out one main transect line representing the whole area, which may be running either from north to south or from east to west.

2. At a distance of 50 m in the main transect line, run an alternately left and right branching sub-transect.

3. In each sub-transect, locate five arbitrary points at a distance of 20 m.

4. Divide each arbitrary point into four quadrants.

5. Locate the tree nearest the point in each quadrant. Then take note of the following:
   5.1 identify the species.

   5.2 determine the basal area or diameter at breast height.

   5.3 determine the point-to-plant distance (from the center of the crown or the center of the rooted base rather than from the edge of the crown).

   5.4 take note of the anthropogenic activities on the site.

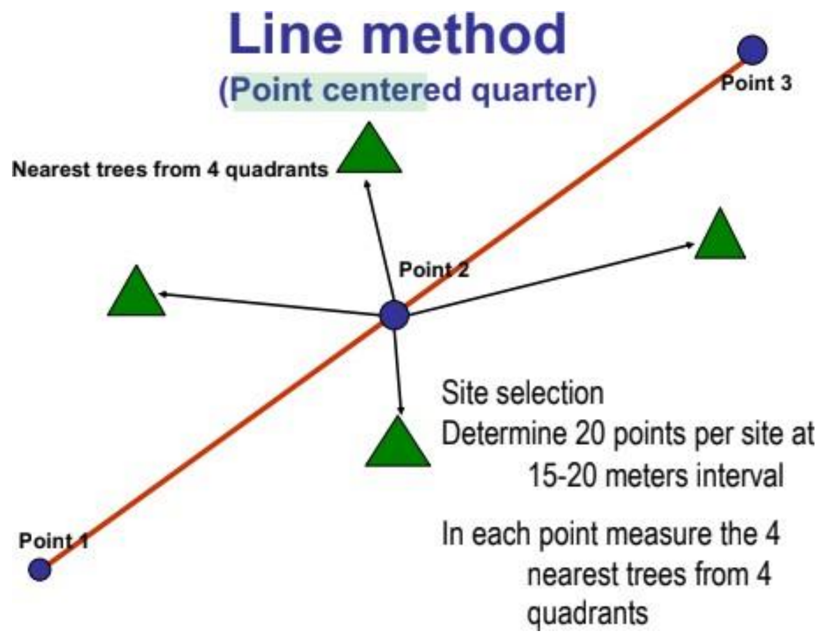


Figure 1. Laying down the points and the quadrants in a point centered quarter method.

6. Compute for the total density of all species as follows:
   6.1 Total all points to plant distances for all species.
   6.2 Obtain mean distance among plants.

$$\text{Mean distance} = \frac{\text{Total point to plant distance}}{\text{Total number of plants}}$$

   6.3 Determine the mean area per plant.
   Mean area/plant = $(\text{mean distance})^2$
   6.4 Obtain total density of all species

$$\text{Total density of all species} = \frac{\text{Unit area (ha.)}}{\text{Mean area/plant}}$$

   6.5 Compute for other parameters

$$\text{6.5.1 Relative density} = \frac{\text{Individuals of a sp.}}{\text{Total individuals of all spp.}} \times 100$$

Basal Area for a sp.
6.5.2 Relative dominance = --------------------------- x 100

Total basal area for all spp.

$$6.5.3\ \text{Frequency} = \frac{\text{Number of points at which a sp. occurs}}{\text{Total number of points sampled}} \quad 100$$

$$6.5.4\ \text{RF} = \frac{\text{Frequency value for a sp.}}{\text{Total frequency value for all spp.}} \times 100$$

6.5.5 I.V = Relative density + Relative Dominance + Relative frequency

B.2 Quadrat Technique *(Buot, Jr., 2019)*

This technique makes use of plots or quadrats as the sampling unit. The students or researchers may utilize the species-area curve to determine the exact size of the plot, or we may opt to use a universally accepted plot size of 100 sq m distributed strategically throughout the area, enough to represent the biodiversity and the physical characteristics of the site. Others use a 200 sq m size plot. This all depends on the heterogeneity of the sampling area. The number of plots also depends on the size and the heterogeneity of the biodiversity in the site.

