La-Net

BIO 407

FIELD COURSE II

Course code: BIO 407

Course title: Field Course II

Course credit load: 1 Unit

Series 1: Foundations of Field Biology

- **Part 1.1: The Nature and Scope of Field Biology**
    - Sub Part 1.1.1: Defining field biology and its place in the biological sciences
    - Sub Part 1.1.2: Types of field studies in biology
    - Sub Part 1.1.3: Field biology in the Nigerian context
- **Part 1.2: Planning and Conducting Field Trips**
    - Sub Part 1.2.1: Objectives, planning, and pre-trip preparation
    - Sub Part 1.2.2: Field safety, conduct, and ethics
    - Sub Part 1.2.3: Time management and teamwork in the field
- **Part 1.3: Field Observation and Basic Recording**
    - Sub Part 1.3.1: Principles of field observation
    - Sub Part 1.3.2: Field notebooks and basic recording techniques
    - Sub Part 1.3.3: Use of GPS, maps, and basic navigation

Introduction

Field biology is the direct study of living organisms and their environments in natural settings, and it forms the practical foundation of ecology, wildlife biology, hydrobiology, taxonomy, and systematics. The knowledge, skills, and habits of careful observation developed through field biology are essential complements to classroom and laboratory learning, giving students direct experience with the complexity, variability, and richness of the natural world in a way that no textbook or laboratory exercise can fully replicate.

This Series establishes the foundational concepts and skills required throughout Field Course II. It begins by defining field biology and its scope within the biological sciences, distinguishing the major types of field study, and situating field biology within the Nigerian biodiversity context. It then addresses the planning, safety, ethics, and time management requirements of field trips, before introducing the core skills of observation, field notebook recording, and basic navigation that underpin all subsequent fieldwork in this course.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** explain the nature and scope of field biology and describe its applications in the Nigerian context,
- **SLO 1.2** plan and prepare for a field trip, applying field safety, ethical conduct, and time management principles, and
- **SLO 1.3** demonstrate correct field observation, notebook recording, and basic GPS and map use.

1.1 The Nature and Scope of Field Biology

1.1.1 Defining field biology and its place in the biological sciences

Field biology is the branch of biological science concerned with the study of living organisms and ecological processes in their natural environments, as opposed to the controlled conditions of the laboratory; it encompasses the observation, description, sampling, and experimentation carried out in natural habitats ranging from tropical forest and savanna to freshwater streams, coastal mangroves, agricultural land, and urban green spaces; the data, specimens, and observations gathered in the field provide the raw material that underpins ecology, wildlife biology, hydrobiology, taxonomy, systematics, conservation biology, and many related disciplines.

Field biology occupies a unique position within the biological sciences because it engages with organisms and communities in their full ecological context, capturing interactions, behaviours, and spatial patterns that are lost or altered when organisms are removed to the laboratory; the complementarity of field and laboratory biology is a defining feature of modern biological research, with field observations generating hypotheses that are tested experimentally in the laboratory, and laboratory results informing the design of more refined field studies; professional biologists working in ecology, conservation, agriculture, fisheries, forestry, and environmental management all rely fundamentally on field biology skills developed through courses such as this one.

Fill in the blank: Field biology studies living organisms in their natural environments, providing raw material for disciplines including ecology, wildlife biology, taxonomy, and ________ biology.

1.1.2 Types of field studies in biology

Field studies in biology take several forms depending on the question being asked and the organisms or systems being studied: descriptive surveys (systematic recording of the species present, their abundance, and their distribution in a defined area, without experimental manipulation); comparative studies (comparing biological properties between sites, habitats, time periods, or treatments); field experiments (manipulating one or more variables in the field to test specific hypotheses, while keeping other variables as constant as possible); and monitoring programmes (repeated surveys at fixed sites over time to detect changes in species composition, abundance, or habitat condition).

Each type of field study has strengths and limitations: descriptive surveys are essential for baseline biodiversity assessment but cannot by themselves establish cause-and-effect relationships; field experiments can establish causation but are logistically demanding and may be confounded by uncontrolled environmental variation; long-term monitoring provides crucial data on trends and responses to disturbance but requires sustained commitment of resources over years or decades; choosing the appropriate study design for a given biological question is a foundational skill developed through field courses and refined throughout a biological career.

Fill in the blank: Field ________ manipulate one or more variables in natural conditions to test specific hypotheses, while descriptive surveys record species presence and abundance without manipulation.

1.1.3 Field biology in the Nigerian context

Nigeria exceptional biodiversity, encompassing tropical rainforest, Guinea and Sudan savanna, freshwater river systems, coastal mangroves, and Sahelian dryland, offers outstanding opportunities for field biology education and research; the Cross River National Park, Yankari Game Reserve, the Niger Delta wetlands, and numerous university and state forest reserves provide field sites of high ecological value within reach of many Nigerian universities; however, rapid habitat loss, fragmentation, and biodiversity decline make field biology in Nigeria increasingly urgent, as field studies are needed to document species, monitor trends, and inform conservation.

Field biology students in Nigeria gain skills that are directly relevant to national priorities including forestry and agro-ecosystem management, fisheries biology, wildlife conservation, environmental impact assessment, and invasive species management; the ability to conduct systematic field surveys, collect and identify biological specimens, and communicate findings in scientific reports equips graduates for careers in government agencies (such as NESREA, FRIN, and the National Parks Service), NGOs, research institutes, universities, and the private sector environmental consulting industry.

Fill in the blank: Nigeria biodiversity, spanning tropical rainforest, savanna, mangroves, and freshwater systems, provides field biology students with outstanding opportunities for ecological study relevant to national ________ priorities.

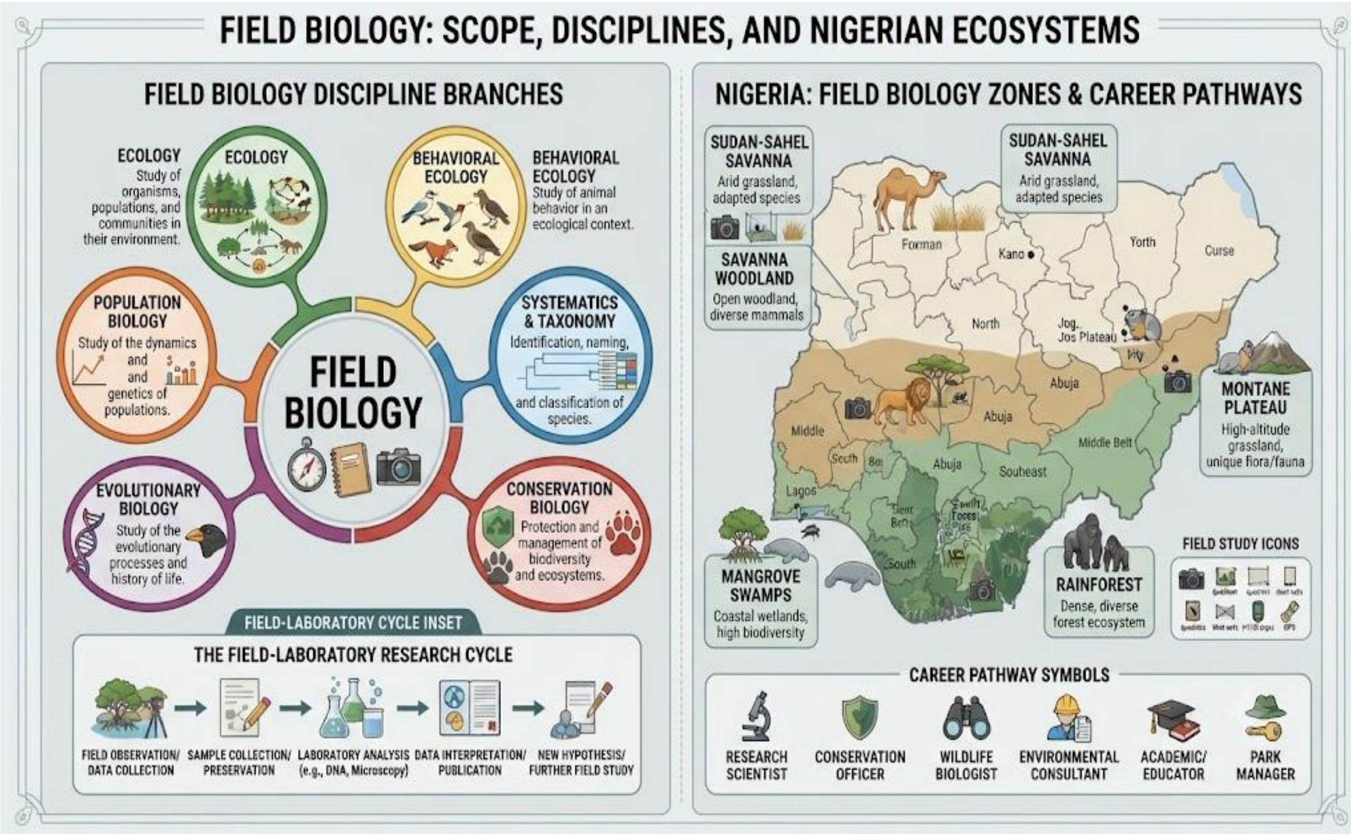

Figure 1.1: Field biology scope and Nigerian context

Pilot questions 1.1

1. Define field biology and explain its relationship to laboratory biology.
2. Name four disciplines that rely on data gathered through field biology.
3. Distinguish between a descriptive survey and a field experiment.
4. Name two major field biology sites in Nigeria.
5. Name two career fields that require field biology skills in Nigeria.

1.2 Planning and Conducting Field Trips

1.2.1 Objectives, planning, and pre-trip preparation

Effective field trips require clear objectives defined before departure: what biological questions will be addressed, which species or communities will be surveyed, what data will be collected, and by what methods; the objectives drive all subsequent planning decisions including the choice of site, the timing and duration of the trip, the equipment and supplies needed, and the number and roles of team members; a written field plan or protocol, prepared before departure and shared with all participants, ensures that the trip proceeds systematically even when unexpected conditions are encountered.

Pre-trip preparation includes: site reconnaissance or background research (identifying the habitat, access routes, permits required, and potential hazards at the planned site); equipment check (ensuring that all required equipment is available, functional, and packed, including GPS receivers, data sheets, collection equipment, first aid kit, and any permits or permissions for collecting or access); a pre-departure briefing covering the objectives, safety protocols, roles and responsibilities of each team member, and the schedule for the day; and logistical arrangements including transport, food, water, and communication arrangements in case of emergency.

Fill in the blank: A written field ________ or protocol, prepared before departure and shared with all team members, ensures the trip proceeds systematically even under unexpected conditions.

1.2.2 Field safety, conduct, and ethics

Field safety principles for BIO 407 build on those established in Field Course I (BIO 307), extending to more demanding and diverse field environments including forest interiors, riverbanks, rocky terrain, and visits to industrial or wildlife park sites; the additional environments introduce specific hazards including venomous snakes and insects in forested areas, currents and crocodiles near waterways, unfamiliar terrain and the risk of getting lost in dense vegetation, and traffic and security considerations during urban or peri-urban site visits; a thorough site-specific hazard assessment and briefing before each field session is essential.

Ethical conduct in field biology means collecting only what is scientifically necessary, minimising habitat disturbance, observing all relevant collection permits and access permissions, treating all living organisms with respect and care, releasing live-captured organisms promptly after examination unless voucher specimens are specifically required, and representing data honestly in all records and reports; students should be aware that falsifying field records is a serious breach of scientific ethics with long-term professional consequences, as is collecting without permits or entering protected areas without authorisation.

Fill in the blank: Ethical field biology requires collecting only what is scientifically ________ , minimising habitat disturbance, and observing all collection permits and access permissions.

1.2.3 Time management and teamwork in the field

Effective time management in the field is essential because field conditions, light, tide, weather, and animal activity are time-dependent, and poor time management can result in incomplete data collection, missed sampling windows, or insufficient time for specimen processing before the return journey; a realistic field schedule allocating time for travel to each sampling station, set-up, actual data collection, processing, and pack-up should be prepared before departure, with contingency time built in for unexpected delays such as difficult terrain, equipment failure, or unexpected species encounters.

Teamwork is a critical skill in field biology because most field studies require coordinated effort across multiple roles simultaneously: one team member may record data while another collects specimens, a third operates the GPS, and a fourth manages equipment; clear role allocation before the field session, with defined responsibilities for each team member, prevents duplication of effort and gaps in coverage; effective field teams also practise active communication (briefing each other on observations, sharing emerging data patterns, and flagging safety concerns as they arise throughout the session) rather than working in isolation until the session ends.

Fill in the blank: Effective field ________ requires clear role allocation before the session, with defined responsibilities for each team member to prevent duplication of effort and gaps in data coverage.

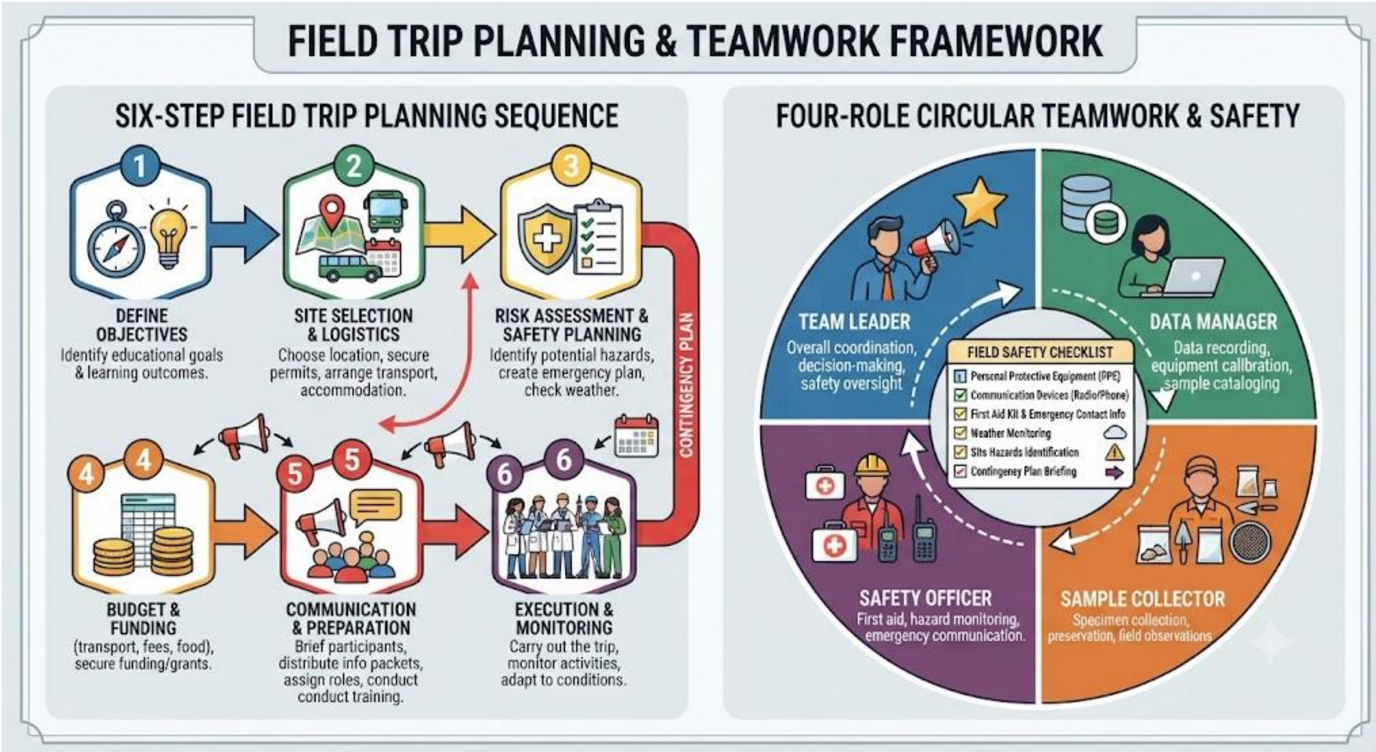

Figure 1.2: Field trip planning and safety

Pilot questions 1.2

1. Name three elements of a field plan that should be prepared before departure.
2. Name three pre-trip preparation activities.
3. Name two hazards specific to forested field sites in Nigeria.
4. Explain what ethical field conduct requires regarding specimen collection.
5. Explain the importance of clear role allocation in field teamwork.

1.3 Field Observation and Basic Recording

1.3.1 Principles of field observation

Effective field observation is a trained skill requiring focused attention, patience, and the ability to notice and record relevant details without disturbing the subject or the habitat; the principles of good field observation include: using all available senses appropriately (sight, sound, smell, and touch where safe), approaching subjects quietly and from downwind where possible, remaining still when close to wildlife rather than moving continuously, scanning the environment systematically (for example, checking ground, low vegetation, mid-canopy, and upper canopy levels in sequence when looking for animals in a forest) rather than looking randomly, and sketching or photographing subjects as well as writing descriptions.

Field observation differs from casual looking by being purposeful, systematic, and recorded; an observation is only scientifically useful if it is recorded at the time and in sufficient detail to be verified, communicated, and analysed; key details to record for any biological observation include the date, time, exact location (GPS coordinates), habitat type, the observer name, the observed organism (to the most precise identification achievable in the field), and any relevant behavioural or ecological context; post-hoc reconstruction of observations from memory is a common source of inaccuracy and should be avoided.

Fill in the blank: An observation is only scientifically useful if it is ________ at the time in sufficient detail to be verified, communicated, and analysed, not reconstructed later from memory.

1.3.2 Field notebooks and basic recording techniques

The field notebook is the primary data collection tool in field biology; a standard field notebook should be hardcover or spiral-bound with water-resistant paper where possible, and all entries made in pencil to prevent run in wet conditions; every page should be headed with the date, site name, GPS coordinates, weather conditions, and the names of the observer or observers; observations should be recorded as they are made using clear, structured notes rather than continuous prose, incorporating sketches, diagrams, and tables where these communicate observations more efficiently than words alone.

Prepared data sheets (designed before the field session to match the specific data to be collected) are often used alongside or instead of free-form notebook entries for quantitative surveys, ensuring that all required data fields are recorded systematically and in a format that facilitates later entry into a database or spreadsheet; photographs taken during field sessions should be numbered and linked to notebook or data sheet entries by page and entry number at the time of photography, not later; all field notes and data sheets are primary scientific records and should be retained as originals even after data have been transferred to digital formats.

Fill in the blank: All field notebook entries should be made in ________ to prevent run in wet conditions, and every page should be headed with date, site, GPS coordinates, and observer name.

1.3.3 Use of GPS, maps, and basic navigation

A Global Positioning System (GPS) receiver determines the user geographic location (latitude, longitude, and elevation) by receiving signals from multiple satellites; in field biology, GPS is used to record the precise location of sampling stations, specimen collection points, and ecological observations, enabling sites to be relocated for repeat surveys and observations to be mapped and analysed spatially; basic GPS operation involves switching on the device and waiting for a satellite fix (at least four satellites for reliable accuracy), then recording the displayed coordinates alongside each observation or sampling event.

Topographic and vegetation maps of the study area provide context for field observations and assist navigation between sampling sites; reading a topographic map requires understanding contour lines (lines connecting points of equal elevation, with closely spaced lines indicating steep slopes and widely spaced lines indicating gentle slopes), compass bearings, scale, and the map legend; in areas with no GPS signal (inside buildings or dense forest), a compass and pace counting (counting steps to estimate distance) can be used to navigate by dead reckoning from a known starting point; all field biologists should be comfortable with both GPS and map-and-compass navigation as complementary tools.

Fill in the blank: A GPS receiver requires a fix from at least ________ satellites to provide reliable location accuracy for recording field observation and sampling station coordinates.