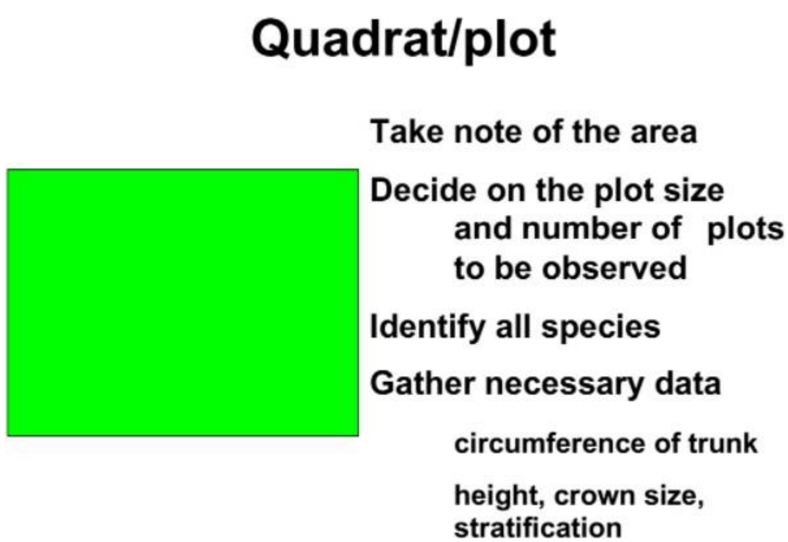


Figure 2. Setting up the plot in a quadrat sampling technique.

Once you have decided as to the size and number of plots, start the activity per plot:

1. identify the species.
2. determine the basal area or diameter at breast height.

3. determine the point-to-plant distance (from the center of the crown or center of the rooted base rather than from the edge of the crown).
4. take note of the anthropogenic activities on the site.
5. tabulate and analyze data of all plots (density, basal area, frequency, dominance).

Types of Quadrat Sampling Techniques

A. Random Sampling Technique

1. Out in the field, use the tent stakes as the corners of your 10 x 10 grid, and run out the twine between the stakes, marking each meter with a piece of flagging tape.
2. Next, find the center of each sample grid, being careful not to trample this area, and mark it off with popsicle sticks and twine.
3. Identify each quadrat with a label, Q1 through Q10, and count the number of the plant within the sample area.
4. For plants on the border of the quadrat, only count them if the center of the plant falls within the sample area.
5. Record your data.

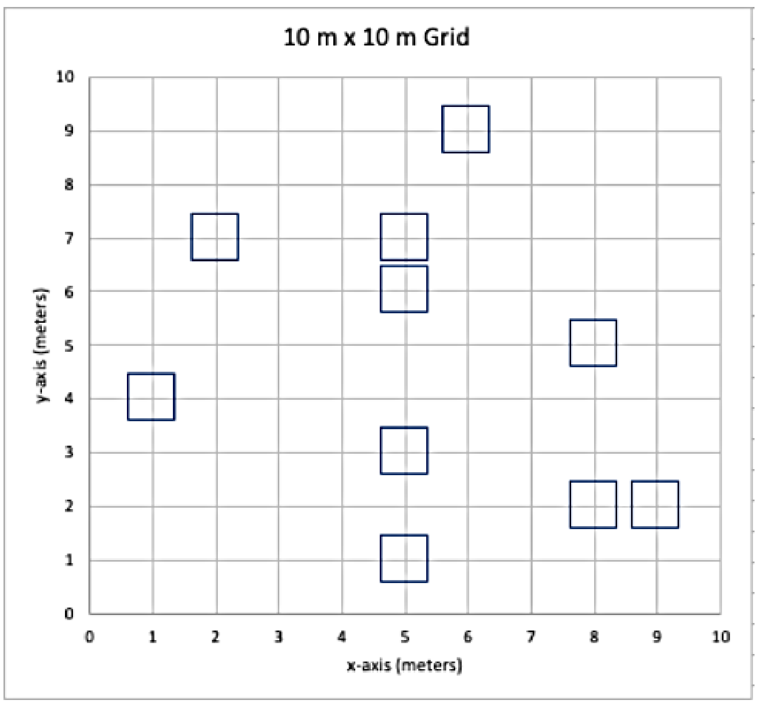


Figure 3. Random sampling within a 10m x 10m grid

***B.3* Line Intercept Technique** *(Buot, Jr., 2019)*

This technique describes the vegetation changes along an environmental gradient or in relation to some marked feature of topography. It gives the number, linear extent, vertical extent and frequency of occurrence of individuals of different species in grasslands, agroecosystems and low statured forest lands (Tansley, 1946).

1. Lay a transect of about 30 m in length subdivided into intervals of any desired size.
2. Make an assessment of each interval and take the following data from each plant that underlie or overlie the transect line:
    - 2.1 name of the plant
    - 2.2 height of the plant
    - 2.3 cover of the plant (This refers to the length of the transect line intercepted by individual plants)

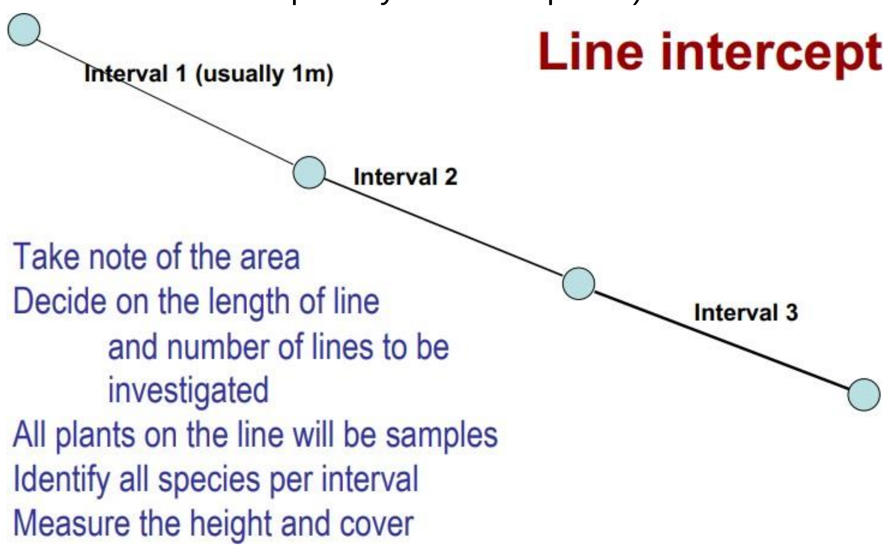


Figure 4. Field set up of a line intercept sampling technique

3. Data for the different transect intervals should be recorded separately. The length of transect segments overlying bare ground should be measured and recorded in the same manner.
4. Get the average height of species encountered in the sampling line.
5. Compute for the following:

5.1 Relative Ht = $\dfrac{\text{Ave. ht. of sp. A}}{\text{Total ave. ht. of all spp.}} \times 100$

5.2 Dominance or Cover = $\dfrac{\text{Total intercept lengths for a sp.}}{\text{Total transect length}} \times 100$

5.3 Relative Cover (RC) = Total intercept lengths for a sp

$$\overline{\qquad\qquad\qquad\qquad} \times 100$$

Total of intercept lengths for all spp.

$$5.4 \text{ Frequency} = \frac{\text{No. of intervals in which a sp. occurs}}{\text{Total number of transect intervals}} \times 100$$

$$5.5 \text{ Relative Frequency} = \frac{\text{Frequency value for a sp}}{\text{Total of frequency values for all spp.}} \times 100$$

5.6 Summed Dominance Ratio (DR)

$$5.6.1 \text{ DR} = \frac{RC + RH}{2}$$

$$5.6.2 \text{ DR} = \frac{RC + RF}{2}$$

$$5.6.3 \text{ DR} = \frac{RC + RH + RF}{3}$$

6. Determine the dominant species.

7. Discuss the implications of your results.

C. Transect or Line Survey

Instead of a grid, the student or researcher wanted to know the distribution and abundance of plants with respect to distance from a roadside, or elevation on a hillside, or along the side of a stream or hiking trail. Transect line survey may be more informative and also avoids bias.