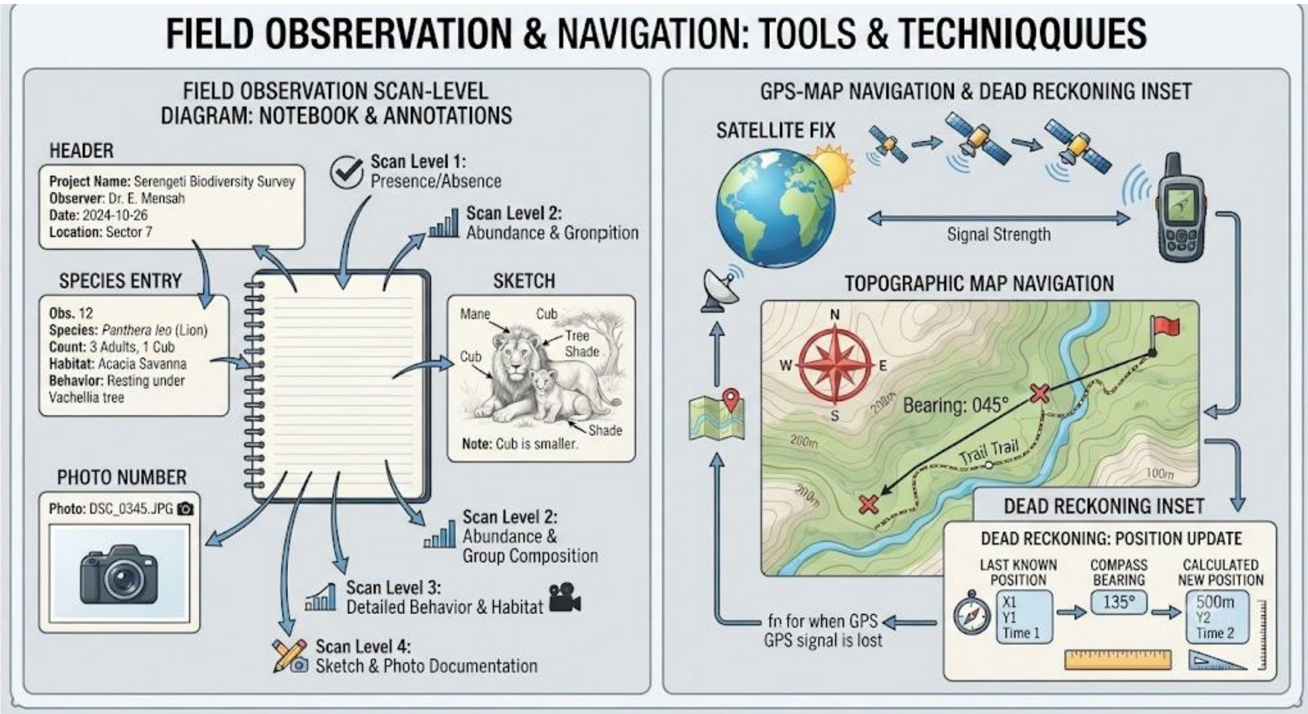

Figure 1.3: Field observation, recording, and navigation

Pilot questions 1.3

1. State four details that should always be recorded for any biological field observation.
2. Explain why observations should be recorded at the time rather than reconstructed from memory.
3. Describe three characteristics of a properly maintained field notebook.
4. Explain what a GPS receiver does and name one field biology use.
5. Explain what contour lines on a topographic map represent.

Series Summary

This Series established the conceptual and practical foundations of Field Course II. Field biology is the direct study of organisms in natural environments, providing the empirical base for ecology, wildlife biology, hydrobiology, taxonomy, and conservation. In Nigeria, the country exceptional range of ecosystems from rainforest to Sahel offers rich opportunities for field study directly relevant to national conservation and resource management priorities. The course builds on BIO 307 by extending to more diverse and demanding field environments.

Effective field practice demands thorough pre-trip planning, clear objectives, rigorous safety and ethical standards, and well-organised teamwork with defined roles. At the heart of all fieldwork is the discipline of careful, systematic observation recorded accurately and completely in the field notebook at the time of collection. GPS receivers and topographic maps provide the spatial framework for locating and later relocating sampling stations, completing the suite of foundational skills on which the data collection, specimen work, and project reporting of the subsequent Series all depend.

Glossary of Terms

- **Contour lines:** lines on a topographic map connecting points of equal elevation; closely spaced lines indicate steep terrain, widely spaced lines indicate gentle slopes.
- **Dead reckoning:** a navigation method that estimates current position from a known starting point using compass bearing and pace-counted distance, used when GPS signals are unavailable.
- **Descriptive survey:** a field study that systematically records the species present, their abundance, and distribution in a defined area without experimental manipulation.
- **Field biology:** the branch of biological science that studies living organisms and ecological processes in their natural environments.
- **Field experiment:** a study that manipulates one or more variables in natural field conditions to test specific hypotheses about biological processes.

- **Field notebook:** the primary data recording tool in field biology, used to document observations, measurements, sketches, and contextual information at the time of collection.
- **GPS (Global Positioning System):** a satellite-based navigation system used to determine geographic location (latitude, longitude, elevation) with high precision.
- **Monitoring programme:** a long-term repeated survey at fixed sites to detect changes in species composition, abundance, or habitat condition over time.
- **Pre-trip preparation:** the planning, equipment checking, permit obtaining, and briefing activities carried out before a field session to ensure it runs safely and effectively.

Concept Check Questions [Series 1]

Objective Questions

1. Field biology studies living organisms in natural environments, feeding disciplines including ecology, taxonomy, and ________ biology. (Linked to SLO 1.1)
2. Field ________ manipulate variables in natural conditions to test hypotheses, unlike descriptive surveys that record without manipulation. (Linked to SLO 1.1)
3. A written field ________ prepared before departure ensures the trip proceeds systematically even under unexpected conditions. (Linked to SLO 1.2)
4. All field notebook entries should be made in ________ to prevent run in wet conditions. (Linked to SLO 1.3)
5. A GPS receiver requires a fix from at least ________ satellites to provide reliable location accuracy. (Linked to SLO 1.3)

hort-Answer Questions

6. Distinguish between a descriptive survey and a field experiment. (Linked to SLO 1.1)
7. Name three pre-trip preparation activities. (Linked to SLO 1.2)
8. State two ethical requirements for field specimen collection. (Linked to SLO 1.2)
9. State four details that should be recorded for any field observation. (Linked to SLO 1.3)
10. Explain what contour lines on a topographic map represent. (Linked to SLO 1.3)

Long-Answer Questions

11. Describe the nature and scope of field biology and its relevance to the Nigerian context. (Linked to SLO 1.1)
12. Describe the planning and safety requirements for a field trip and explain the principles of field observation and recording. (Linked to SLOs 1.2, 1.3)

Answers to Concept Check Questions [Series 1]

Objective Questions

1. Conservation.
2. Experiments.
3. Plan/protocol.
4. Pencil.
5. Four.

Short-Answer Questions

6. A descriptive survey records species presence and abundance without manipulation; a field experiment manipulates one or more variables to test specific hypotheses.
7. Site reconnaissance or background research, equipment check and packing, and obtaining permits and permissions (or pre-departure briefing).
8. Collect only what is scientifically necessary, and observe all relevant collection permits and access permissions.
9. Date, time, exact GPS location, and the observed organism to the most precise identification achievable (or habitat type, observer name, behavioural context).
10. Contour lines connect points of equal elevation; closely spaced lines indicate steep slopes, widely spaced lines indicate gentle slopes.

Long-Answer Questions

11. Field biology studies organisms in their natural environments, providing the empirical base for ecology, wildlife, hydrobiology, taxonomy, conservation, and environmental management. Types of field study: descriptive surveys (no manipulation), field experiments (hypothesis testing), monitoring programmes (long-term trend data). Nigeria context: exceptional biodiversity across rainforest, savanna, wetlands, mangroves; field sites include Cross River NP, Yankari; skills relevant to NESREA, FRIN, National Parks Service, NGOs, environmental consulting.
12. Planning: clear objectives, site reconnaissance, equipment check, permits, pre-departure briefing, time-allocated schedule. Safety: site-specific hazard assessment, PPE, first-aid kit, never work alone, emergency contacts. Ethics: minimum collection, permits, honest recording, release of live organisms. Field observation: purposeful, systematic, recorded at the time with date, GPS,

habitat, organism. Field notebook: pencil, waterproof, heading on every page, sketches and tables; GPS for location; topographic maps and compass for navigation.

Answers to Pilot Questions [Series 1]

Part 1.1

1. Field biology is the study of living organisms and ecological processes in natural environments; it complements laboratory biology by capturing interactions and patterns lost when organisms are removed to controlled conditions, and laboratory findings in turn inform more refined field studies.
2. Ecology, wildlife biology, hydrobiology, and taxonomy (or conservation biology, environmental management).
3. A descriptive survey records species, abundance, and distribution without manipulation; a field experiment manipulates one or more variables to test a specific hypothesis under natural conditions.
4. Cross River National Park and Yankari Game Reserve (or Niger Delta wetlands, university forest reserves).
5. Wildlife conservation and environmental impact assessment (or forestry, fisheries, environmental consulting, NESREA, FRIN).

Part 1.2

1. The biological questions to be addressed, the data to be collected, and the methods to be used (or site, timing, team roles).
2. Site reconnaissance or background research, equipment check and packing, and obtaining permits and permissions.
3. Venomous snakes and stinging insects in forested areas (or dense vegetation and risk of disorientation).
4. Ethical conduct requires collecting only what is scientifically necessary, observing all permits and permissions, and releasing live-captured organisms promptly after examination.
5. Clear role allocation prevents duplication of effort and gaps in data coverage, ensuring all required tasks are performed simultaneously and efficiently by defined individuals.

Part 1.3

1. Date, time, exact GPS location, and the observed organism to the most precise identification achievable (or habitat type, observer name, behavioural context).
2. Memory is unreliable and selective; post-hoc reconstruction introduces errors and omissions that cannot be verified; recording at the time preserves the accuracy and completeness of the original observation.
3. Written in pencil, every page headed with date, site, GPS, and observer name, and entries recorded at the time with sketches and tables where appropriate.
4. A GPS receiver determines geographic location from satellite signals; used in field biology to record the precise coordinates of sampling stations and collection points.
5. Contour lines connect points of equal elevation; closely spaced lines indicate steep slopes, widely spaced lines indicate gentle slopes.

References and Attribution

Textual References (Books and External Sources)

- Sutherland, W. J. (Ed.). (2006). Ecological census techniques: A handbook (2nd ed.). Cambridge University Press.
- Henderson, P. A., & Southwood, T. R. E. (2016). Ecological methods (4th ed.). Wiley-Blackwell.
- Krebs, C. J. (2014). Ecology: The experimental analysis of distribution and abundance (6th ed.). Pearson.
- National Open University of Nigeria (NOUN). (2023). Field course II course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 1.1: Field biology scope and Nigerian context Attribution: AI generated. Suggested OER search string: "field biology scope Nigeria biodiversity ecology taxonomy hydrobiology wildlife conservation field study OER".
- Figure 1.2: Field trip planning and safety Attribution: AI generated. Suggested OER search string: "field trip planning safety teamwork field biology roles time management ethics Nigeria OER".
- Figure 1.3: Field observation, recording, and navigation Attribution: AI generated. Suggested OER search string: "field observation notebook recording GPS topographic map navigation biology field course OER".

Course code: BIO 407

Course title: Field Course II

Course credit load: 1 Unit

Series 2: Field Experimentation and Data Collection

- **Part 2.1: Designing Simple Field Experiments**
  - Sub Part 2.1.1: Scientific method in the field
  - Sub Part 2.1.2: Variables, controls, and replication
  - Sub Part 2.1.3: Sampling design for field experiments
- **Part 2.2: Quantitative Data Collection Methods**
  - Sub Part 2.2.1: Vegetation and plant sampling
  - Sub Part 2.2.2: Animal and invertebrate sampling
  - Sub Part 2.2.3: Physicochemical measurements in the field
- **Part 2.3: Data Recording, Management, and Basic Analysis**
  - Sub Part 2.3.1: Constructing and using field data sheets
  - Sub Part 2.3.2: Entering and organising field data
  - Sub Part 2.3.3: Basic descriptive statistics and data presentation

Introduction

Field experimentation moves beyond observation and description to test specific hypotheses about biological processes in their natural context, bringing scientific rigour to questions that cannot be adequately addressed in the laboratory. The ability to plan a simple field experiment, collect quantitative data systematically, and manage and summarise those data correctly are among the most practically valuable skills a biology student can acquire, underpinning independent research, professional environmental assessment, and a wide range of applied biological careers.

This Series covers the scientific method as applied to field experimentation; the key concepts of variables, controls, and replication; sampling design; the major quantitative methods for sampling vegetation, animals, and invertebrates; physicochemical measurements of soil and water; and the construction and use of data sheets, data entry, and basic descriptive statistical analysis and presentation. These skills equip students to plan, conduct, and report on the field experiments required for the individual and group projects in the later Series of this course.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** explain the scientific method as applied in field experiments and describe the roles of variables, controls, replication, and sampling design,
- **SLO 2.2** describe and apply quantitative methods for sampling vegetation, animals, and physicochemical parameters in the field, and
- **SLO 2.3** construct and use field data sheets, enter and organise data, and calculate and present basic descriptive statistics.

2.1 Designing Simple Field Experiments

2.1.1 Scientific method in the field

The scientific method applied to field biology follows the same logical structure as in any scientific discipline: observation of a natural phenomenon generates a question; a hypothesis (a testable, falsifiable statement predicting the relationship between variables) is formulated; a study is designed to collect data capable of supporting or refuting the hypothesis; data are collected and analysed; and conclusions are drawn that relate back to the original hypothesis; however, the field context introduces particular challenges including environmental variability (which cannot be controlled as it can in the laboratory), logistical constraints, weather dependence, and the ethical imperative to minimise disturbance to the study system.

A hypothesis must be stated in a form that is testable with the available methods and within the available time frame; common forms include null hypotheses (stating that no difference or relationship exists between variables, which are tested statistically and either rejected or not rejected) and directional hypotheses (predicting the direction as well as the existence of a difference or relationship); the choice between experimental (manipulative) and observational (non-manipulative) approaches in the field depends on the nature of the question, the feasibility of manipulation, and the ethical implications of altering the study system.

Fill in the blank: A ________ hypothesis states that no difference or relationship exists between the variables being studied, and is tested statistically to be either rejected or not rejected.

2.1.2 Variables, controls, and replication

In any field experiment, variables are classified as independent (the variable deliberately manipulated by the researcher, such as grazing intensity, shade level, or distance from a water source), dependent (the variable measured to assess the response to the manipulation, such as plant species richness, insect abundance, or soil moisture), and controlled (all other variables that are kept as constant as possible between experimental and control units to ensure that any observed differences can be attributed to the independent variable rather than to confounding factors).

Replication (the repetition of each experimental treatment across multiple independent units) is essential for distinguishing a real biological effect from random variation; without replication, a single observation in each treatment cannot determine whether any difference observed is due to the treatment or to chance; the minimum number of replicates required depends on the expected effect size and the natural variability of the system, and is formally determined by a power analysis, though in practice field courses often use a minimum of five replicates per treatment as a practical guideline; controls (untreated or unmanipulated units measured alongside experimental units) provide the baseline against which treatment effects are measured.

Fill in the blank: ________ is the repetition of each experimental treatment across multiple independent units, essential for distinguishing a real biological effect from random variation.

2.1.3 Sampling design for field experiments

The sampling design specifies how experimental units or sampling stations are allocated across the study area; the three principal designs parallel those introduced for descriptive surveys: random sampling (allocating units to randomly chosen locations, minimising placement bias but potentially missing important habitat features), systematic sampling (placing units at regular grid intervals across the study area, ensuring even spatial coverage), and stratified random sampling (dividing the study area into strata reflecting known habitat or environmental variation, then randomly allocating sampling units within each stratum, combining the spatial coverage of systematic sampling with the bias reduction of random allocation).

Matched-pairs design (pairing each experimental unit with a control unit as similar as possible in all factors except the treatment) and randomised block design (grouping experimental and control units into spatial blocks within which all treatments are represented, to control for spatial gradients in environmental conditions across the study area) are additional designs used when the study area is environmentally heterogeneous; selecting an appropriate sampling design that matches the spatial structure of the study area and the question being asked is one of the most important decisions in field experimental design.

Fill in the blank: Stratified ________ sampling divides the study area into strata reflecting environmental variation and randomly allocates sampling units within each stratum.

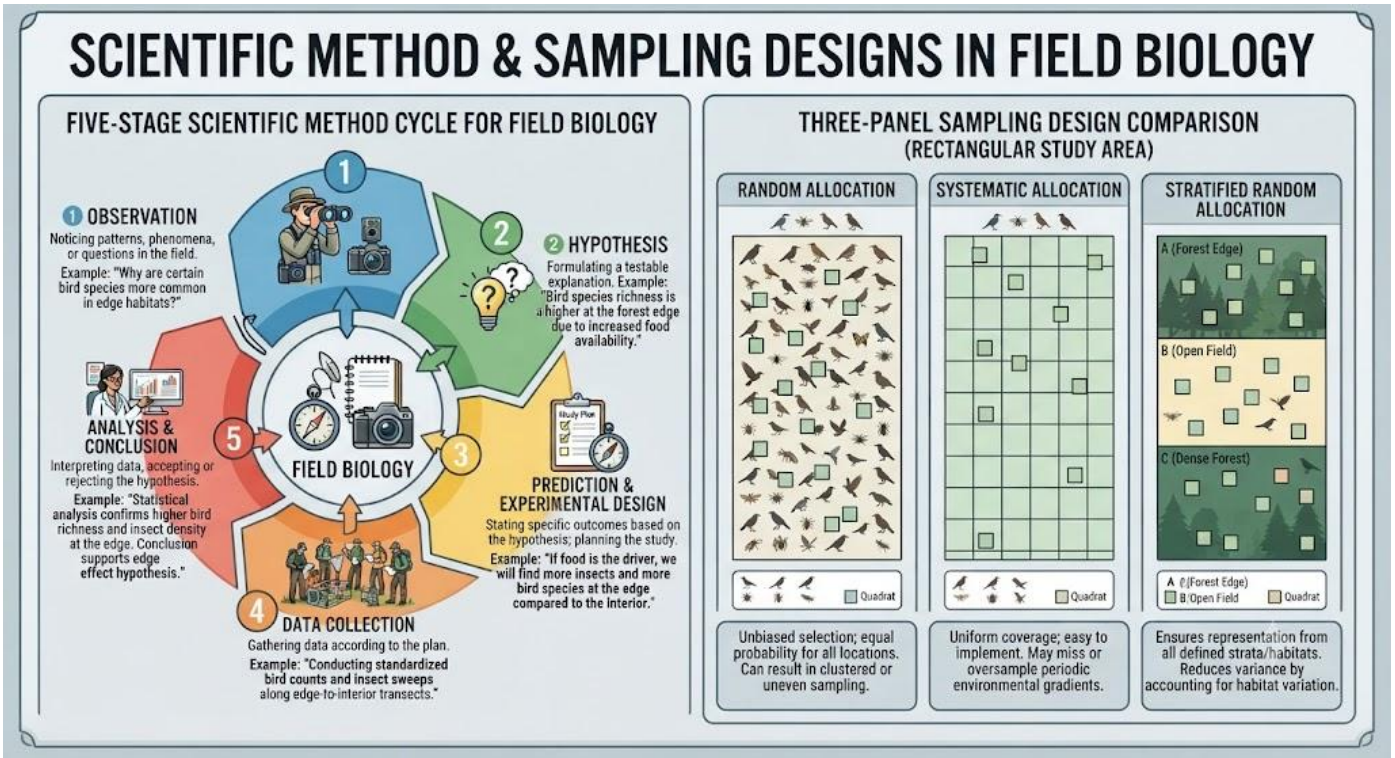

Figure 2.1: Field experiment design

Pilot questions 2.1

1. State the steps of the scientific method as applied in field biology.
2. Distinguish between a null hypothesis and a directional hypothesis.
3. Define independent, dependent, and controlled variables.
4. Explain why replication is essential in field experiments.
5. Distinguish between systematic and stratified random sampling.