1. Sample every 10 meters along the 100 m line.

2. Document your method.

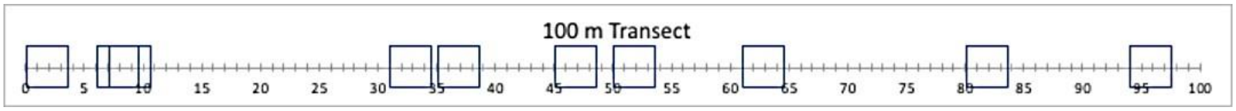


Figure 5. Random Sampling along a 100m transect

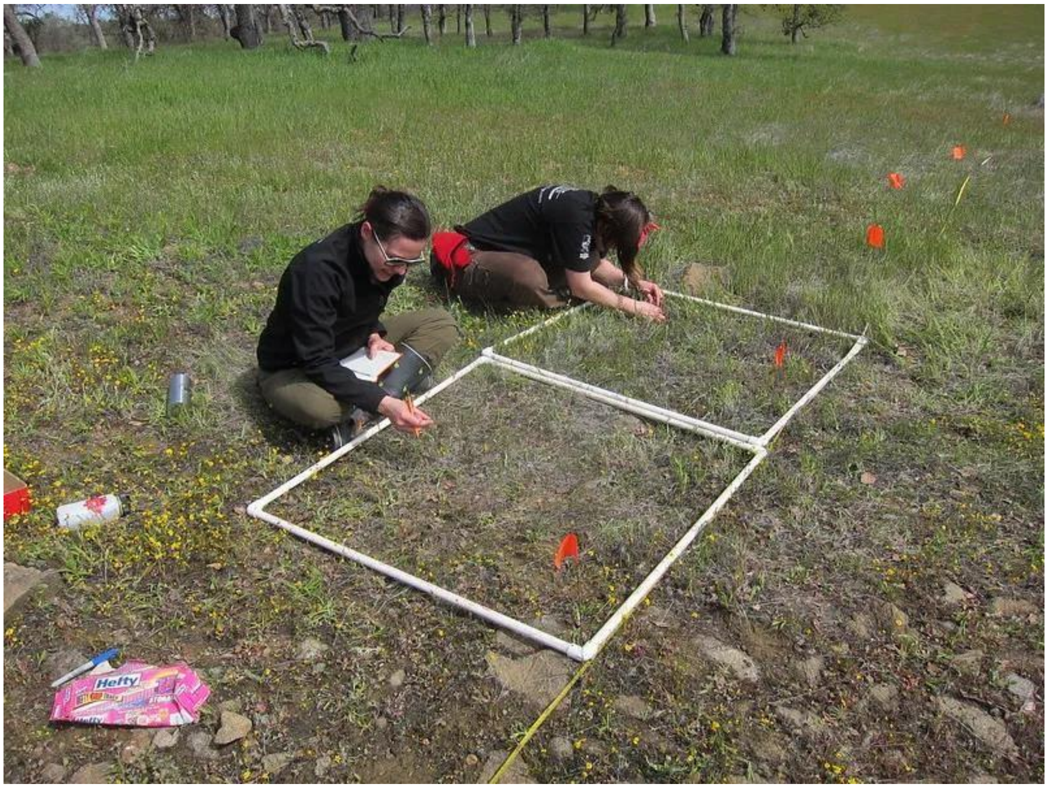
Data Analysis:

Data Analysis	**Number of Plant Species**
Q1	
Q2	
Q3	
Q4	
Q5	
Q6	
Q7	
Q8	
Q9	
Q10	
Sum	
Average (Mean)	
Standard Deviation	
95% Confidence Interval	

C.1 Belt Transect (Udayangani, 2021)

The key difference between belt and line transect is that belt transect uses a rectangular area centered on a line to collect information while line transect uses a straight line to gather data.

Belt transect is a systematic sampling method. It is a rectangular area centered on a line that is set across an area having a clear environmental gradient. In other words, a belt transect can be considered as a widening of the line transect to form a continuous belt or a series of quadrats. Hence, this method produces more data than a line transect. This method uses a quadrat to collect data. Quadrats are placed over the line to collect the data. Once the plants and/or animals inside the quadrat are identified, their abundance can be estimated. It also can be taken as a permanent sampling plot to gather data for a longer period of time.



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Instruction:

Find a nearby vacant lot that be used for this simple activity (Alberto, 2012).

1. Go to the area, measure 1 meter square area, this is your quadrat. You will study the organisms within the one square meter quadrat.
2. Fix a wooden stick at each corner of your quadrat. Tie the rope of the four sticks enclosing the quadrat.
3. Count the species of plants found in the quadrat. Study each species.
4. Count and record the number of plants belonging to the same species. Use the main stem of the plant in counting.

Guide Questions:

1. What plants are common in your quadrat and in other quadrats?
2. In your quadrat, what plant species has the largest population? Show your computation and discuss the results.

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____
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____.