2.2 Quantitative Data Collection Methods

2.2.1 Vegetation and plant sampling

Quantitative vegetation sampling uses quadrats and transects to record plant species composition, frequency, cover, and density across defined areas, as introduced in BIO 307; in BIO 407, students apply these methods in more complex and ecologically varied settings, including forest plots, riparian strips, disturbed roadsides, and agricultural field margins, requiring adaptation of standard methods to the specific structural complexity of each habitat; for forest tree surveys, variables measured within 10 x 10 m or 20 x 20 m plots include species identity, diameter at breast height (DBH), and height, from which basal area (the cross-sectional area of tree trunks at breast height, a standard measure of forest structure) can be calculated.

The point-intercept method (lowering a thin rod or pin at regular intervals along a transect and recording every plant species or bare ground that the pin touches) provides a rapid, objective estimate of vegetation cover and composition for grassland and low-herb communities without requiring the subjective visual cover estimates of the Braun-Blanquet approach; the line-intercept method (recording the length of vegetation canopy intercepted by a horizontal tape measure at ground level along a transect) is used for measuring shrub cover in savanna and bush habitats; student ability to select and apply the method most appropriate to the specific vegetation type encountered is a key learning objective of field experiments in BIO 407.

Fill in the blank: Basal area is the cross-sectional area of tree trunks measured at ________ height, a standard structural measure in forest vegetation surveys.

2.2.2 Animal and invertebrate sampling

Animal sampling methods applied in BIO 407 extend the approaches introduced in BIO 307 to additional taxa and more demanding environmental contexts; pitfall trap arrays (for ground-active invertebrates), sweep nets (for vegetation-dwelling and aerial invertebrates), light traps (for nocturnal moths and beetles), and aquatic kick nets (for freshwater macroinvertebrates) are all used in field experiments; for vertebrates, point count transects are used for birds, Sherman live traps for small mammals, and visual encounter surveys for reptiles and amphibians; each method provides a standardised sample of the target taxon that can be compared between treatments, sites, or time periods.

Diversity indices, including species richness (the total number of species recorded), Shannon-Wiener diversity index (H = negative sum of pi times log pi, where pi is the proportional abundance of each species), and Simpson index (a measure of dominance that takes into account both species richness and evenness of abundances), are used to summarise and compare the biodiversity of animal communities between sampling units in field experiments; calculating diversity indices from field-collected data, interpreting the results, and linking them to habitat characteristics are core quantitative skills developed in BIO 407 field experiments.

Fill in the blank: Species ________ is the simplest measure of biodiversity, recording the total number of species present in a sample, while diversity indices such as Shannon-Wiener also incorporate the evenness of abundances.

2.2.3 Physicochemical measurements in the field

Ecological field experiments typically include measurements of the physical and chemical environment alongside biological sampling, to allow interpretation of biological patterns in relation to environmental drivers; standard soil measurements include soil pH (measured with a portable pH meter or colorimetric test kit on a soil-water suspension), soil moisture (gravimetric method: weighing a soil sample before and after oven-drying to calculate moisture content as a percentage of dry weight, or volumetric method using a portable soil moisture probe), and soil temperature (using a soil thermometer inserted to 5 cm depth).

Freshwater quality measurements include temperature, pH, dissolved oxygen (measured with a DO meter or Winkler titration), turbidity (Secchi disc depth or turbidity meter), and electrical conductivity (a measure of dissolved salts); light intensity at ground level and canopy level (measured with a lux meter) is an important environmental variable in vegetation studies, particularly for experiments on the effects of canopy cover or shade on understorey plant diversity; all physicochemical measurements should be taken at the same time of day across all experimental units to minimise the effect of diurnal variation on comparability.

Fill in the blank: The gravimetric method measures soil ________ by comparing the weight of a soil sample before and after oven-drying, expressing the result as a percentage of dry weight.

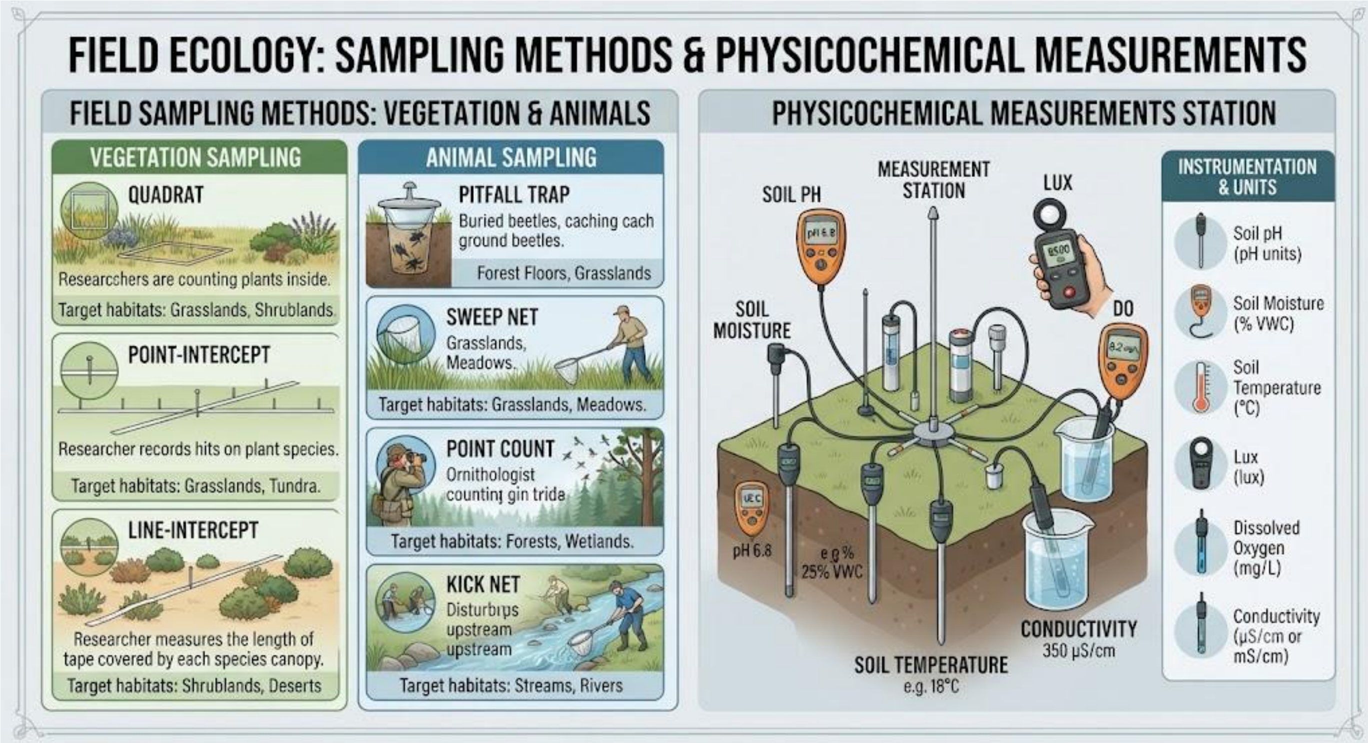

Figure 2.2: Quantitative field data collection

Pilot questions 2.2

1. Explain what basal area is and how it is used in forest surveys.
2. Describe the point-intercept method for vegetation sampling.
3. Name four animal or invertebrate sampling methods and state what each captures.
4. Explain what the Shannon-Wiener diversity index measures.
5. Name four physicochemical variables measured in freshwater field experiments.

2.3 Data Recording, Management, and Basic Analysis

2.3.1 Constructing and using field data sheets

A well-designed field data sheet collects all necessary data in a structured format that minimises transcription errors and facilitates subsequent entry into a database or spreadsheet; effective data sheets include: a clear header block (site name, date, time, GPS coordinates, habitat type, weather conditions, observer names, and sampling method), a systematic recording table with column headings for all variables to be recorded and units specified in the heading rather than written repeatedly in each cell, clearly defined data entry rules (such as whether presence/absence is recorded as 1/0 or Y/N), and a notes section for recording qualitative observations that do not fit the standard table format.

Data sheets should be prepared before the field session by the team leader or instructor, pilot-tested at a preliminary site if possible to identify any missing fields or ambiguities, and printed in sufficient copies for each sampling station plus spares; during the field session, all entries should be made at the point of observation rather than reconstructed later, and any corrections should be made by crossing out with a single line and initialling, never by erasing or overwriting, so that the original entry remains legible as part of the primary scientific record; data sheets constitute primary scientific data and must be retained as originals after digital transfer.

Fill in the blank: Corrections to field data sheets should be made by crossing out with a ________ line and initialling, never by erasing, so that the original entry remains part of the primary record.

2.3.2 Entering and organising field data

Field data should be transferred from paper data sheets to a digital spreadsheet (such as Microsoft Excel or LibreOffice Calc) as soon as possible after the field session, while memory of any ambiguous entries is still fresh; the spreadsheet should be organised with one row per observation unit (one quadrat, one trap, one sampling station) and one column per variable, with the header block information (site, date, GPS) repeated in the first columns of every row to facilitate sorting and filtering; a separate metadata sheet within the same workbook should record the full description of each variable, the units used, and any notes on sampling protocols or deviations.

Data quality checks after entry include: verifying that all expected data sheets have been entered (no missing stations), checking that values fall within biologically plausible ranges (for example, a recorded species richness of 150 species in a single 1 m x 1 m quadrat is implausible and warrants checking against the original data sheet), checking for data entry errors by comparing a random sample of entered values with the original data sheets, and checking for consistency in codes and category names across rows (for example, that "forest" and "Forest" are not treated as different categories by the software).

Fill in the blank: In a field data spreadsheet, one ________ should represent each observation unit and one column should represent each variable, with header information repeated in the first columns.

2.3.3 Basic descriptive statistics and data presentation

Descriptive statistics summarise the central tendency and variability of a dataset without making inferences beyond the data collected; the key descriptive statistics used in field biology data summaries are the mean (the arithmetic average of all values in a sample, the most commonly reported measure of central tendency), the median (the middle value when data are arranged in order, more appropriate than the mean when data are skewed or contain extreme outliers), the standard deviation (SD, a measure of how spread out individual values are around the mean, calculated as the square root of the variance), and the standard error of the mean (SE, the standard deviation divided by the square root of the sample size, representing the precision of the mean as an estimate of the true population mean).

Field biology data are typically presented in tables (for precise numerical values allowing comparison across multiple sites, species, or treatments) or graphs (for visualising patterns and trends more effectively than tables); bar charts or column graphs are appropriate for comparing means across discrete categories; scatter plots for showing relationships between two continuous variables; box-and-whisker plots for showing the distribution and variability of data including outliers; all figures and tables should have clear, informative titles, labelled axes with units, and should be accompanied by explanatory legends so that they can be understood without reference to the text.

Fill in the blank: Standard ________ of the mean (SE) is the standard deviation divided by the square root of the sample size, representing the precision of the mean as an estimate of the true population mean.

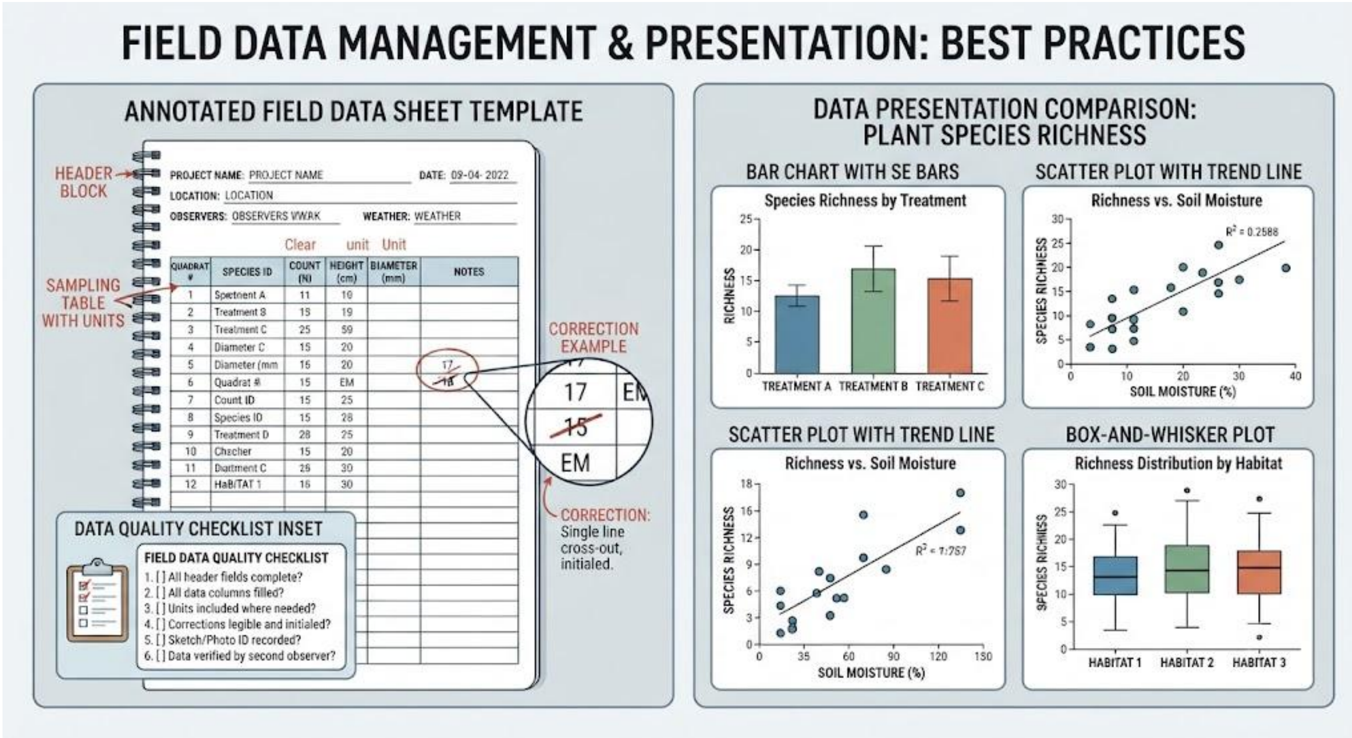

Figure 2.3: Data recording, entry, and presentation

Pilot questions 2.3

1. Name five elements that should appear in the header block of a field data sheet.
2. Explain how corrections should be made on a field data sheet and why.
3. Explain how a field data spreadsheet should be organised.
4. Define mean, standard deviation, and standard error of the mean.
5. Name three types of graph used to present field biology data and state when each is most appropriate.

Series Summary

This Series developed the skills needed to design, execute, and analyse simple field experiments. The scientific method in the field follows the same logical structure as laboratory science, but must account for environmental variability and logistical constraints; null and directional hypotheses, independent and dependent variables, controls, and replication are the foundational design concepts. Sampling designs including random, systematic, and stratified random allocation match the spatial structure of the study area to the research question.

Quantitative data collection methods covered span vegetation surveys using quadrats, point-intercept, and line-intercept approaches; animal and invertebrate sampling using pitfall traps, sweep nets, point counts, and kick nets; and physicochemical measurements of soil and water. Field data sheets must be carefully designed, completed at the time of observation, and entered into well-organised spreadsheets with data quality checks. Basic descriptive statistics including mean, standard deviation, and standard error, and appropriate graphical presentation, complete the data analysis pipeline from field to report.

Glossary of Terms

- **Basal area:** the cross-sectional area of tree trunks measured at breast height (1.3 m), used as a standard measure of forest structure and stand biomass.
- **Dependent variable:** the biological variable measured to assess the response to an experimental manipulation.
- **Independent variable:** the variable deliberately manipulated in a field experiment to test its effect on the dependent variable.
- **Null hypothesis:** a testable statement that no difference or relationship exists between the variables being studied, tested statistically.
- **Point-intercept method:** a vegetation sampling technique that records the species or ground category touched by a pin lowered at regular intervals along a transect.

- **Replication:** the repetition of each experimental treatment across multiple independent units to distinguish real effects from random variation.
- **Shannon-Wiener index:** a diversity index that quantifies species diversity by incorporating both species richness and the evenness of abundance distribution.
- **Standard error of the mean (SE):** the standard deviation divided by the square root of sample size, representing the precision of the sample mean as an estimate of the true population mean.
- **Stratified random sampling:** a sampling design that divides the study area into strata reflecting known environmental variation, then randomly allocates sampling units within each stratum.

Concept Check Questions [Series 2]

Objective Questions

1. A ________ hypothesis states that no difference or relationship exists between variables and is tested statistically. (Linked to SLO 2.1)
2. ________ is the repetition of each experimental treatment across multiple independent units to distinguish real effects from random variation. (Linked to SLO 2.1)
3. Basal area is calculated from tree trunk diameter measured at ________ height. (Linked to SLO 2.2)
4. Species ________ is the simplest biodiversity measure, recording the total number of species in a sample. (Linked to SLO 2.2)
5. Standard ________ of the mean is the standard deviation divided by the square root of sample size. (Linked to SLO 2.3)

Short-Answer Questions

1. Define independent, dependent, and controlled variables in a field experiment. (Linked to SLO 2.1)
2. Distinguish between systematic and stratified random sampling. (Linked to SLO 2.1)
3. Name four animal sampling methods and state what each targets. (Linked to SLO 2.2)
4. Explain how corrections should be made on a field data sheet. (Linked to SLO 2.3)
5. Name three types of graph used to present field biology data and state when each is most appropriate. (Linked to SLO 2.3)

Long-Answer Questions

1. Describe the scientific method in field biology and explain the roles of variables, controls, replication, and sampling design. (Linked to SLO 2.1)
2. Describe quantitative field data collection methods and explain data recording, management, and basic statistical presentation. (Linked to SLOs 2.2, 2.3)

Answers to Concept Check Questions [Series 2]

Objective Questions

1. Null.
2. Replication.
3. Breast.
4. Richness.
5. Error.

Short-Answer Questions

1. Independent: deliberately manipulated by the researcher. Dependent: measured to assess the response. Controlled: kept constant to prevent confounding.
2. Systematic sampling places units at regular grid intervals ensuring even coverage; stratified random sampling divides the area into habitat strata and randomly allocates units within each stratum.
3. Pitfall traps (ground-active invertebrates), sweep nets (vegetation invertebrates), point count transects (birds), and kick nets (freshwater macroinvertebrates).
4. Corrections should be made by crossing out with a single line and initialling, never erasing, so that the original entry remains legible as part of the primary scientific record.
5. Bar chart: comparing means across discrete categories. Scatter plot: showing relationships between two continuous variables. Box-and-whisker: showing data distribution and variability including outliers.

Long-Answer Questions

1. Scientific method: observation, hypothesis (null or directional), study design, data collection, analysis, conclusion. Variables: independent (manipulated), dependent (measured), controlled (constant). Controls provide the baseline; replication (multiple independent units per treatment) distinguishes real effects from chance variation. Sampling designs: random (unbiased placement), systematic (even spatial coverage), stratified random (strata matching environmental variation, random allocation within each).
2. Vegetation: quadrats/plots (DBH, basal area for forest), point-intercept (grassland cover), line-intercept (savanna shrubs). Animals: pitfall traps, sweep nets, point counts, kick nets.