Glossary

Ecosystem	a group of organisms and their interaction or interrelationships with the nonliving environment.
Habitat	a place where an organisms lives.
Population	a collective group of organisms of the same species occupying a particular space, has various characteristics which, although, best expressed as statistical functions.
Species abundance	associated with species diversity, it refers to the number of individuals of a species in a given area.
Wetland	are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.

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Module 3
Data Analysis

Overview of Module 3

This Module aims to organize the information in a logical manner. It aids in the analysis of data from various viewpoints and statistical approaches. This process aims to discover useful information and serves as the basis for decision-making.

Duration: 2 hours

Specific Learning Objectives

Upon completion of this module, the participants will be able to:

1. Understand how to compute for relative frequency, relative density, and relative dominance of flora to determine the species importance value index.
2. Determine if the populations of flora are homogenous or heterogeneous.
3. Identify the diversity status of flora through determination of different diversity indices.

Suggested Methods: lecture with power point presentation and board notes

Resources

- **A. Supplies:** white board marker
- **B. Equipment:** multimedia projector and projection screen
- **C. Visual Aids:** slides or photos
- **D. Handouts:** see inserts

Introduction

Peatlands cover an estimated 50 million hectares (Mha) across the tropics with a carbon pool of at least 100 billion tonnes, or about half of the global peatland emitted carbon. Nearly 35%-50% (approximately 27.1 Mha) of these tropical peatlands are located in Southeast Asia and formed on coastal and subcoastal lowlands under forest vegetation (Mishra, *et al*., 2021). Recent studies show that anthropogenic activities and climate change threaten the stability of this ecosystem. Of the 27.1 Mha of peatland in Southeast Asia, 12.9 Mha had been deforested and mostly drained by 2006 because mainly of increasing land development pressures (Hooijer, *et al*., 2010). Some peat swamp forests have been extensively logged for agriculture and human settlement, like in the case of peatlands in Sumatra, Indonesia where these became very attractive to investors for oil palm and pulp plantations. In 2010, oil palm plantations in Indonesia occupied around 2.5 Mha of peatlands and are projected to be more than 3.5 Mha in 2030.

Another significant destruction to this ecosystem is the conversion of approximately 1.4 Mha of peat swamp forests in Central Kalimantan, Indonesia, during the mid to late 1990s, where 0.5 Mha of rice fields and 1 Mha for other crops and the construction of 700 km of primary canals and numerous secondary canals were made. But these conversions failed and left mounting ecological problems, including fires and long-lasting emissions of Green House Gases (GHGs) (Murdiyarso, *et al*., 2019). Therefore, effective conservation and sustainable management of these tropical peatlands is a major challenge. One of the basic techniques on how to efficiently conserve and manage an ecosystem is through the assessment of biodiversity. By looking at species richness and relative abundance, researchers may certainly measure the damage of an ecosystem and recommend solutions to existing problems.

Lesson Proper

Data in biodiversity assessment may be used to determine the 'biological health' of an ecosystem. This determines the complexity of interactions happening within the ecosystem and therefore estimates the net primary productivity, which in turn provides more food resources for heterotrophic animals inhabiting the area, as well as delivers more by-products and services to humans.

I. Abundance Estimation

Basic data that the researchers must get to start is a combined abundance estimate, usually expressed as relative values, including relative frequency, relative density, and relative dominance.

A.1. Frequency is equals to the number of quadrats that the species occurred over the total number of all quadrats. Showed as:

$$\text{Frequency} = \frac{No. of\ quadrats\ where\ the\ species\ occurred}{Total\ number\ of\ quadrats}$$

A.2. Relative frequency is the frequency of a given species expressed as a percentage of the sum of frequency values for all species present. Illustrated as:

$$\text{Relative frequency} = \frac{Frequency\ of\ a\ species}{Summation\ of\ all\ frequencies}\ x\ 100$$

In a given example, researchers went to a peatland and survey the tree composition, thus had the frequency data of trees to compute for relative frequency as shown in Table 1.

Table 1. Frequency and Relative frequency of trees in peatland

Scientific Name	Frequency	Relative Frequency
Terminalia copelandii	0.32	16.67%
Goniothalamus malayanus	0.68	35.42%
Kayea paniculata	0.22	11.46%
Cratoxylum sumatranum	0.24	12.5%
Elaeocarpus cumingii	0.46	23.96%
Total	1.92	100.01%

Note that in the survey the researchers used 50 quadrats with dimensions 1,000 m^2.