Physicochemical: soil pH, moisture, temperature; water temperature, DO, turbidity, conductivity; light intensity. Data sheets: header block, structured table with units, corrections by single line. Spreadsheet: one row per unit, one column per variable, metadata sheet. Statistics: mean (central tendency), SD (spread), SE (precision of mean). Graphs: bar chart, scatter plot, box-and-whisker.

Answers to Pilot Questions [Series 2]

Part 2.1

1. Observation, hypothesis formulation, study design, data collection, analysis, conclusion (with feedback to new observations).
2. A null hypothesis states no difference or relationship exists; a directional hypothesis predicts both the existence and the direction of a difference or relationship.
3. Independent: the variable deliberately manipulated. Dependent: the variable measured to assess the response. Controlled: all other variables kept constant to prevent confounding.
4. Without replication, a single observation per treatment cannot determine whether any observed difference is due to the treatment or to chance variation in the system.
5. Systematic sampling places units at regular grid intervals for even spatial coverage; stratified random sampling divides the area into habitat strata and randomly allocates units within each, ensuring all habitat types are represented.

Part 2.2

1. Basal area is the cross-sectional area of tree trunks at breast height (1.3 m); it is used as a standard measure of forest stand structure and biomass, calculated from DBH measurements within forest plots.
2. A thin pin or rod is lowered at regular intervals along a tape measure; the plant species or ground category (bare soil, litter) that the pin touches at each point is recorded; this gives an objective, repeatable estimate of vegetation cover and composition.
3. Pitfall traps (ground-active invertebrates), sweep nets (vegetation-dwelling and aerial invertebrates), point count transects (birds), kick nets (freshwater macroinvertebrates).

4. The Shannon-Wiener index quantifies biodiversity by combining species richness and evenness of abundances, giving higher values to communities with more species and more equal abundances among species.
5. Temperature, pH, dissolved oxygen, and turbidity (or electrical conductivity).

Part 2.3

1. Site name, date, time, GPS coordinates, and observer names (or habitat type, weather conditions, sampling method).
2. By crossing out with a single line and initialling, never erasing; this preserves the original entry as part of the primary scientific record and allows any correction to be traced if the data are later questioned.
3. One row per observation unit (quadrat, trap, sampling station), one column per variable, with header block information (site, date, GPS) in the first columns of every row; a metadata sheet describes each variable and its units.
4. Mean: the arithmetic average of all values, the most common measure of central tendency. Standard deviation: measures spread of individual values around the mean. Standard error of the mean: SD divided by the square root of sample size, representing the precision of the mean.
5. Bar chart: comparing means across discrete categories with error bars. Scatter plot: showing relationships between two continuous variables. Box-and-whisker: showing the distribution and variability of a dataset including outliers.

References and Attribution

Textual References (Books and External Sources)

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- Henderson, P. A., & Southwood, T. R. E. (2016). Ecological methods (4th ed.). Wiley-Blackwell.
- Fowler, J., Cohen, L., & Jarvis, P. (1998). Practical statistics for field biology (2nd ed.). Wiley.
- National Open University of Nigeria (NOUN). (2023). Field course II course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 2.1: Field experiment design Attribution: AI generated. Suggested OER search string: "field experiment design scientific method hypothesis variables controls replication sampling design OER".
- Figure 2.2: Quantitative field data collection Attribution: AI generated. Suggested OER search string: "field experiment vegetation quadrat point intercept pitfall trap sweep net physicochemical soil pH moisture OER".
- Figure 2.3: Data recording, entry, and presentation Attribution: AI generated. Suggested OER search string: "field data sheet data entry spreadsheet descriptive statistics bar chart scatter plot standard error field biology OER".

Course title: Field Course II

Course credit load: 1 Unit

Series 3: Specimen Classification and Preservation

- **Part 3.1: Classification and Sorting of Field-Collected Specimens**
  - Sub Part 3.1.1: Principles of biological classification
  - Sub Part 3.1.2: Sorting and preliminary identification in the field
  - Sub Part 3.1.3: Use of identification keys and reference materials
- **Part 3.2: Plant Specimen Preservation and Herbarium Methods**
  - Sub Part 3.2.1: Field collection and preparation of plant specimens
  - Sub Part 3.2.2: Pressing, drying, and mounting herbarium specimens
  - Sub Part 3.2.3: Herbarium organisation and curation
- **Part 3.3: Animal Specimen Preservation and Museum Methods**
  - Sub Part 3.3.1: Killing, fixing, and preserving animal specimens
  - Sub Part 3.3.2: Pinning insects and preparing study skins
  - Sub Part 3.3.3: Museum labelling, curation, and long-term storage

Introduction

The collection, classification, and preservation of biological specimens is a defining activity of field biology, transforming field observations into permanent, verifiable scientific records that can be examined, re-identified, and studied long after the original collection event. In BIO 407, students extend the introductory specimen skills developed in BIO 307 to a wider range of organism groups and more demanding preparation standards, producing specimens of the quality required for deposit in university herbaria and museum collections.

This Series covers the principles of biological classification and the practical skills of sorting, preliminary identification, and the use of identification keys; the complete workflow of plant specimen collection, pressing, drying, mounting, labelling, and herbarium curation; and the methods for killing, fixing, preserving, pinning, and mounting animal specimens, with guidance on museum labelling, curation, and long-term storage. Together these skills complete the chain from field collection to institutional deposit that gives specimens their lasting scientific value.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** explain the principles of biological classification and apply identification keys and reference materials to sort and identify field-collected specimens,
- **SLO 3.2** describe and apply the complete workflow of plant specimen preparation from field collection to herbarium deposit, and
- **SLO 3.3** describe and apply methods for killing, fixing, preserving, pinning, and curating animal specimens to museum standard.

3.1 Classification and Sorting of Field-Collected Specimens

3.1.1 Principles of biological classification

Biological classification is the systematic ordering of organisms into hierarchical groups (taxa) based on shared characteristics, with the goal of reflecting evolutionary relationships as closely as possible; the Linnaean hierarchy (Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species) provides the fundamental framework used in all field biology specimen work, with the species (a group of organisms capable of interbreeding and producing fertile offspring) as the basic unit of classification; each species is given a unique two-part (binomial) scientific name consisting of the genus name (capitalised) and the specific epithet (lower case), both written in italics.

Modern biological classification increasingly follows phylogenetic principles, grouping organisms into clades (groups sharing a common ancestor and all its descendants) based on molecular and morphological evidence rather than superficial similarity; in practical field biology, classification provides the framework for sorting and identifying collected specimens, and understanding the major groups and their defining characteristics is essential for selecting the appropriate identification key and interpreting the characters it uses; the major groups encountered in Nigerian field surveys include flowering plants, ferns and mosses, insects and other arthropods, birds, mammals, fish, reptiles, and amphibians.

Fill in the blank: Each species is given a unique ________ scientific name consisting of the genus name (capitalised) and the specific epithet (lower case), both written in italics.

3.1.2 Sorting and preliminary identification in the field

Sorting is the process of grouping collected specimens into recognisable morphological categories before formal identification, usually done in the field or at the field camp immediately after collection; effective sorting requires ability to recognise the major taxonomic groups from morphological features visible without magnification (such as the number and arrangement of legs for arthropods, the type of leaves and stem for plants, or the presence of scales, feathers, or fur for vertebrates); specimens are sorted into labelled containers or bags with a temporary label bearing the site, date, and collector information while awaiting formal identification.

Preliminary identification aims to assign each specimen to the lowest possible taxonomic level achievable in the field, using visible morphological characters and available reference materials; even identification to family or order level is valuable because it informs decisions about preservation method (different methods are appropriate for different taxonomic groups), determines which identification key to use for more detailed identification in the laboratory, and allows initial assessment of the biodiversity of the collection; photographs of specimens in the field (showing key diagnostic features such as leaf arrangement, insect wing venation, or fish scale pattern) are a valuable supplement to physical specimens.

Fill in the blank: Sorting groups collected specimens into recognisable ________ categories before formal identification, usually done in the field or at field camp immediately after collection.

3.1.3 Use of identification keys and reference materials

Identification keys are structured tools that guide the user to the identity of an organism by presenting a series of choices based on observable morphological characters; dichotomous keys (the most common format, presenting two mutually exclusive alternatives at each step) are used for all major organism groups in Nigerian field biology, including West African trees, grasses, freshwater fish, insects, and birds; effective use of a dichotomous key requires careful examination of the specimen (often under magnification), understanding the technical terminology used in the key, and willingness to retrace steps and try the alternative lead if the initial identification produces an implausible result.

Reference materials used alongside identification keys in BIO 407 include photographic field guides (for birds, butterflies, and other visually distinctive groups), institutional herbarium and museum reference collections (allowing direct comparison of a field specimen with identified reference specimens), online databases and image repositories (such as iNaturalist, Plants of the World Online, and AfriBirds, which provide photographs and distribution maps for many Nigerian species), and regional flora and fauna monographs published by FRIN, universities, and international institutions; the appropriate combination of keys and reference materials varies by taxonomic group and the level of identification required.

Fill in the blank: ________ keys present two mutually exclusive alternative character statements at each step and are the most widely used format for identifying organisms in Nigerian field biology.

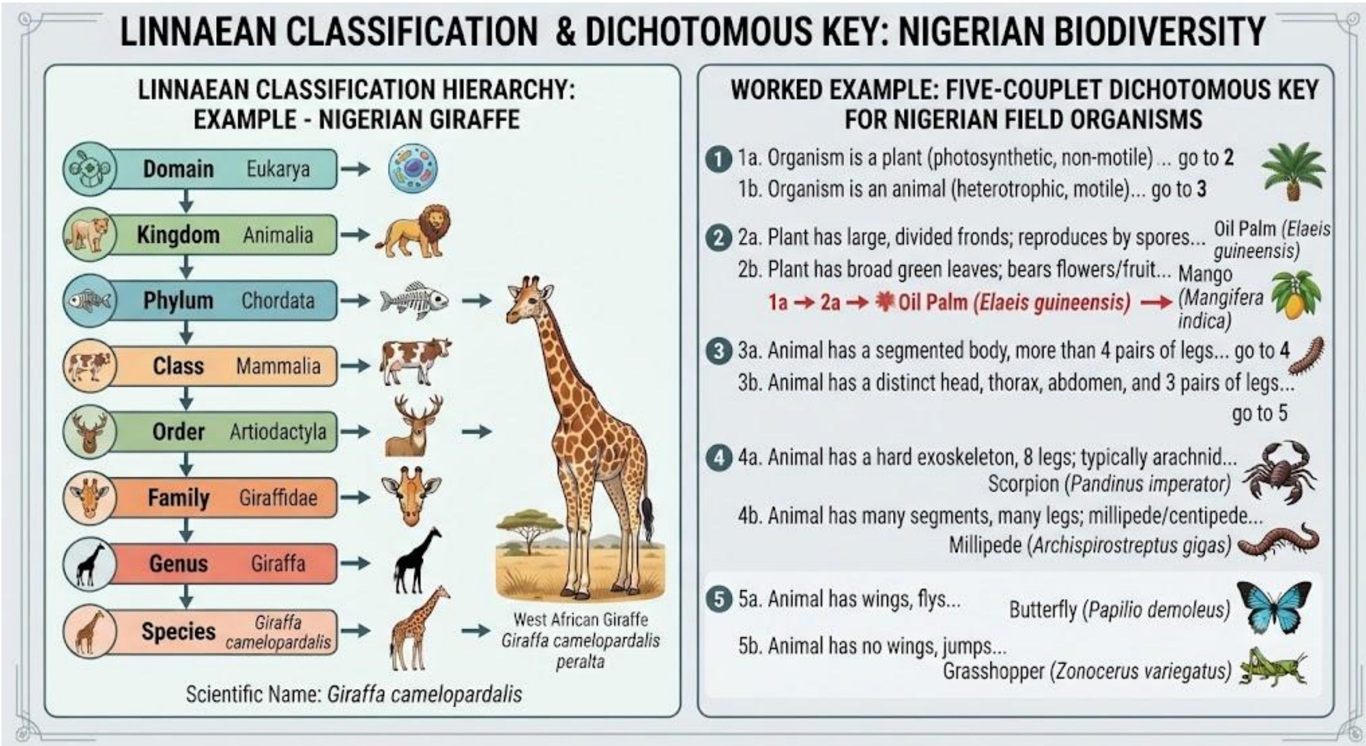

Figure 3.1: Specimen classification and identification

Pilot questions 3.1

1. Name the seven levels of the Linnaean classification hierarchy from broadest to most specific.
2. Explain what binomial nomenclature is and give one example.
3. Explain the purpose of sorting field specimens and name two things sorting determines.
4. Explain how a dichotomous identification key works.
5. Name three types of reference material used alongside identification keys in BIO 407.

3.2 Plant Specimen Preservation and Herbarium Methods

3.2.1 Field collection and preparation of plant specimens

Collecting a herbarium-quality plant specimen requires obtaining all the diagnostic features needed for identification: for flowering plants, this means a shoot of approximately 30 to 40 cm bearing leaves (showing both upper and lower surfaces), flowers or flower buds if in season, and fruits if present; for trees and shrubs, at least two leaves, flowers, and fruits should be collected from different parts of the canopy where possible to represent the natural variation in the specimen; for grasses, the complete culm from base to tip including roots, ligule, and the entire inflorescence is required for accurate identification of grass species.

Each specimen is assigned a collection number (collector surname and sequential number, such as Bello 045) at the time of collection, and the following field data are recorded in the field notebook for each collection number: locality and GPS coordinates, altitude, date, habitat description (vegetation type, associated species, soil type), description of characters visible in the living plant but lost on drying (flower colour, latex colour and presence, stem hollow or solid, bark texture and colour), and the collector name; duplicate specimens (additional shoots of the same individual collected simultaneously) should be taken where possible for exchange with other herbaria or as insurance against damage during preparation.

Fill in the blank: Each herbarium specimen is assigned a ________ number at collection, and field data including GPS coordinates, habitat, and living-plant characters are recorded for every number.

3.2.2 Pressing, drying, and mounting herbarium specimens

Collected plant specimens are pressed as soon as possible after collection by arranging each shoot between sheets of folded newspaper within a plant press (two rigid wooden boards held together by tightening straps, with sheets of corrugated aluminium or ventilated cardboard between newspaper layers to allow airflow), tightening the press firmly, and placing it in the sun or near a heat source; newspaper is changed daily for the first three to four days as it becomes saturated with moisture from the specimens, and specimens are examined during each newspaper change to check for mould and to reposition any leaves or flowers that have shifted; most specimens are dry and rigid within seven to fourteen days depending on the thickness of plant material and ambient humidity.

Once fully dried, specimens are mounted on standard herbarium sheets (42 x 29 cm acid-free card) using archival PVA glue or linen tape strips; the specimen is arranged to display all diagnostic features clearly (leaves showing both surfaces, flowers opened to reveal internal structures if possible), small paper packets for loose seeds or flowers are glued to the sheet, and the completed herbarium label (bearing the collection number, scientific name, family, collector, date, locality, GPS, habitat, and institutional name) is attached to the lower right corner; mounted specimens are fumigated or frozen to kill any insects before filing in the herbarium cabinet.

Fill in the blank: Once fully dried, plant specimens are mounted on standard ________ sheets of acid-free card using archival glue or linen tape to produce a permanent herbarium specimen.

3.2.3 Herbarium organisation and curation

Herbaria (plural of herbarium) are institutional collections of dried, pressed, mounted, and labelled plant specimens, arranged systematically by family and genus for ease of reference; the arrangement used in most African herbaria follows the Angiosperm Phylogeny Group (APG) classification system for flowering plants, with the specimen sheets filed in genus folders within family folders stored in metal cabinets that protect against light, moisture, and pests; access to herbaria for research requires registration with the curator and may require institutional permission for borrowing of specimens for study.

Curation of a herbarium collection requires: regular inspection for pest damage (dermestid beetles and psocid booklice are the most destructive museum pests, capable of destroying entire collections if unchecked), with routine application of pest deterrents (naphthalene, paradichlorobenzene, or in modern herbaria, controlled freezing of incoming specimens); monitoring of temperature and humidity (high humidity promotes mould growth and deterioration, while excessively dry conditions make specimens brittle); regular updating of nomenclature (when the accepted scientific name of a species changes following taxonomic revision, all specimens of that species in the herbarium should be annotated); and the maintenance of a specimen catalogue or database linking physical specimens to digital records.

Fill in the blank: Herbarium specimens are arranged by family and genus following the Angiosperm Phylogeny Group (________) classification system used in most African herbaria.

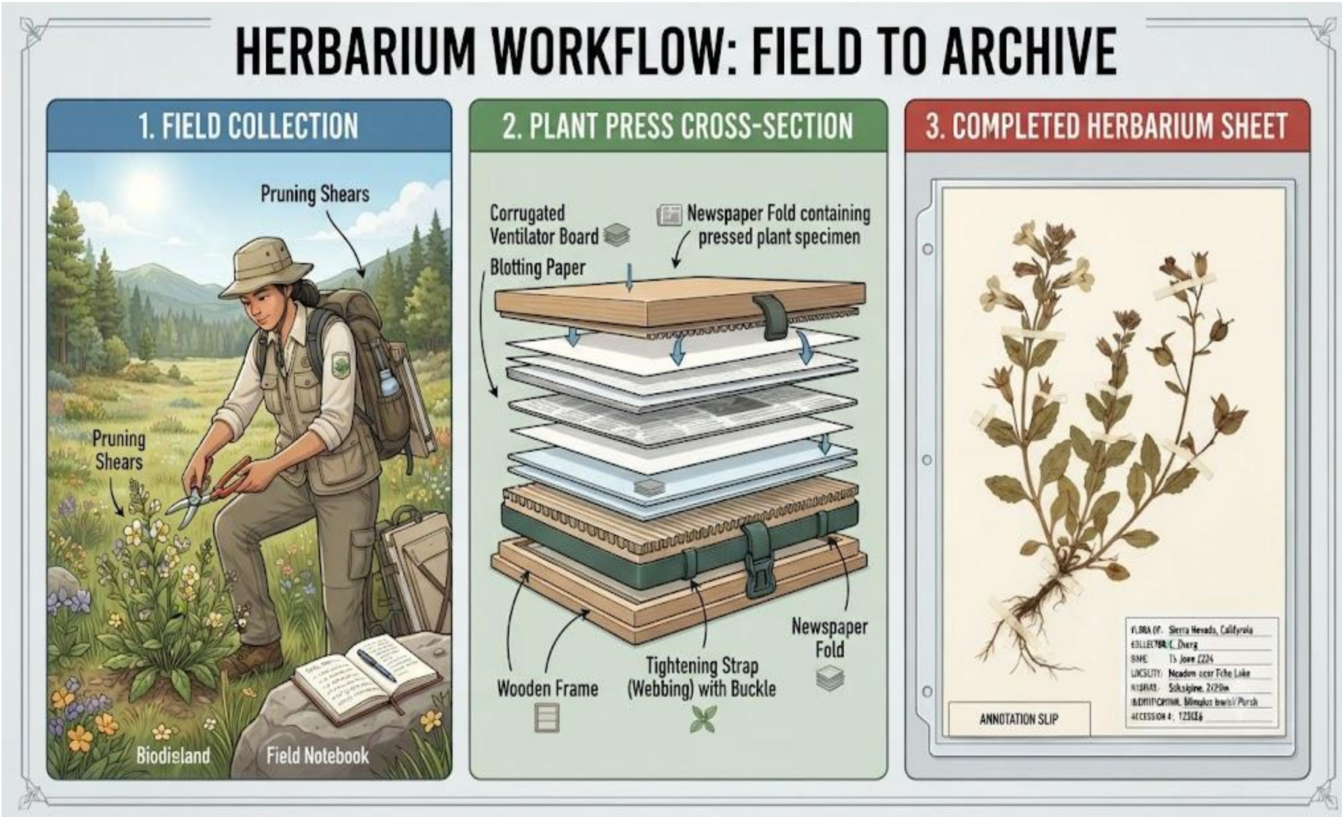

Figure 3.2: Plant specimen preparation and herbarium methods

Pilot questions 3.2

1. Name four plant parts that should be included in a good herbarium specimen of a flowering plant.
2. What is a collection number and what field data are recorded alongside it?
3. Describe the components of a plant press and explain the role of corrugated sheets.
4. Name five items of information that should appear on a herbarium label.
5. Name two herbarium pests and explain how they are controlled.