B.1. Density is the total number of individuals per species per total area sampled shown as:

$$\text{Density} = \frac{Total\ number\ of\ individuals\ per\ species}{Total\ area\ sampled}$$

B.2. Relative density is the number of a given species expressed as a percentage of all species present. Illustrated as:

$$\text{Relative density} = \frac{Density\ of\ a\ species}{Summation\ of\ all\ densities}\ x\ 100$$

Density data is needed to compute for relative density as shown in Table 2.

Table 2. Density and Relative density of trees in peatland

Scientific Name	Density	Relative Density
Terminalia copelandii	0.035	20.23%
Goniothalamus malayanus	0.051	29.48%
Kayea paniculata	0.027	15.61%
Cratoxylum sumatranum	0.032	18.50%
Elaeocarpus cumingii	0.028	16.18%
Total	0.173	100%

C.1. Diameter at breast height (DBH) measure the circumference of the tree at breast height.

$$\text{DBH} = \frac{C}{\pi}$$

Note that the measurement should be in terms of centimeters.

C.2. Basal area can be computed using diameter at breast height (DBH) data as shown:

$$Basal\ area = 0.7584\ (DBH)^2$$

Note that the basal area should be computed in meter.

C.2. Dominance is the summation of basal area of a species over total area sampled. Illustrated as:

$$\text{Dominance} = \frac{Summation\ of\ basal\ area\ of\ a\ species}{Total\ area\ sampled}$$

C.3. Relative dominance is the basal area of a given species expressed as a percentage of the total basal area of all species present. Illustrated as:

$$\text{Relative dominance} = \frac{Dominance\ of\ a\ species}{Summation\ of\ all\ dominance}\ x\ 100$$

Dominance data is needed to compute for relative dominance as shown in Table 3.

Table 3. Dominance and Relative dominance of trees in peatland

Scientific Name	DBH (cm)	Basal area (m)	Dominance	Relative Dominance
Terminalia copelandii	19,934.3	30,136.11	30.14	7.14%
Goniothalamus malayanus	64,560.18	316,100.63	316.1	74.90%
Kayea paniculata	8,471.55	5,443.4	5.44	1.29%
Cratoxylum sumatranum	9,452.62	6,777	6.78	1.61%
Elaeocarpus cumingii	28,953.67	63,579	63.58	15.06%
Total			422.04	100%

D. Species importance value index is a measure of how dominant a species is in a given ecosystem. This can be calculated by summing the three relative values (Relative frequency, Relative density and Relative dominance) and divide the total by 3. Illustrated as:

$$\text{Importance value index} = \frac{Rel.frequency + Rel.density + Rel.dominance}{3}$$

Table 4 shows the Important value index of each species of plant following the computation.

Table 4. Important value index of trees in peatland

Scientific Name	Relative Frequency	Relative Density	Relative Dominance	Important Value Index
Terminalia copelandii	16.67%	20.23%	7.14%	14.68

Goniothalamus malayanus	35.42%	29.48%	74.90%	46.60
Kayea paniculata	11.46%	15.61%	1.29%	9.45
Cratoxylum sumatranum	12.50%	18.50%	1.61%	10.87
Elaeocarpus cumingii	23.96%	16.18%	15.06%	18.40

Note that the sum of all the important values for a given slope should add up to 100. A high important value indicates that *Cocos nucifera* is well represented in the sampled area because: (a) a large number of individuals of *Cocos nucifera* compared with other species in the area or (b) a smaller number of individuals of *Cocos nucifera*, but the tree is large compared with others in the area.

II. Homogeneity and Heterogeneity

Vegetation heterogeneity can be described as the difference or diversity in the structure and composition of plant communities over space and time (Toombs, *et al*., 2010). In contrast, homogeneity is the ecosystem's state of being uniform in terms of the arrangement of component elements or constituents.

In order to demonstrate the homogeneity or heterogeneity of the ecosystem's vegetation, relative frequency data is needed. Example from the estimation abundance will be taken in this section to demonstrate homogeneity and heterogeneity of population as shown in Table 5.