3.3 Animal Specimen Preservation and Museum Methods

3.3.1 Killing, fixing, and preserving animal specimens

The method used to kill, fix, and preserve an animal specimen depends on the taxonomic group and the intended use of the specimen: soft-bodied invertebrates (worms, aquatic larvae, slugs) are killed and fixed directly in 10 percent formalin (which hardens tissues and prevents decomposition) and subsequently transferred to 70 percent ethanol for long-term storage, as formalin is unsuitable for indefinite storage due to tissue degradation over time; insects to be pinned are killed in a killing jar containing ethyl acetate fumes, which kills rapidly without damaging fragile wings or appendages.

Fish, amphibians, and reptiles are typically fixed by injection of 10 percent formalin into the body cavity followed by immersion in 10 percent formalin for 24 to 48 hours to complete fixation, then transferred to 70 percent ethanol for storage; birds and small mammals are either made into study skins (skinned specimens stuffed with cotton wool, as described in the following sub-part) or preserved as fluid specimens for research requiring intact internal anatomy; all specimens must be labelled with a tie-on tag at the moment of collection bearing the collection number, date, locality, and collector name, before any preservation step is carried out.

Fill in the blank: Soft-bodied invertebrates are killed and fixed in 10 percent ________ and subsequently transferred to 70 percent ethanol for long-term storage.

3.3.2 Pinning insects and preparing study skins

Insects to be pinned must be relaxed before mounting if they have stiffened after killing; relaxing is done by placing the specimen in a sealed relaxing box (a closed container with damp sand or moist tissue at the base and a wire mesh platform above, left for 24 to 48 hours until the specimen is fully flexible again); the insect is then mounted by passing an entomological pin of the appropriate size (000 to 7, selected according to body width) through the correct thorax position for the order (right side of mesoscutum for beetles, Coleoptera; through the mesothorax between the wings for Diptera and Hymenoptera; through the right forewing at the base for

Hemiptera), and the wings are spread symmetrically on a spreading board and held with paper strips and pins until fully dry.

Study skins of birds and small mammals are prepared by making a ventral midline incision from sternum to vent, carefully removing the body (preserving the skull and major limb bones in a folded paper wrap attached to the skin), stuffing the cleaned skin with cotton wool to restore the natural body shape in a standardised pose (bill pointing forward for birds, limbs extended for mammals), sewing the incision closed with a few stitches, and drying in a warm location; the collection data label is tied to the leg (birds) or tail (mammals) and must include collection number, date, locality, sex (determined from gonad examination during skinning), and body measurements (total length, tail, hindfoot, and ear for mammals; wing, tarsus, culmen, and weight for birds).

Fill in the blank: Insects to be pinned must first be ________ in a sealed damp box for 24 to 48 hours if they have stiffened after killing, to restore flexibility before mounting.

3.3.3 Museum labelling, curation, and long-term storage

Every museum specimen must carry a permanent label with all collection data recorded in a format that will remain legible for decades; for pinned insect specimens, a small primary data label (approximately 15 x 5 mm, printed on acid-free card, never handwritten in pencil alone as lead pencil on thin card is easily lost) is pinned directly below the specimen on the same pin, with a secondary determination label added below the primary when the specimen has been identified; for fluid specimens (invertebrates, fish, amphibians, reptiles), labels are written in pencil (which is unaffected by ethanol, unlike ink which fades) and placed inside the container with the specimen.

Pinned insect collections are stored in insect boxes or glass-fronted museum drawers lined with cork or polyethylene foam (into which the pins are inserted to hold specimens), with naphthalene or paradichlorobenzene pest deterrent crystals renewed regularly and the drawers kept in sealed cabinets away from light, moisture, and temperature extremes; fluid collections are stored in sealed glass or plastic jars in cool, dark conditions with the fluid level checked periodically and topped up with fresh 70 percent ethanol as needed to prevent specimens from drying; a specimen catalogue or database recording all collection data enables specimens to be found, cited in publications, and tracked through institutional loans.

Fill in the blank: Labels inside fluid-preserved specimen jars are written in ________ , which is unaffected by ethanol, unlike ink which dissolves and becomes illegible over time.

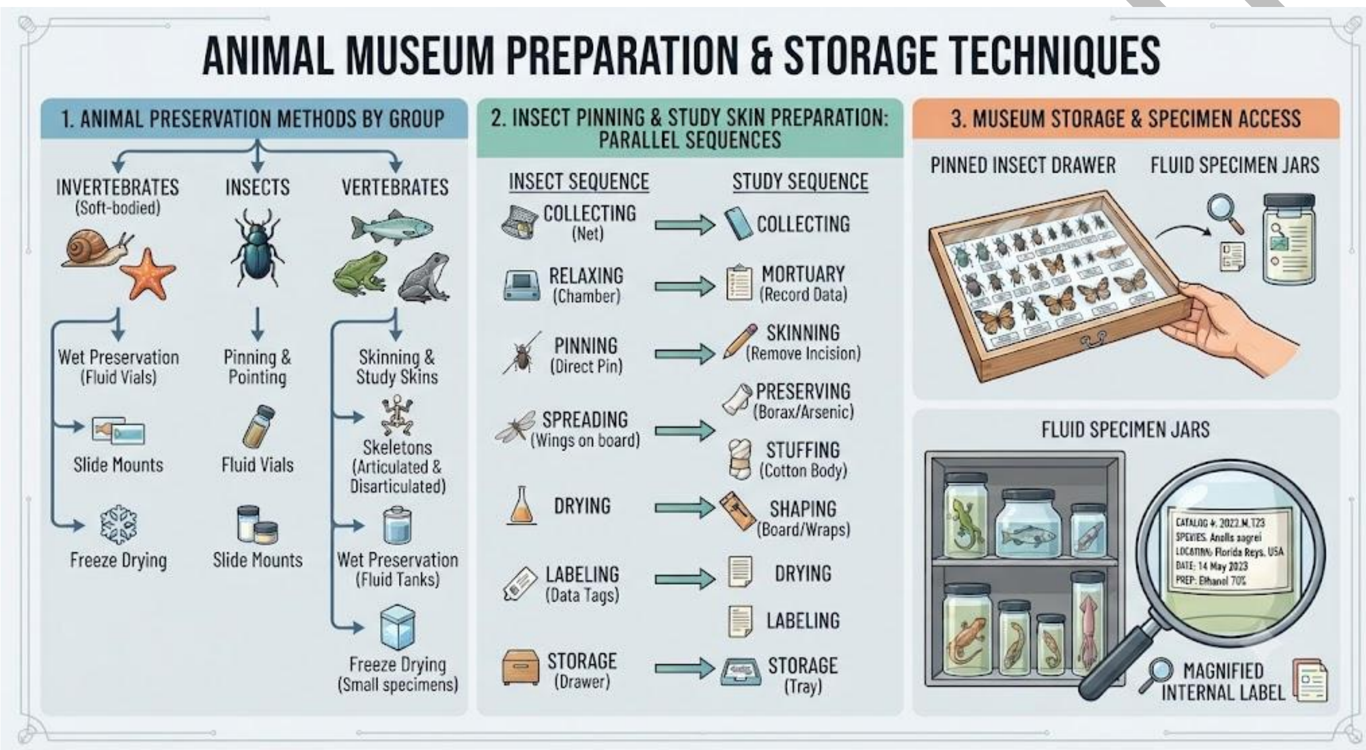

Figure 3.3: Animal specimen preparation and museum methods

Pilot questions 3.3

1. Explain why soft-bodied invertebrates are transferred from formalin to ethanol for long-term storage.
2. Explain what a relaxing box is and when it is used.
3. Describe the correct pin insertion position for a beetle specimen.
4. Describe the steps in preparing a study skin of a small bird.
5. Explain why labels inside fluid specimen jars must be written in pencil.

Series Summary

This Series covered the complete chain from field collection of specimens to their deposit in institutional herbaria and museum collections. Biological classification provides the conceptual framework for sorting field-collected material into recognisable groups, while dichotomous identification keys and complementary reference materials allow specimens to be named to the lowest achievable taxonomic level. Sorting and preliminary identification in the field determine which preservation method is appropriate and which key to use, making them a necessary first step before any specimen preparation begins.

Plant preparation follows a well-defined sequence from collecting a diagnostic shoot with all required parts, assigning a collection number and recording full field data, pressing and drying correctly in a ventilated press with daily newspaper changes, and mounting on acid-free herbarium sheets with a complete label. Animal preparation methods vary by group, from formalin fixation and ethanol storage for invertebrates and vertebrates through killing jars, relaxing boxes, and spreading boards for pinned insects to study skins for birds and small mammals, each requiring permanent, legible labelling and systematic curation to preserve long-term scientific value.

Glossary of Terms

- **Binomial nomenclature:** the system of giving each species a unique two-part scientific name consisting of the genus name (capitalised) and specific epithet (lower case), both written in italics.
- **Clade:** a group of organisms comprising a common ancestor and all its descendants, the fundamental unit of phylogenetic classification.
- **Collection number:** a unique identifier (collector name and sequential number) assigned to each specimen at the time of collection, linking the specimen to its field notebook record.
- **Dichotomous key:** an identification tool presenting two mutually exclusive alternative character descriptions at each step, guiding the user to an identification through successive choices.

- **Herbarium:** an institutional collection of dried, pressed, mounted, and labelled plant specimens, systematically arranged for scientific reference and research.
- **Killing jar:** a sealed glass container charged with ethyl acetate fumes, used to kill insects quickly and cleanly for pinning.
- **Relaxing box:** a sealed container with a damp substrate used to restore flexibility to stiffened insect specimens before they are mounted on pins.
- **Study skin:** a preserved bird or small mammal specimen in which the body is replaced with cotton wool stuffing while the skin, skull, and selected bones are retained.
- **Voucher specimen:** a preserved specimen deposited in a recognised institutional collection as a permanent, verifiable reference for an identification used in scientific work.

Concept Check Questions [Series 3]

Objective Questions

1. Each species is given a unique ________ scientific name consisting of the genus name and the specific epithet, both written in italics. (Linked to SLO 3.1)
2. ________ keys present two mutually exclusive character alternatives at each step and are the most widely used identification format. (Linked to SLO 3.1)
3. Each herbarium specimen is assigned a collection ________ at the moment of collection, linking it to its field notebook record. (Linked to SLO 3.2)
4. Soft-bodied invertebrates are killed and fixed in 10 percent ________ then transferred to 70 percent ethanol for long-term storage. (Linked to SLO 3.3)
5. Labels inside fluid specimen jars must be written in ________, which is unaffected by ethanol. (Linked to SLO 3.3)

Short-Answer Questions

1. Explain the purpose of sorting field specimens. (Linked to SLO 3.1)
2. Name four plant parts that should be in a good herbarium specimen. (Linked to SLO 3.2)
3. Name five items on a herbarium label. (Linked to SLO 3.2)
4. Explain what a relaxing box is and when it is used. (Linked to SLO 3.3)
5. Describe the steps in preparing a study skin of a small bird. (Linked to SLO 3.3)

Long-Answer Questions

1. Explain biological classification principles and describe how field specimens are sorted and identified. (Linked to SLO 3.1)
2. Describe the complete workflow for plant herbarium preparation and animal museum preparation. (Linked to SLOs 3.2, 3.3)

Answers to Concept Check Questions [Series 3]

Objective Questions

1. Binomial.
2. Dichotomous.
3. Number.
4. Formalin.
5. Pencil.

Short-Answer Questions

1. Sorting groups collected specimens into recognisable morphological categories before formal identification, determines the appropriate preservation method, and identifies which key to use for more detailed identification.
2. Leaves (both surfaces), stem or shoot, flowers or buds, and fruits.
3. Collection number, scientific name, collector, date, and locality with GPS coordinates (or family, habitat, institution).
4. A relaxing box is a sealed container with a damp base and wire mesh platform; stiffened insects are placed on the platform for 24 to 48 hours until flexibility is restored for mounting.
5. Make a ventral incision, remove the body while keeping skin, skull, and limb bones, stuff with cotton wool in a standardised pose, sew incision, attach a data label to the leg.

Long-Answer Questions

1. Classification organises organisms into the Linnaean hierarchy (Domain to Species) using shared characters reflecting evolutionary relationships; each species has a unique binomial name. Sorting groups specimens morphologically in the field, determines preservation method, and identifies the appropriate key. Dichotomous keys guide identification through paired character alternatives; reference materials including field guides, herbarium collections, and online databases supplement keys.
2. Plant herbarium: collect diagnostic shoot (leaves, flowers, fruits), assign collection number, record field data. Press in ventilated press, change newspaper daily, dry 7-14 days. Mount on acid-free sheet, attach label to lower right corner. Curate against pests. Animal museum: invertebrates fixed in formalin, stored in ethanol. Insects killed in killing jar, relaxed if

stiffened, pinned through correct thorax point, spread and dried; study skins prepared by skinning, stuffing with cotton wool, labelling. Labels in pencil for fluid specimens; pinned specimens have primary data label on same pin.

Answers to Pilot Questions [Series 3]

Part 3.1

1. Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species.
2. Binomial nomenclature gives each species a unique two-part name; example: Terminalia superba (Combretum Family, a West African forest tree), written in italics with genus capitalised.
3. Sorting groups specimens into morphological categories before formal identification; it determines which preservation method is appropriate and which key to use for the next identification step.
4. A dichotomous key presents two mutually exclusive character alternatives at each step; the user examines the specimen, selects the matching alternative, and follows to the next couplet or to a species name, repeating until identification is complete.
5. Photographic field guides, institutional herbarium and museum reference collections, and online databases such as iNaturalist and Plants of the World Online.

Part 3.2

1. Leaves (both upper and lower surfaces), stem bearing the leaves, flowers or buds, and fruits.
2. A collection number is the collector surname and sequential number assigned at collection; field data recorded alongside it include GPS coordinates, date, habitat, associated species, and descriptions of living characters lost on drying (flower colour, latex, bark texture).
3. Two rigid wooden boards with tightening straps; corrugated aluminium sheets are placed between newspaper layers to allow airflow through the press, which is essential for even and rapid drying.
4. Collection number, scientific name, collector name, date, and locality with GPS coordinates (any five from: family, habitat, altitude, institution).
5. Dermestid beetles and psocid booklice; controlled with naphthalene or paradichlorobenzene crystals renewed regularly in storage cabinets, or by freezing incoming specimens before they enter the collection.

Part 3.3

1. Formalin degrades tissues over time when specimens are stored in it long-term; transferring to 70 percent ethanol after initial fixation preserves specimen integrity indefinitely.
2. A relaxing box is a sealed container with damp sand or tissue at the base and a wire mesh platform above; used when a killed insect has stiffened before it could be mounted, restoring flexibility after 24 to 48 hours.
3. The pin is inserted through the right side of the mesoscutum (the central section of the thorax) for beetles; for other orders the correct position varies (e.g. through the mesothorax between the wings for flies).
4. Make a ventral midline incision; remove the body while preserving skin, skull, and limb bones; clean the skull; stuff the skin with cotton wool to restore body shape in a standardised pose; sew the incision closed; attach a data label to the leg with collection number, date, locality, sex, and body measurements.
5. Ethanol dissolves and fades ink over time; pencil graphite is chemically inert and remains legible even after prolonged immersion in ethanol, making it the only reliable medium for internal specimen labels.

References and Attribution

Textual References (Books and External Sources)

- Bridson, D., & Forman, L. (Eds.). (1998). The herbarium handbook (3rd ed.). Royal Botanic Gardens, Kew.
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- National Open University of Nigeria (NOUN). (2023). Field course II course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 3.1: Specimen classification and identification Attribution: AI generated. Suggested OER search string: "biological classification Linnaean hierarchy dichotomous key species identification Nigeria field biology OER".
- Figure 3.2: Plant specimen preparation and herbarium methods Attribution: AI generated. Suggested OER search string: "herbarium plant specimen collection pressing mounting label curation Nigeria field biology OER".
- Figure 3.3: Animal specimen preparation and museum methods Attribution: AI generated. Suggested OER search string: "insect pinning study skin museum preparation fluid preservation label curation herbarium Nigeria field biology OER".

Course code: BIO 407

Course title: Field Course II

Course credit load: 1 Unit

Series 4: Ecology, Taxonomy, and Systematics

- **Part 4.1: Applied Ecology in Field Studies**
  - Sub Part 4.1.1: Ecological concepts revisited in the field
  - Sub Part 4.1.2: Community ecology in field surveys
  - Sub Part 4.1.3: Hydrobiology, wildlife, and forestry in field context
- **Part 4.2: Taxonomy in Field Practice**
  - Sub Part 4.2.1: Principles and practice of taxonomy
  - Sub Part 4.2.2: Taxonomic characters and morphological description
  - Sub Part 4.2.3: Writing formal taxonomic descriptions
- **Part 4.3: Systematics and Phylogenetics**
  - Sub Part 4.3.1: Systematics and its relationship to taxonomy
  - Sub Part 4.3.2: Phylogenetics and cladistics in field biology
  - Sub Part 4.3.3: Applying systematics to field-collected material

Introduction

Field biology draws its greatest scientific value from the theoretical frameworks of ecology, taxonomy, and systematics that give meaning to the raw observations and specimens collected in the field. Understanding how ecological concepts apply at the community and ecosystem scale in real field settings, how taxonomic characters are identified and formally described, and how systematic relationships among organisms are reconstructed and applied, transforms field data from descriptive inventories into contributions to biological knowledge.

This Series connects the practical field skills developed in the previous three Series to the disciplinary frameworks of ecology, taxonomy, and systematics. It revisits key ecological concepts in the context of the actual habitats studied during the course, including community structure, hydrobiology, wildlife ecology, and forestry; introduces the principles and practice of taxonomy as applied to field-collected specimens; and explains the foundations of phylogenetics and cladistics and how systematic thinking is applied to the classification and interpretation of field material.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** apply ecological concepts to field survey data and describe community ecology, hydrobiology, wildlife, and forestry in field contexts,
- **SLO 4.2** explain the principles and practice of taxonomy, describe taxonomic characters, and write a formal taxonomic description, and
- **SLO 4.3** explain the principles of systematics and phylogenetics and describe how they are applied to field-collected material.

4.1 Applied Ecology in Field Studies

4.1.1 Ecological concepts revisited in the field

The field environment provides the living context for ecological concepts studied theoretically in lecture courses; in the field, students observe directly the phenomenon of species distribution and abundance varying across environmental gradients (for example, plant species richness declining from riparian zones to dry upland areas as soil moisture decreases), the operation of ecological interactions such as competition (evidenced by the spacing patterns of trees or the mutual exclusion of competing plants in adjacent microhabitats), and the realised outcomes of predation and herbivory (browsing damage on vegetation, prey remains at predator dens, or the selective removal of preferred food plants by grazers).