Table 5. Relative frequency of trees in peatland

Scientific Name	Relative Frequency
Terminalia copelandii	16.67%
Goniothalamus malayanus	35.42%
Kayea paniculata	11.46%
Ctatoxylum sumatranum	12.5%
Elaeocarpus cumingii	23.96%

Divide the species or structural types that occur in the study area into five classes based on percentage frequencies. Afterwards, determine how many species of plant will fall in every class using the relative frequency data as shown in Table 6. Create a histogram with the percentage of the total number of species in y-axis and the classes in the x-axis as shown in Figure 1.

Table 6. Number of species fall per class

Classes	Percentage Frequencies	No. of species fall in class
Class A	1-20%	3
Class B	21-40%	2
Class C	41-60%	0
Class D	61-80%	0
Class E	81-100%	0

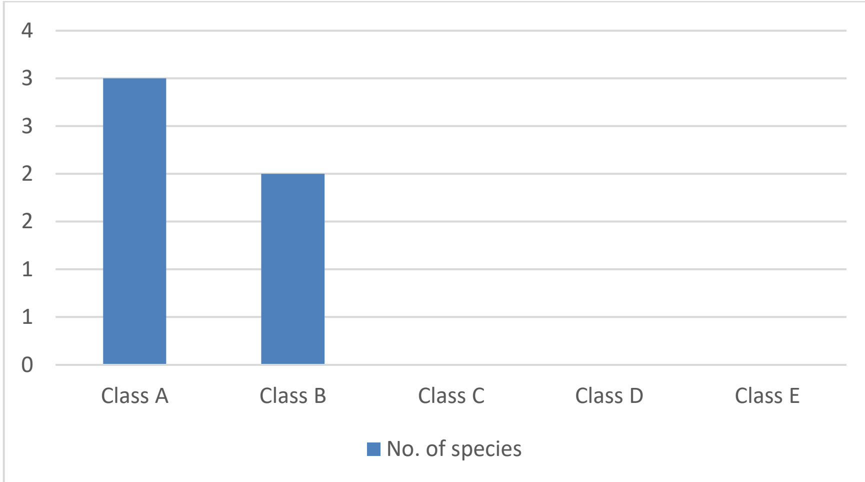

Figure 6. Histogram illustrating the homogeneity/heterogeneity of trees in peatland

In a heterogenous stand, classes B, C and D are relatively high while class A is the highest. Therefore, homogenous is indicated when class E is greater

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III. Diversity Indices

Diversity index is the quantitative measure of species diversity in a given ecosystem based on the species richness (the number of species present) and species abundance (the number of individuals per species). As a general rule, the more species you have sampled, the more diverse the area.

There are two types of indices which are Simpson's Index of Diversity (D) and Shannon Index (H). The Simpson's Index of Diversity is a dominance index because it gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity. While the Shannon Index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled.

In **Simpson's Index of Diversity**, p_i is the proportion of individuals in the i-th species. Illustrated as:

$$1 - \mathrm{D} = \sum p\,i^2$$

In the **Shannon Index**, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species. Illustrated as:

$$\mathrm{H} = -\sum_{i=1}^{s} pi \ln pi$$

As an example, let us consider the following data and computation in Table 7.

Table 7. Data to be computed for Simpson's Index of Diversity and Shannon Index

Scientific Name	Number of Individuals (n)	n/N	p_i	p_i^2	ln p_i	p_i ln p_i
Terminalia copelandii	35	35/173	0.202	0.041	-1.599	-0.323
Goniothalamus malayanus	51	51/173	0.295	0.087	-1.221	-0.360

Kayea paniculata	27	27/173	0.156	0.024	-1.858	-0.290
Cratoxylum sumatranum	32	32/173	0.185	0.034	-1.687	-0.312
Elaeocarpus cumingii	28	28/173	0.162	0.026	-1.820	-0.295
Total	173			0.212		-1.58

s (number of species) = 5
N (total number of individuals) = 173
Σ (sum) of p_i^2 $(n/N)^2$ = 0.212
Σ (sum) of $p_i \ln p_i$ = 1.58
D = 1-0.212 = 0.788
H = - (-0.323 + -0.360 + -0.290 + -0.312 +-0.295) = - (-1.58) = 1.58

Simpson's Index of Diversity represents the probability that two individuals randomly selected from a community will belong to different species. The value of this index ranges between 0 and 1, the greater the value, the greater the diversity. Hence, in the example D = 0.788 which is relatively high. High species diversity suggests that the ecosystem is more stable meaning there are more available ecological niches, there are complex food webs, and the environment is less likely to be hostile. But when the species diversity is low this suggests that there are relatively few ecological niches available, and the food webs are simple due to may be quite stressful environment allowing only few species to adapt.

Shannon Index increases as both the richness and the evenness of the community increase. The fact that the index incorporates both the components of biodiversity, it can be seen as both a strength and weakness. It is a strength because even the rarest species in the area have an actual contribution to the diversity, but it is a weakness because it makes it difficult to compare communities that differ greatly in richness. The value of the index is interpreted using the descriptions proposed by Fernando (1998):

Description	Value
Low	H = 1.00-2.49
Moderate	H = 2.50-2.90
High	H = 3.00-4.00

In the example H = 1.58 which is considered to have low diversity.

Due to the confounding of richness and evenness in the Shannon Index, many biodiversity researchers prefer to stick to two numbers for comparative studies, combining a direct estimate of species richness with some measure of dominance or evenness.

IV. Community Similarity

Two ecosystems can be compared in terms of commonality of species present. One of the ways on how to determine this similarity of 2 ecosystems is by using Sorenson's coefficient (CC). The equation is:

$$\mathrm{CC} = \frac{2ab}{a + b}$$

Where (ab) is the number of species the two communities have in common, (a) is the total number of species found in community 1, and (b) is the total number of species found in community

2. CC gives a value between 0 to 1, the closer the value to 1, the more the communities have in common. Value of CC equals to 1 means complete community overlap while value equals to 0 means complete community dissimilarity.

GLOSSARY

Basal area. The cross-sectional area of trees at breast height. It is a common way to describe stand density. Formula is Tree Basal Area (TBA) = 0.005454 $(DBH)^2$.

Biological health. A state of condition of an ecosystem. It is whether the ecosystem is in stable or unstable condition.

Carbon pool. The reservoir of carbon that have the capacity to both take in and release carbon.
Ecological niche. A term for the position of a species within an ecosystem, describing both the range of conditions necessary for persistence of the species, and its ecological role in the ecosystem.

Greenhouse gases. These gases trap heat in the atmosphere and warm the planet. The main gases responsible for greenhouse effect include carbon dioxide, methane, nitrous oxide, water vapor and fluorinated gases.

Histogram. A graphical representation that organizes a group of data points into user-specified ranges.

Peatland. A terrestrial wetland ecosystem in which waterlogged conditions prevent plant material from fully decomposing. Consequently, the production of organic matter exceeds its decomposition, which results in a net accumulation of peat. A type of wetland which occur in almost every country and are known to cover at least 3% of global land surface.

Primary productivity. The rate at which energy is converted to organic substances by photosynthetic producers (photoautotrophs), which obtain energy and nutrients by harnessing sunlight, and chemosynthetic producers (chemoautotrophs), which obtain chemical energy through oxidation.

Species evenness. A description of the distribution of abundance across the species in a community. Species evenness is highest when all species in a sample have the same abundance. Evenness approaches zero as relative abundances vary.

Species richness. The number of different species represented in an ecological community. It does not take into account the abundances of the species or their relative abundance distributions. Sometimes considered synonymous with species diversity, but the formal metric species diversity takes account both species richness and evenness.

Sustainable management. The application of sustainable practices in the environment by managing in a way that will benefit current generations and future generations.

TEST YOUR KNOWLEDGE

Activity 2: Abundance and Diversity Estimates

After the assessment of 1,000 m^2 peatland from Caimpugan Peatland in Agusan del Sur the researchers divided the area into 50 quadrats and following trees were sampled:

Scientific Name	No. of Individuals (n)	No. of quadrats where the species occurred	DBH
Semecarpus macrophyllus	8	5	5,239.24
Mangifera caesia	15	11	28,474.30
Goniothalamus malayanus	32	20	50,106.32
Elaeocarpus cumingii	19	8	34,743.70
Terminalia copelandii	40	28	85,289.55

I. Compute for the following:

1. Frequency and Relative frequency
2. Density and Relative density
3. Basal area, Dominance, and Relative dominance
4. Important Value Index
5. Simpson's Index of Diversity
6. Shannon Index

II. Answer the following questions:

1. Why there's a need to analyze the data in biodiversity assessment?
2. What is the importance of determining the species importance value index?
3. Why is it better use both Simpson and Shannon Index of Diversity?

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