Ecological succession (the progressive change in species composition over time following disturbance) is observable in field sites with contrasting disturbance histories, from recently cleared roadsides through regrowth areas to mature undisturbed forest; habitat heterogeneity (variation in physical conditions within a landscape) and its relationship to species diversity can be directly measured by comparing quadrat-level species data across contrasting microhabitats within the same study site; connecting each observation to the underlying ecological principle it illustrates is a key learning practice in BIO 407, and students are expected to make these connections explicit in their field notebooks and project reports.

Fill in the blank: Ecological ________ is the progressive change in species composition over time following disturbance, observable in field sites with contrasting disturbance histories.

4.1.2 Community ecology in field surveys

Community ecology examines the composition, structure, and dynamics of multi-species assemblages; key community-level metrics calculated from field survey data include species richness (total number of species), species diversity indices (Shannon-Wiener H, Simpson D), relative abundance (the proportion of total individuals represented by each species), and species evenness (the degree to which individuals are distributed equally among species); these metrics allow communities in different habitats or at different times to be compared quantitatively.

Trophic structure (the organisation of a community into feeding levels including producers, primary consumers, secondary consumers, and decomposers) can be inferred from field observations and specimen identifications by assigning each recorded species to its trophic level; indicator species (species whose presence, absence, or abundance provides information about the ecological condition of a habitat, such as lichens indicating air quality, freshwater invertebrate families indicating water quality through BMWP scoring, or frugivorous birds indicating intact seed-dispersal networks) are particularly useful in field monitoring because they integrate ecological conditions over time and across space rather than reflecting only the conditions at the moment of sampling.

Fill in the blank: ________ species provide information about the ecological condition of a habitat through their presence, absence, or abundance, integrating conditions over time.

4.1.3 Hydrobiology, wildlife, and forestry in field context

Hydrobiology (the study of freshwater ecosystems and their organisms) is a major component of BIO 407 field trips to rivers, streams, ponds, and wetlands; field hydrological studies combine physicochemical measurements (temperature, dissolved oxygen, pH, conductivity, turbidity, and flow velocity) with biological sampling of macroinvertebrates, fish, macrophytes, and algae, allowing the relationship between water quality and biological community composition to be examined; the BMWP biotic index applied to freshwater macroinvertebrate samples provides a practical biological water quality assessment directly applicable to Nigerian river systems.

Wildlife ecology field activities in BIO 407 include guided visits to wildlife parks, game reserves, and zoological gardens, where students observe animal behaviour, habitat use, and interspecific interactions in semi-natural or managed conditions; forestry field activities involve visits to afforestation sites, woodlot parks, and natural forest reserves, where forest structure measurements (tree density, DBH distribution, basal area, canopy height, and species composition) are used to characterise stand structure, and the practical applications of ecological knowledge to sustainable forestry and reforestation are observed and discussed with site managers.

Fill in the blank: The BMWP ________ index provides a practical biological water quality assessment using freshwater macroinvertebrate family sensitivity scores, directly applicable to Nigerian river systems.

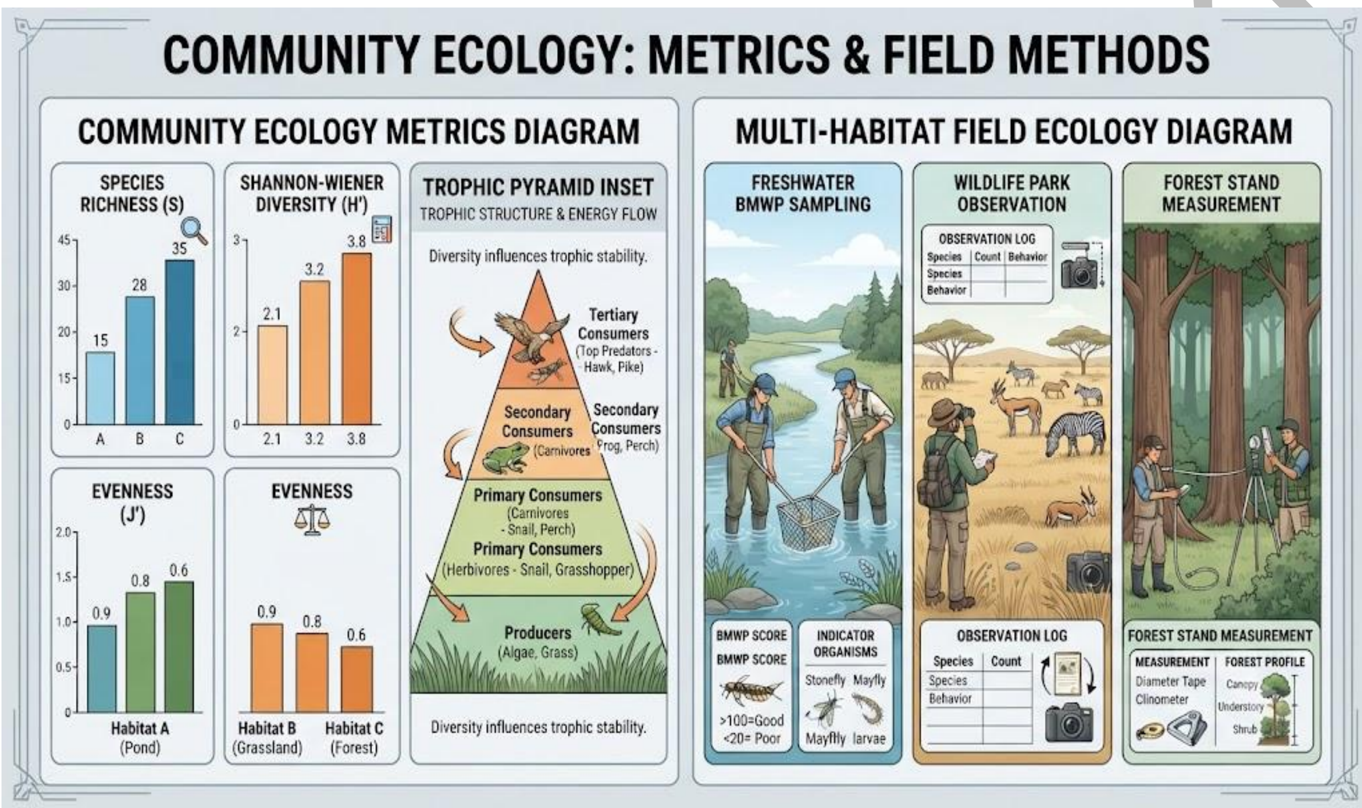


Figure 4.1: Applied ecology in BIO 407 field settings

Pilot questions 4.1

1. Name three ecological concepts directly observable during field surveys.
2. Define species richness and species evenness.
3. Explain what an indicator species is and give one example relevant to Nigerian field biology.
4. Name three physicochemical variables measured in hydrobiology field studies.
5. Name two types of measurement used to characterise forest stand structure in forestry field visits.

4.2 Taxonomy in Field Practice

4.2.1 Principles and practice of taxonomy

Taxonomy is the science of describing, naming, and classifying organisms; it is the discipline most directly connected to field biology because it depends on the accurate observation and documentation of the morphological characters of organisms in the field and the laboratory; the core activities of taxonomy are: description (formally documenting the morphological characters of a specimen in standardised terminology), naming (assigning a valid scientific name according to the rules of the International Code of Nomenclature for algae, fungi, and plants, or the International Code of Zoological Nomenclature), and classification (placing the named taxon in its correct position within the existing classification hierarchy).

The practice of taxonomy requires access to type specimens (the physical specimens on which the original formal description of a species was based, deposited in institutional collections and serving as the permanent nomenclatural reference), comprehensive literature (including original species descriptions, revision monographs, and flora and fauna works covering the relevant geographic region), and comparative material (identified specimens of related species allowing comparison with the specimen under study); BIO 407 field activities introduce students to basic taxonomic practice through the identification, description, and labelling of field-collected specimens to the standards required for herbarium and museum deposit.

Fill in the blank: A type ________ is the physical specimen on which the original formal description of a species was based, deposited in an institutional collection as the permanent nomenclatural reference.

4.2.2 Taxonomic characters and morphological description

Taxonomic characters are the observable features of organisms used to distinguish between taxa and to construct classifications; they are divided into vegetative characters (features of non-reproductive structures such as stems, leaves, roots, and bark), reproductive characters (flowers, fruits, seeds, cones, or spores, which are typically the most taxonomically reliable because they are under stronger selection for species-specific recognition and are less environmentally variable than vegetative characters), and in animals, anatomical characters (dentition, bone structure, wing venation, scale patterns, and similar structural features used to distinguish animal species and higher taxa).

Morphological description in taxonomy follows a standardised sequence and uses a defined technical vocabulary to ensure precision and reproducibility; for a flowering plant, the formal description covers, in sequence: habit (tree, shrub, herb, climber) and approximate size; stem characteristics (cross-section, surface texture, colour, and any specialised structures); leaf arrangement (alternate, opposite, whorled), shape (lanceolate, ovate, orbicular), margin (entire, serrate, lobed), texture (glabrous, pubescent, scabrid), venation pattern, and petiole length; inflorescence type (raceme, panicle, umbel, spike, head) and position; and flower structure (petal number and arrangement, sepal number and fusion, stamen number, ovary position and number of locules), followed by fruit and seed characters.

Fill in the blank: ________ characters such as flower structure and fruit type are typically the most taxonomically reliable because they are under stronger selection and less environmentally variable than vegetative characters.

4.2.3 Writing formal taxonomic descriptions

A formal taxonomic description communicates the diagnostic characters of a specimen in a standardised format that allows any other biologist to match the description to the organism it describes; for teaching purposes in BIO 407, students produce descriptions at the level of detail appropriate for plant family or genus level identification rather than full species-level formal descriptions, but following the same logical structure and technical vocabulary used in professional taxonomy; the description should be based entirely on direct observation of the specimen rather than on literature sources, and should capture the range of variation observed in the material collected.

Good taxonomic descriptions are precise (using technical terms with agreed definitions rather than vague everyday language), complete (covering all the structural parts of the organism in the standardised sequence), objective (describing what is observed rather than interpretations or comparisons with other taxa), and concise (avoiding unnecessary repetition or explanation); after writing the description, students should cross-check it against an identification key for the relevant group to verify that the characters described are sufficient to lead to a correct identification and that no key characters have been omitted; this cross-checking is a valuable self-assessment that reveals gaps in the original description.

Fill in the blank: A good taxonomic description is precise, complete, objective, and ________ , avoiding unnecessary repetition while covering all diagnostic characters in the standardised sequence.

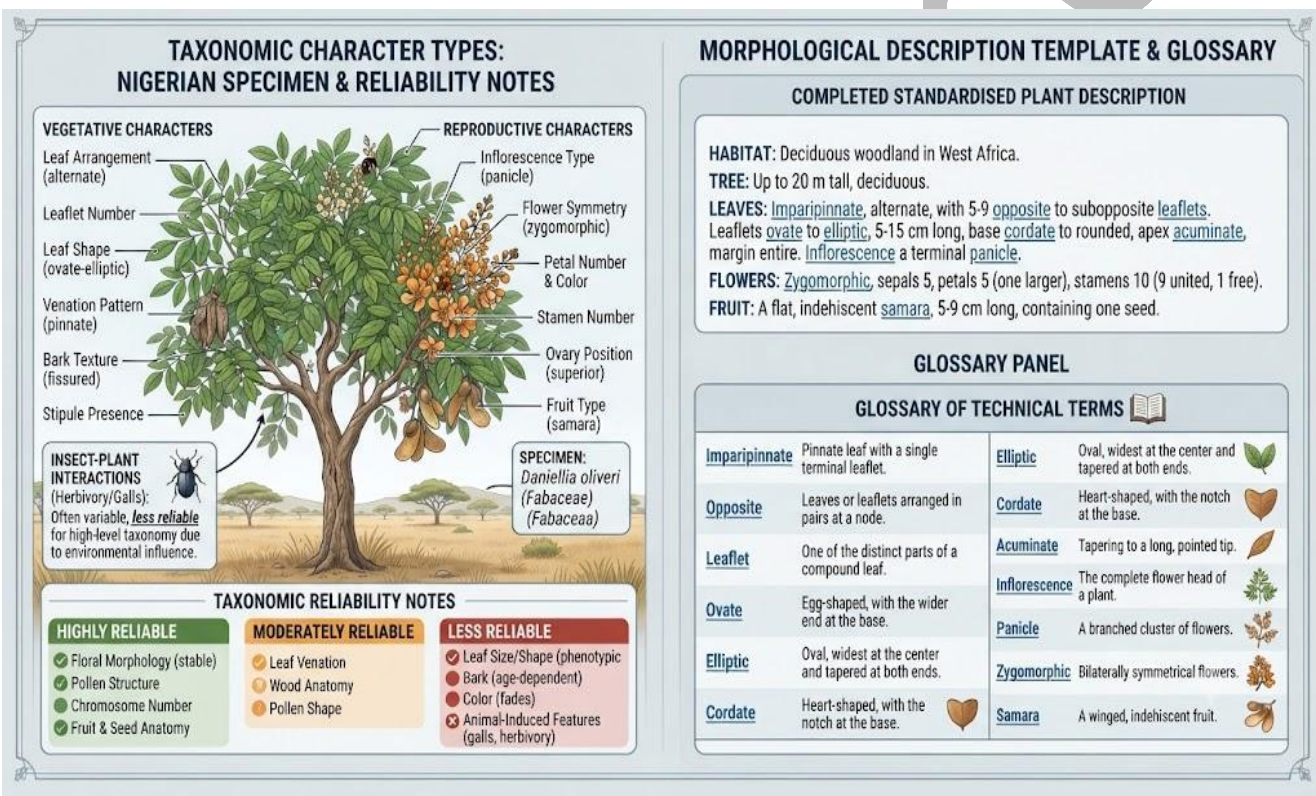


Figure 4.2: Taxonomy in field practice

Pilot questions 4.2

1. Define taxonomy and name its three core activities.
2. Explain what a type specimen is and its importance in taxonomy.
3. Distinguish between vegetative and reproductive taxonomic characters.
4. Name five leaf characters that should be described in a plant morphological description.
5. State four qualities of a good formal taxonomic description.

4.3 Systematics and Phylogenetics

4.3.1 Systematics and its relationship to taxonomy

Systematics is the scientific study of the diversity of organisms and their evolutionary relationships, encompassing taxonomy (the description, naming, and classification of organisms) but extending beyond it to include the reconstruction of phylogenetic (evolutionary) relationships and the study of the patterns and processes of biological diversification; while taxonomy asks "what is this organism and what should it be called?", systematics asks the broader question "how are organisms related to each other and what does that tell us about the history of life?"; the two disciplines are intimately connected because a sound classification should reflect evolutionary history, making phylogenetic information essential for modern classification.

The move from phenetic classification (grouping organisms by overall similarity across many characters, without explicitly considering evolutionary relationships) to phylogenetic or cladistic classification (grouping organisms strictly into natural groups sharing a common ancestor and all its descendants, based on shared derived characters indicating common ancestry) has transformed biological taxonomy over the past several decades; molecular data (DNA sequences) have provided new and powerful evidence for phylogenetic relationships, in many cases revising classifications based on morphology alone and revealing unexpected evolutionary relationships between groups previously placed far apart in traditional classifications.

Fill in the blank: ________ classification groups organisms by overall morphological similarity across many characters, while phylogenetic classification groups organisms into natural groups based on shared derived characters indicating common ancestry.

4.3.2 Phylogenetics and cladistics in field biology

Phylogenetics is the study of evolutionary relationships among organisms, typically represented as phylogenetic trees (branching diagrams in which the tips represent taxa and the branching points represent inferred common ancestors); the branch lengths may represent time (in time-calibrated trees) or amount of character change; cladistics is the methodological framework for reconstructing phylogenetic relationships using shared derived characters (synapomorphies) that are shared by two or more taxa and inherited from their most recent common ancestor, as opposed to symplesiomorphies (ancestral characters shared by a broader group) or homoplasies (similar characters that evolved independently in different lineages, confounding phylogenetic analysis).

In field biology, phylogenetic thinking informs specimen collection strategies (ensuring that closely related species are sampled together to allow comparative study), the interpretation of distributional patterns (closely related species that replace each other geographically are often separated by vicariance events rather than ecological differences), and the recognition of morphologically convergent species (species that appear similar in form but are phylogenetically distant, such as cacti and African spurges which are both succulent stem plants but belong to very different families); recognising convergence is important to avoid misidentification based on superficial morphological similarity.

Fill in the blank: A ________ is a shared derived character inherited from the most recent common ancestor of a group, used in cladistics to infer phylogenetic relationships.

4.3.3 Applying systematics to field-collected material

Systematic thinking is applied to field-collected material in BIO 407 through the process of building morphological matrices: for a set of field-collected specimens representing several species, students record the presence or absence (or state) of a defined set of characters for each specimen; this character-by-taxon matrix provides the raw data for comparing the specimens systematically, identifying which characters are shared by which species, and inferring which characters are informative about relationships versus which are uninformative (present in all or absent from all specimens); even a simple matrix of ten characters and five to eight species reveals the structure of systematic thinking in a concrete, hands-on way.

Applying systematic principles to field-collected material also requires students to distinguish between analogous characters (similar in function but not in evolutionary origin, such as the wings of birds and insects, which provide no evidence of common ancestry) and homologous characters (similar in evolutionary origin, derived from a common ancestral structure, such as the forelimbs of bats, whales, and humans, all derived from the same ancestral tetrapod limb); only homologous characters provide valid evidence of phylogenetic relationship, and recognising the distinction between homology and analogy is a key conceptual contribution of systematics to field biology interpretation.

Fill in the blank: ________ characters are similar in evolutionary origin (derived from a common ancestral structure) and provide valid evidence of phylogenetic relationship, unlike analogous characters which are similar in function only.

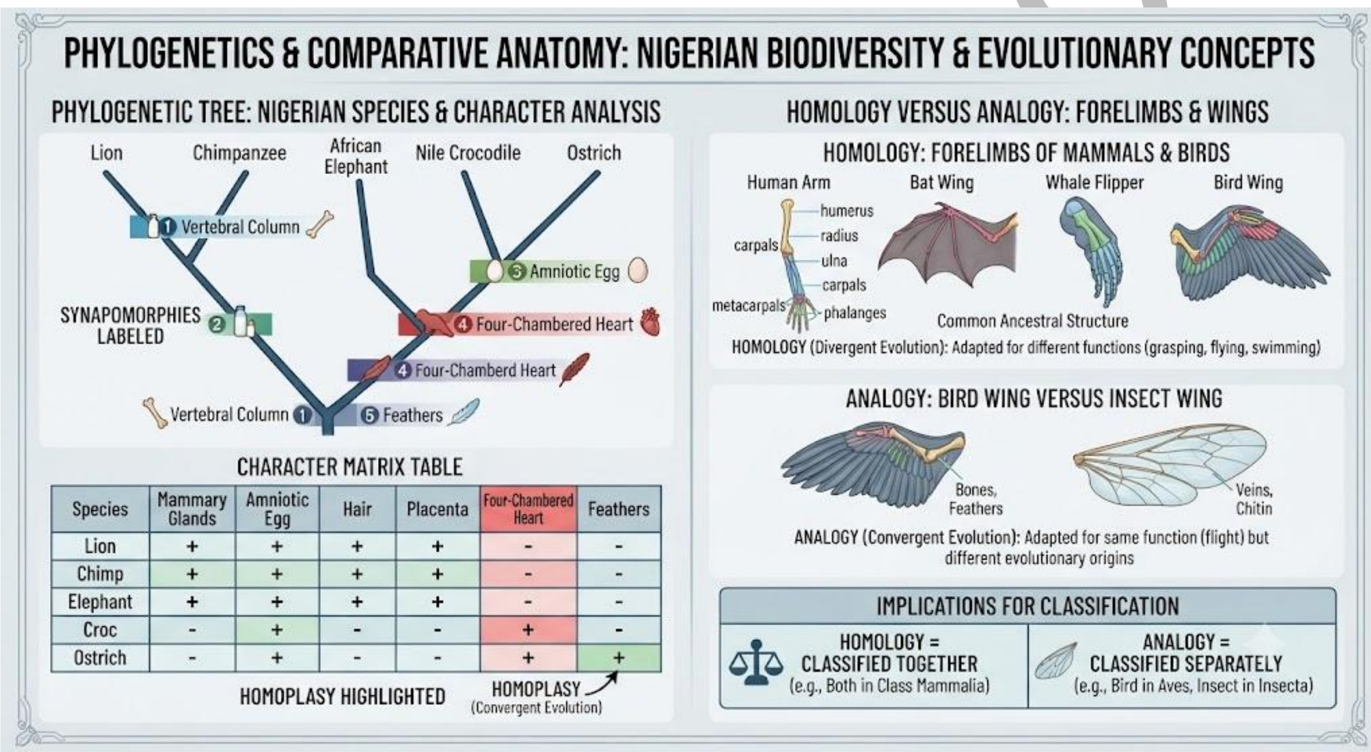


Figure 4.3: Systematics and phylogenetics

Pilot questions 4.3

1. Distinguish between taxonomy and systematics.
2. Distinguish between phenetic and phylogenetic classification.
3. Define synapomorphy and explain its role in cladistics.
4. Explain what a morphological matrix is and how it is used in systematics.
5. Distinguish between homologous and analogous characters and explain why the distinction matters.

Series Summary

This Series connected the practical field skills of BIO 407 to the theoretical frameworks of ecology, taxonomy, and systematics that give them scientific meaning. In the field, students observed ecological concepts directly, calculating community metrics such as species richness, diversity indices, and evenness, recognising indicator species, and conducting hydrological, wildlife, and forestry surveys that integrate biological community data with physical environment measurements. These field applications bring to life the ecological theory encountered in lecture courses by placing it in the real complexity of Nigerian habitats.

Taxonomy provides the naming and description framework for field-collected specimens, requiring careful observation of vegetative and reproductive characters and formal description in standardised technical language. Systematics extends taxonomy to the reconstruction of evolutionary relationships, using synapomorphies to build phylogenetic trees and character matrices. The distinction between homologous and analogous characters, and between phenetic and phylogenetic classification, equips students to interpret their field collections not just as inventories of names but as evidence of the evolutionary history of the Nigerian biota they have studied directly in the field.

Glossary of Terms

- **Analogy:** similarity in function between characters in different organisms that does not reflect shared evolutionary origin; analogous characters are not valid evidence of phylogenetic relationship.
- **Cladistics:** the systematic methodology for reconstructing phylogenetic relationships using shared derived characters (synapomorphies) inherited from a most recent common ancestor.
- **Homology:** similarity between characters in different organisms that reflects derivation from the same structure in a common ancestor; homologous characters provide valid evidence of phylogenetic relationship.

- **Indicator species:** a species whose presence, absence, or abundance reflects the ecological condition of a habitat, integrating environmental conditions over time and space.
- **Phenetic classification:** grouping of organisms based on overall morphological similarity across many characters, without explicitly considering evolutionary relationships.
- **Phylogenetic tree:** a branching diagram representing the inferred evolutionary relationships among a group of taxa, with branch points representing common ancestors.
- **Synapomorphy:** a shared derived character inherited from the most recent common ancestor of a group of taxa, used as evidence of shared ancestry in cladistic analysis.
- **Taxonomy:** the science of describing, naming, and classifying organisms, forming the core of biological diversity documentation.
- **Type specimen:** the physical specimen on which the original formal description of a species was based, deposited in an institutional collection as the permanent nomenclatural reference.

Concept Check Questions [Series 4]

Objective Questions

1. Ecological ________ is the progressive change in species composition following disturbance, observable in field sites with contrasting histories. (Linked to SLO 4.1)
2. ________ species reflect habitat ecological condition through their presence, absence, or abundance, integrating conditions over time. (Linked to SLO 4.1)
3. A type ________ is the physical specimen on which a species original formal description was based. (Linked to SLO 4.2)
4. ________ characters, such as flower structure and fruit type, are typically the most taxonomically reliable. (Linked to SLO 4.2)
5. A ________ is a shared derived character inherited from the most recent common ancestor, used in cladistics. (Linked to SLO 4.3)

Short-Answer Questions

1. Name three community ecology metrics calculated from field survey data. (Linked to SLO 4.1)
2. Define taxonomy and name its three core activities. (Linked to SLO 4.2)
3. Name five leaf characters described in a plant morphological description. (Linked to SLO 4.2)
4. Distinguish between phenetic and phylogenetic classification. (Linked to SLO 4.3)
5. Distinguish between homologous and analogous characters. (Linked to SLO 4.3)

Long-Answer Questions

1. Describe how ecological concepts are applied in BIO 407 field surveys, including community ecology, hydrobiology, wildlife, and forestry. (Linked to SLO 4.1)
2. Explain the principles of taxonomy and systematics, describe taxonomic characters and description, and explain phylogenetics and cladistics. (Linked to SLOs 4.2, 4.3)

Answers to Concept Check Questions [Series 4]

Objective Questions

1. Succession.
2. Indicator.
3. Specimen.
4. Reproductive.
5. Synapomorphy.

Short-Answer Questions

1. Species richness, species diversity index (Shannon-Wiener H), and species evenness (or relative abundance).
2. Taxonomy describes, names, and classifies organisms; core activities: description, naming, and classification.
3. Arrangement (alternate/opposite/whorled), shape (lanceolate/ovate), margin (entire/serrate), texture (glabrous/pubescent), and venation pattern.
4. Phenetic classification groups by overall morphological similarity; phylogenetic classification groups organisms into natural clades based on shared derived characters indicating common ancestry.
5. Homologous characters are similar in evolutionary origin (derived from a common ancestral structure) and provide valid phylogenetic evidence; analogous characters are similar in function only (different evolutionary origins) and do not.

Long-Answer Questions

1. Field ecology: observe succession, habitat heterogeneity, competition, predation directly. Community metrics: species richness, Shannon-Wiener H, evenness, relative abundance, trophic structure, indicator species. Hydrobiology: physicochemical measurements (DO, pH, turbidity) plus macroinvertebrate BMWP scoring for water quality. Wildlife: visits to parks/reserves for animal behaviour and habitat use observation. Forestry: forest stand measurements (DBH, basal area, density, canopy height, species composition) at afforestation and natural forest sites.

2. Taxonomy: describes, names, classifies organisms; requires type specimens, literature, comparative material. Characters: vegetative (stem, leaf) and reproductive (flower, fruit, most reliable). Formal description: standardised sequence, technical vocabulary, precise, complete, objective, concise. Systematics: extends taxonomy to evolutionary relationships; phenetic (overall similarity) versus phylogenetic (cladistic, shared derived characters/synapomorphies). Phylogenetic trees show relationships; character matrices compare taxa; homologous characters (valid phylogenetic evidence) versus analogous characters (convergent function only).

Answers to Pilot Questions [Series 4]

Part 4.1

1. Ecological succession (in sites with contrasting disturbance histories), habitat heterogeneity (variation in microhabitat conditions), and competition (evidenced by spacing patterns or mutual exclusion of species).
2. Species richness is the total number of species in a community; species evenness is the degree to which individuals are distributed equally among all the species present.
3. An indicator species is one whose presence, absence, or abundance reflects habitat ecological condition; example: freshwater macroinvertebrate families used in BMWP scoring to assess Nigerian river water quality.
4. Temperature, dissolved oxygen, and pH (or conductivity, turbidity, flow velocity).
5. DBH (diameter at breast height) and basal area (or tree density, canopy height, species composition).

Part 4.2

1. Taxonomy is the science of describing, naming, and classifying organisms; core activities: description, naming, and classification.
2. A type specimen is the physical specimen on which a species original formal description was based; it is deposited in an institutional collection as the permanent nomenclatural reference that defines the application of that species name.

3. Vegetative characters describe non-reproductive structures (leaves, stem, roots, bark); reproductive characters describe flowers, fruits, and seeds; reproductive characters are more taxonomically reliable because they are under stronger species-specific selection and less environmentally variable.
4. Arrangement (alternate, opposite, or whorled), shape (e.g. lanceolate, ovate), margin (e.g. entire, serrate, lobed), texture (e.g. glabrous, pubescent), and venation pattern.
5. Precise (uses defined technical terms), complete (covers all parts in standardised sequence), objective (describes observations not interpretations), and concise (no unnecessary repetition).

Part 4.3

1. Taxonomy describes, names, and classifies organisms; systematics extends this to reconstructing evolutionary relationships and studying patterns of biological diversification, asking how organisms are related rather than just what they are.
2. Phenetic classification groups organisms by overall morphological similarity across many characters without explicitly considering evolutionary relationships; phylogenetic classification groups organisms strictly into natural groups (clades) based on shared derived characters indicating common ancestry.
3. A synapomorphy is a shared derived character inherited from the most recent common ancestor of a group of taxa; in cladistics it is used as positive evidence that the taxa sharing it form a natural (monophyletic) group.
4. A morphological matrix has species as rows and characters as columns, with each cell coded as the state of that character in that species; it allows systematic comparison of character distributions across taxa, identifying informative characters and inferring relationships.
5. Homologous characters are similar in evolutionary origin (derived from the same ancestral structure) and provide valid phylogenetic evidence; analogous characters are similar in function but of different evolutionary origin (convergent evolution) and do not indicate shared ancestry.

References and Attribution

Textual References (Books and External Sources)

- Krebs, C. J. (2014). Ecology: The experimental analysis of distribution and abundance (6th ed.). Pearson.
- Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., & Donoghue, M. J. (2016). Plant systematics: A phylogenetic approach (4th ed.). Sinauer Associates.
- Wiley, E. O., & Lieberman, B. S. (2011). Phylogenetics: Theory and practice of phylogenetic systematics (2nd ed.). Wiley-Blackwell.
- National Open University of Nigeria (NOUN). (2023). Field course II course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 4.1: Applied ecology in BIO 407 field settings Attribution: AI generated. Suggested OER search string: "community ecology field survey species richness diversity hydrobiology wildlife forestry Nigeria field biology OER".
- Figure 4.2: Taxonomy in field practice Attribution: AI generated. Suggested OER search string: "taxonomy morphological description taxonomic characters flowering plant description field biology Nigeria OER".
- Figure 4.3: Systematics and phylogenetics Attribution: AI generated. Suggested OER search string: "phylogenetics cladistics systematics synapomorphy homology analogy phylogenetic tree field biology Nigeria OER".

Course code: BIO 407

Course title: Field Course II

Course credit load: 1 Unit

Series 5: Field Projects and Report Writing

- **Part 5.1: Planning and Conducting Field Projects**
  - Sub Part 5.1.1: Individual and group project design
  - Sub Part 5.1.2: Managing a field project from inception to completion
  - Sub Part 5.1.3: Time management and individual skills in project work
- **Part 5.2: Scientific Report Writing**
  - Sub Part 5.2.1: Structure and content of a field biology report
  - Sub Part 5.2.2: Writing style, accuracy, and scientific conventions
  - Sub Part 5.2.3: Referencing, citations, and academic integrity
- **Part 5.3: Course Assessment and Examination**
  - Sub Part 5.3.1: Assessment components of BIO 407
  - Sub Part 5.3.2: Practical examination in field biology
  - Sub Part 5.3.3: Reflecting on field biology learning

Introduction

The field project and the scientific report that documents it are the culminating activities of Field Course II, bringing together all the skills developed across the preceding four Series into a sustained, independent investigation that produces an original contribution to knowledge of the local study area. The ability to plan a field project, collect and analyse data systematically, and communicate findings clearly in a scientific report are among the most transferable skills a biology graduate can develop, applicable across research, environmental management, and applied biology careers.

This final Series covers the design and management of individual and group field projects, including the key challenge of time management across an extended project; the structure, content, and style of a scientific field biology report, including referencing and academic integrity; and the assessment components of BIO 407, including the practical examination, and closes with an invitation to reflect on the learning achieved through the course as a whole. Together these elements complete the transition from guided field activities to independent biological investigation.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** plan, manage, and conduct an individual or group field project from inception to completion,
- **SLO 5.2** write a scientific field biology report that is correctly structured, clearly written, and properly referenced, and
- **SLO 5.3** describe the assessment components of BIO 407, prepare for the practical examination, and reflect on field biology learning.

5.1 Planning and Conducting Field Projects

5.1.1 Individual and group project design

A field project in BIO 407 is a sustained, self-directed investigation of a specific biological question using the field methods, data recording practices, and specimen preparation skills developed throughout the course; projects may be individual or group-based, and typically span several weeks from initial planning through fieldwork to report submission; the project design begins with identifying a researchable question of appropriate scope and feasibility for the available time, sites, and equipment, and then specifying the methods, sampling design, and data collection approach that will generate the evidence needed to address it.

A well-designed project proposal includes: the biological question and its ecological or taxonomic context (why the question matters and what is already known from the literature); the specific null hypothesis or objectives to be addressed; the study site(s) selected and justification for the choice; the methods to be used (sampling design, equipment, number of replicates, and environmental variables to be measured); an analysis plan (how the data will be organised, summarised, and tested); and a realistic timeline allocating specific field sessions and write-up time; the proposal should be reviewed and approved by the course instructor before fieldwork commences.

Fill in the blank: A field project ________ should specify the biological question, null hypothesis, study sites, methods, analysis plan, and timeline before fieldwork commences.

5.1.2 Managing a field project from inception to completion

Successful project management requires maintaining progress across multiple phases: the planning phase (designing the study, writing the proposal, obtaining equipment and permissions); the field data collection phase (executing the field plan according to the timeline, recording data systematically, and maintaining field notebooks); the specimen preparation phase (processing collected specimens, completing identifications, depositing vouchers in the herbarium or museum); the data analysis phase (entering data, checking quality, calculating summary statistics and diversity indices, producing figures); and the write-up phase (drafting the report, seeking feedback, revising, and submitting on time).

Common project management failures include: leaving field data collection too late in the semester and running out of time for adequate sampling replication; failing to process and identify specimens promptly after collection (fresh specimens are much easier to identify and preserve than dried or deteriorated ones); losing data through failure to back up field notes and data sheets to digital formats promptly; and underestimating the time required for the write-up phase, which for a well-structured scientific report is typically at least as long as the data collection and analysis phases combined; building a realistic written timeline with milestones for each phase and sharing it with group members prevents these common failures.

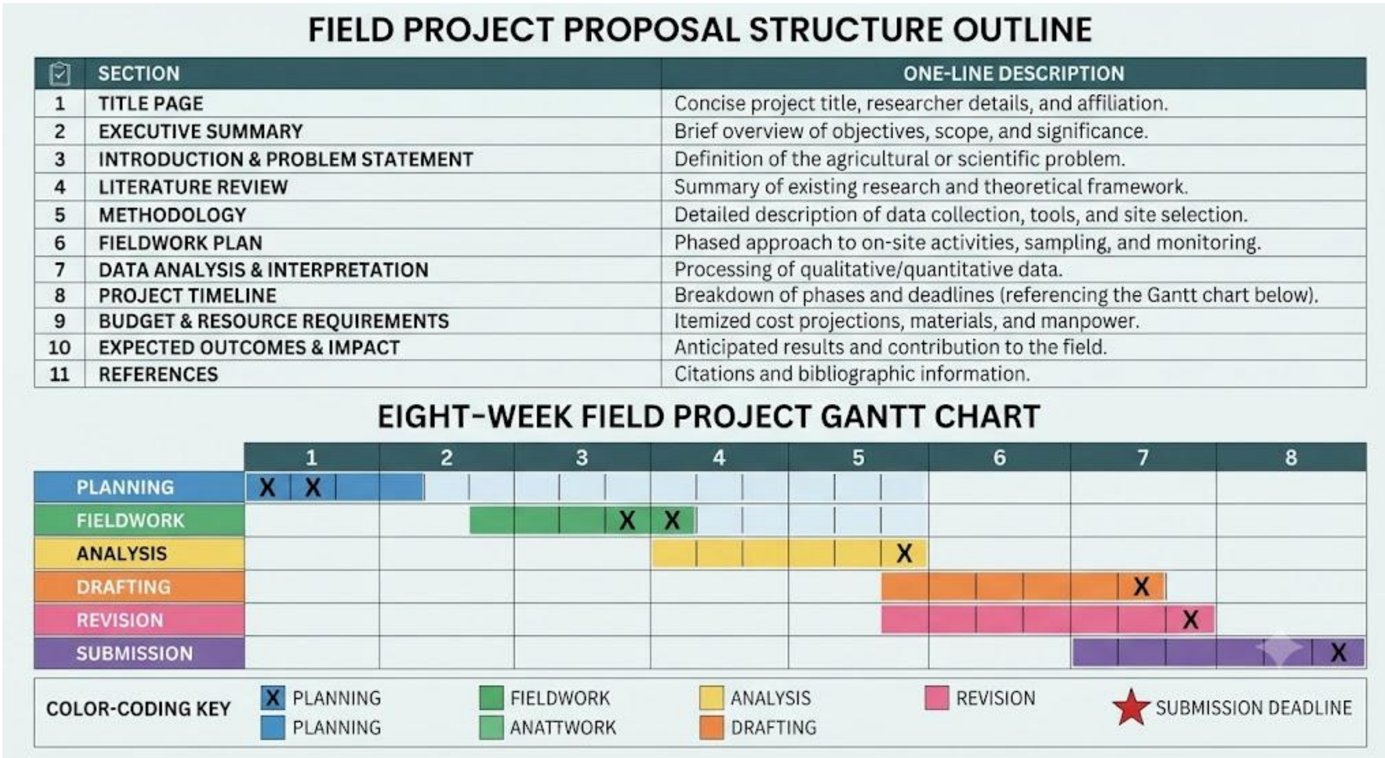
Fill in the blank: Specimens should be processed and identified ________ after collection, as fresh material is much easier to identify and preserve than deteriorated specimens.

5.1.3 Time management and individual skills in project work

Time management in field projects differs from time management in a single field session because it operates over weeks rather than hours, and requires the student to be self-directed rather than following an instructor-led schedule; effective strategies include: breaking the project into discrete tasks with individual deadlines (creating a Gantt chart or simple task list with due dates for each phase), setting aside dedicated time blocks for field, analysis, and writing work each week rather than working reactively when deadlines approach, and maintaining regular communication with project partners and the instructor so that problems are identified and addressed early rather than escalating.

Individual skills developed through field project work include independence of judgement (making scientific decisions in the field when the instructor is not immediately available to advise), troubleshooting (adapting methods when planned approaches prove impractical in the field), and persistence (maintaining methodological rigour and data quality standards under the challenging physical conditions of tropical fieldwork); these qualities are not only assessed in the project itself but are directly relevant to employment as a field biologist, environmental consultant, or research scientist, and should be explicitly reflected upon in the personal reflection section of the final report.

Fill in the blank: A Gantt chart or task list with ________ for each project phase helps students manage time effectively across the multiple weeks of a field project.


FIELD PROJECT PROPOSAL STRUCTURE OUTLINE

	SECTION	ONE-LINE DESCRIPTION
1	TITLE PAGE	Concise project title, researcher details, and affiliation.
2	EXECUTIVE SUMMARY	Brief overview of objectives, scope, and significance.
3	INTRODUCTION & PROBLEM STATEMENT	Definition of the agricultural or scientific problem.
4	LITERATURE REVIEW	Summary of existing research and theoretical framework.
5	METHODOLOGY	Detailed description of data collection, tools, and site selection.
6	FIELDWORK PLAN	Phased approach to on-site activities, sampling, and monitoring.
7	DATA ANALYSIS & INTERPRETATION	Processing of qualitative/quantitative data.
8	PROJECT TIMELINE	Breakdown of phases and deadlines (referencing the Gantt chart below).
9	BUDGET & RESOURCE REQUIREMENTS	Itemized cost projections, materials, and manpower.
10	EXPECTED OUTCOMES & IMPACT	Anticipated results and contribution to the field.
11	REFERENCES	Citations and bibliographic information.

Figure 5.1: Field project planning and management

Pilot questions 5.1

1. Name the five phases of a field project from inception to completion.
2. Name five elements that should appear in a field project proposal.
3. Explain two common causes of field project failure and how each can be avoided.
4. Explain what a Gantt chart is and how it helps project management.
5. Name two individual skills developed through field project work.

5.2 Scientific Report Writing

5.2.1 Structure and content of a field biology report

A scientific field biology report follows the standard IMRAD structure used in biological research publications: Introduction (providing the biological background and rationale for the study, reviewing relevant literature, and stating the specific hypothesis or objectives), Methods (describing the study site, sampling design, data collection procedures, and analysis methods in sufficient detail that the study could be repeated by another researcher from the description alone), Results (presenting the data collected using appropriate tables and figures, with the text summarising the key findings without interpreting them), Discussion (interpreting the results in the context of the stated hypothesis and existing literature, addressing unexpected findings, and acknowledging limitations), and Conclusion (summarising the main findings and their significance).

Additional sections required in a BIO 407 field report include an abstract (a concise summary of the entire report, typically 200 to 250 words, covering the question, methods, main results, and principal conclusions, written last but placed first in the report), a references section (a complete list of all cited sources in a consistent format), and appendices (raw field data sheets, specimen lists with collection numbers, and any additional material that supports the report but is too detailed for the main text); the report should begin with a title page bearing the title, author(s), course code, date, and institutional affiliation.

Fill in the blank: The IMRAD structure stands for Introduction, ________ , Results, and Discussion, the standard format for scientific research reports.

5.2.2 Writing style, accuracy, and scientific conventions

Scientific writing differs from everyday prose in requiring precision, economy, and objectivity: every claim must be supported by data or citation; vague qualitative language ("many species", "large area") should be replaced by specific quantitative statements ("27 species", "0.5 ha"); the passive voice is conventionally used in the Methods section ("specimens were collected", "quadrats were placed") to emphasise the procedure rather than the person carrying it out, though the active voice ("we observed", "the results show") is increasingly accepted in the Discussion and Conclusion sections of modern scientific writing; abbreviations should be defined at first use; all scientific names should be italicised.

Accuracy in scientific writing requires that numbers reported in the text match those in tables and figures, that statistical values are reported with the appropriate number of significant figures and with the correct notation (mean plus or minus SE, or 95% confidence intervals), and that all figures and tables have clear, complete titles that allow them to be understood without reference to the text; a common source of inaccuracy is transcription errors introduced when values are copied from spreadsheets into the report text, and students should check all numbers against the original data at the proofreading stage; the report should be proofread carefully for spelling, grammar, and formatting consistency before submission.

Fill in the blank: In the Methods section, the ________ voice is conventionally used to emphasise the procedure rather than the person carrying it out (e.g. "specimens were collected").

5.2.3 Referencing, citations, and academic integrity

All sources of information used in a field report must be acknowledged through citations and a reference list; the citation style used in BIO 407 is the author-date (Harvard) system, in which citations appear in the text as the author surname and year in parentheses (Smith, 2020) or as part of the sentence (Smith (2020) showed that...), and a complete reference list is provided at the end of the report in alphabetical order by first author surname; each reference includes all information needed to locate the original source: for journal articles, author(s), year, title, journal name (in italics), volume, issue, and page numbers; for books, author(s), year, title (in italics), edition if applicable, publisher, and place of publication.

Academic integrity in report writing requires that all text in the report is the student own words (or is explicitly marked as a direct quotation with quotation marks and a page reference), that all ideas or data originating from other sources are cited, and that no text is copied from another student report, from an online source, or from a previous assignment; plagiarism, whether deliberate or through careless paraphrasing, is a serious academic offence that results in severe penalties including course failure; fabrication of field data (recording results that were not genuinely obtained) is a still more serious offence constituting scientific fraud; students are expected to submit a declaration of originality with their report confirming that the work is entirely their own.

Fill in the blank: The ________ -date (Harvard) citation system places the author surname and year in parentheses in the text and provides a complete alphabetical reference list at the end of the report.

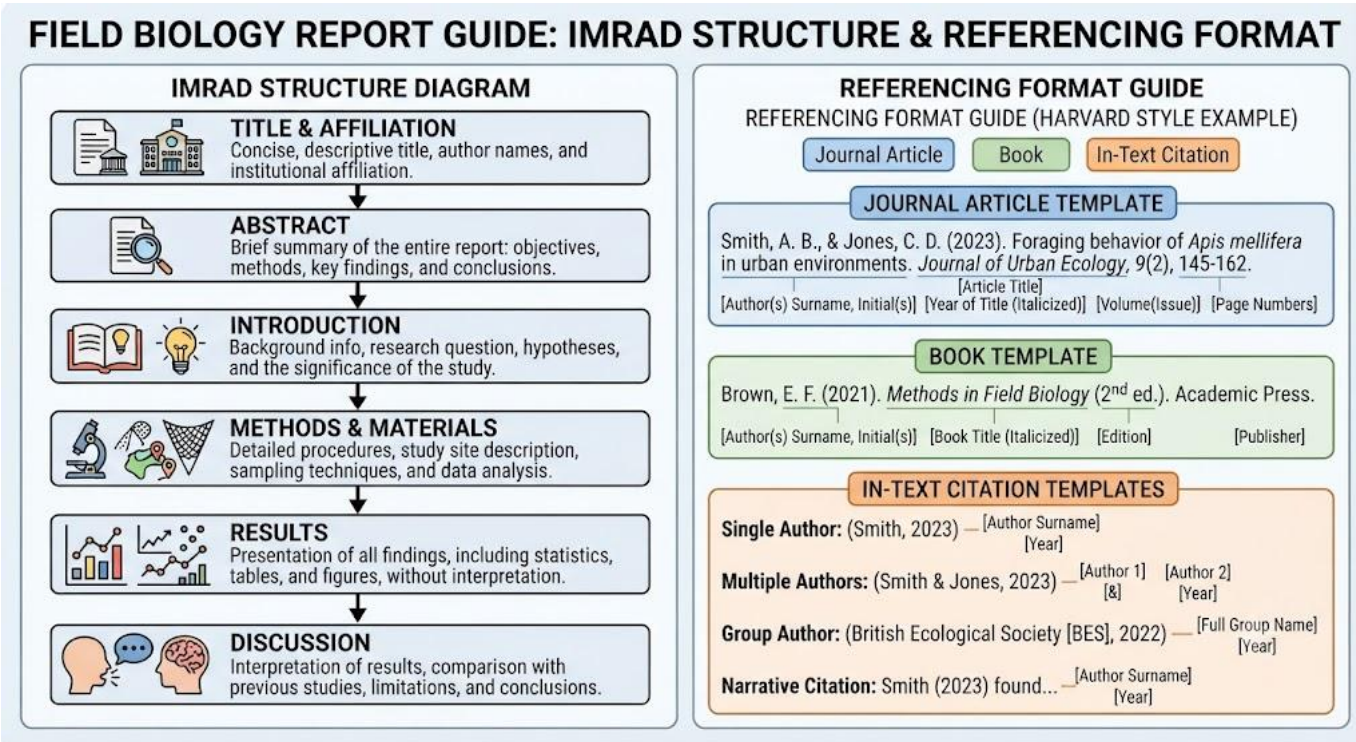


Figure 5.2: Scientific report structure and writing

Pilot questions 5.2

1. Name the five sections of the IMRAD report structure and state the purpose of each.
2. Explain what an abstract is and what it should contain.
3. Explain two differences between scientific writing and everyday prose.
4. Describe the Harvard author-date citation system.
5. Define plagiarism and explain two ways it can occur.

5.3 Course Assessment and Examination

5.3.1 Assessment components of BIO 407

BIO 407 assessment is structured to evaluate both practical field competence and the ability to communicate field findings scientifically; the assessment components typically include: continuous assessment (marks awarded for participation, field notebook quality, data sheet accuracy, specimen preparation standard, and professional conduct throughout the field sessions), the field project report (the major written assessment, either individual or group, demonstrating the ability to design, conduct, and report an original field investigation), and a practical examination (testing specimen identification, method knowledge, and data interpretation under examination conditions).

Continuous assessment in BIO 407 is cumulative, rewarding consistent good practice throughout the course rather than a single strong performance; students who maintain complete and accurate field notebooks, prepare specimens to an acceptable standard at each session, and participate actively and safely in all field activities accumulate marks progressively; students should be aware that the practical skills assessed continuously (such as the ability to use a GPS receiver correctly, to apply a kick net properly, or to press a plant specimen without mould) are also directly tested in the practical examination, making consistent practice the most effective preparation for all assessment components.

Fill in the blank: Continuous assessment rewards ________ good practice throughout the course, including field notebook quality, specimen preparation, and professional conduct at every field session.

5.3.2 Practical examination in field biology

The practical examination in BIO 407 tests the core field biology skills developed across all five Series; typical practical examination stations include: specimen identification stations (where a set of field-collected or reference specimens, such as pinned insects, pressed plants, or freshwater invertebrates, must be identified to the lowest achievable taxonomic level using available keys and reference materials within a time limit); data interpretation stations (where a prepared data set, graph, or map must be interpreted to answer specific questions about species composition, diversity, or environmental relationships); and method demonstration stations (where students must describe or demonstrate the correct procedure for a specific field method such as quadrat placement, pitfall trap setup, or GPS recording).

Preparation for the practical examination should focus on: thorough knowledge of the organisms collected and identified during the course (students should be able to identify their own specimens to family or order level without the key, and to genus or species level with a key and appropriate reference material); the ability to read and interpret graphs, tables, and maps of the types produced during field data analysis; and confident knowledge of the practical procedures, including the correct equipment, sequence of steps, and any safety or ethical considerations associated with each major field method covered in the course.

Fill in the blank: Practical examination specimen identification stations require students to identify field-collected specimens to the lowest achievable taxonomic level using available ________ and reference materials within a time limit.

5.3.3 Reflecting on field biology learning

Reflection is the deliberate process of examining one own learning experience to identify what has been learned, how it was learned, what was challenging, and how the experience connects to broader personal and professional goals; in BIO 407, a final personal reflection section is required as part of the field report or as a separate reflective journal submission; effective reflection goes beyond describing what happened during the field course to analysing why specific activities were valuable, what skills or insights have been most transformative, and what the student would do differently if repeating the experience.

Reflecting on field biology learning in BIO 407 should address: the practical skills acquired or significantly improved during the course (from GPS operation and quadrat placement to plant pressing and insect mounting); the conceptual connections made between field observations and ecological, taxonomic, or systematic theory; the teamwork, communication, and time management competencies developed through project work; and the career relevance of the field skills and professional habits developed, with specific reference to the types of employment for which BIO 407 has prepared the student; a reflective statement of two to three paragraphs, specific to the student own experience, demonstrates learning at a depth that factual recall questions cannot assess.

Fill in the blank: Effective reflection goes beyond describing what happened to ________ why specific activities were valuable and what skills or insights have been most transformative.

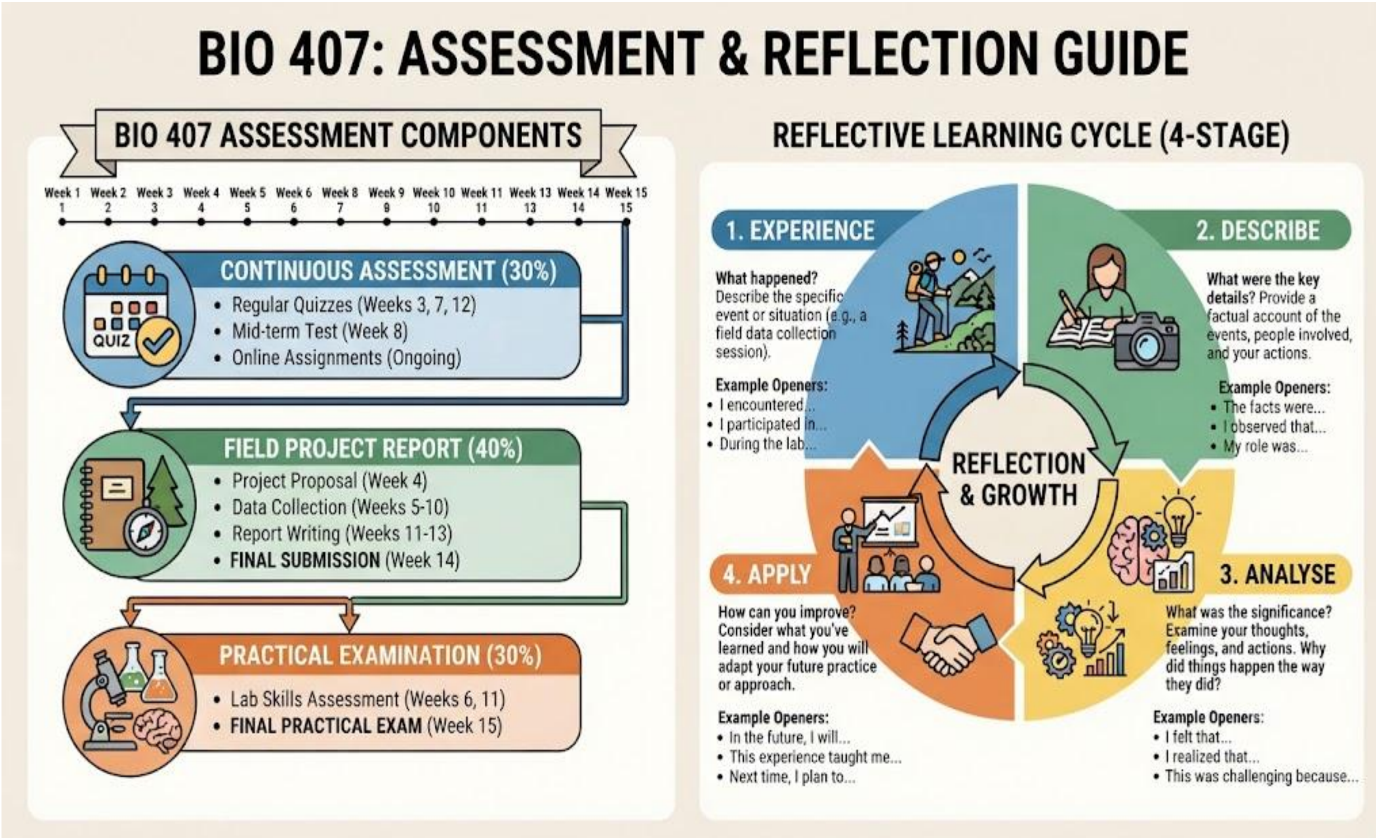


Figure 5.3: Assessment and reflection in BIO 407

Pilot questions 5.3

1. Name three assessment components of BIO 407.
2. Explain why continuous assessment rewards consistent practice rather than a single strong performance.
3. Name three types of station in the BIO 407 practical examination.
4. Explain how students should prepare for specimen identification stations in the practical examination.
5. Explain what makes an effective reflective statement, using three criteria.

Series Summary

This final Series completed the arc of Field Course II by addressing the sustained, independent investigation that is the culmination of all preceding work. Field project design requires a clear biological question, testable hypotheses or objectives, well-chosen sites and methods, an analysis plan, and a realistic timeline managed through phases from planning through fieldwork, specimen preparation, and data analysis to report submission. Individual and group project work develops the independence, troubleshooting ability, and persistence that field biology careers demand.

Scientific report writing in IMRAD format, with precise and objective language, correct Harvard referencing, and full academic integrity, translates field findings into the communicable scientific record that gives them lasting value. BIO 407 assessment across continuous assessment, the project report, and the practical examination evaluates the full range of practical and intellectual skills developed through the course. Reflection on this learning, connecting specific field experiences to ecological and taxonomic understanding and to career aspirations, brings the student to the end of the course as a more capable, more independent, and more reflective field biologist.

Glossary of Terms

- **Abstract:** a concise summary of an entire scientific report, typically 200 to 250 words, covering the question, methods, main results, and conclusions, written last but placed first.
- **Academic integrity:** the ethical standard requiring honest, original, and properly attributed academic work, prohibiting plagiarism and fabrication.
- **Discussion:** the report section interpreting results in the context of the stated hypothesis and existing literature, addressing unexpected findings and limitations.
- **Gantt chart:** a project management tool showing tasks and their scheduled timeframes as horizontal bars on a calendar timeline, with milestones marking key completion points.
- **IMRAD:** the standard scientific report structure: Introduction, Methods, Results, and Discussion.

- **Methods:** the report section describing the study site, sampling design, data collection procedures, and analysis methods in sufficient detail to allow replication.
- **Plagiarism:** the academic integrity violation of presenting another person work or words as one own without appropriate citation or attribution.
- **Project proposal:** a written plan submitted before fieldwork commences, specifying the biological question, hypothesis, study sites, methods, analysis plan, and timeline.
- **Reflection:** the deliberate process of examining a learning experience to identify what was learned, why it was valuable, and how it connects to future study or practice.

Concept Check Questions [Series 5]

Objective Questions

1. A field project ________ should specify the question, hypothesis, sites, methods, analysis plan, and timeline before fieldwork begins. (Linked to SLO 5.1)
2. Specimens should be processed and identified ________ after collection for best preservation and identification quality. (Linked to SLO 5.1)
3. The IMRAD structure stands for Introduction, ________ , Results, and Discussion. (Linked to SLO 5.2)
4. In the Methods section, the ________ voice is conventionally used to emphasise the procedure. (Linked to SLO 5.2)
5. Continuous assessment rewards ________ good practice across all field sessions rather than a single performance. (Linked to SLO 5.3)

Short-Answer Questions

1. Name the five phases of a field project. (Linked to SLO 5.1)
2. Name five sections of a field biology report in IMRAD order. (Linked to SLO 5.2)
3. Explain what an abstract should contain. (Linked to SLO 5.2)
4. Describe the Harvard author-date citation system. (Linked to SLO 5.2)
5. Name three types of station in the BIO 407 practical examination. (Linked to SLO 5.3)

Long-Answer Questions

1. Describe how to plan and manage a field project from inception to completion. (Linked to SLO 5.1)
2. Describe the structure and writing requirements of a scientific field biology report, and explain the assessment components of BIO 407. (Linked to SLOs 5.2, 5.3)

Answers to Concept Check Questions [Series 5]

Objective Questions

1. Proposal.
2. Promptly.
3. Methods.
4. Passive.
5. Consistent.

Short-Answer Questions

1. Planning, field data collection, specimen preparation, data analysis, and write-up.
2. Introduction, Methods, Results, Discussion, Conclusion (plus Abstract, References, Appendices for a complete report).
3. An abstract concisely summarises the question, methods, main results, and conclusions of the report, typically in 200 to 250 words.
4. The Harvard system places citations in text as (Author, Year) or Author (Year), and provides a complete alphabetical reference list at the end with full publication details for each source.
5. Specimen identification stations, data interpretation stations, and method demonstration stations.

Long-Answer Questions

1. Project design: clear biological question, null hypothesis or objectives, study site justification, methods, sampling design, analysis plan, realistic timeline; written proposal approved by instructor before fieldwork. Management phases: planning, field collection, specimen preparation, data analysis, write-up. Common failures: late start, failure to process specimens promptly, not backing up data, underestimating write-up time. Strategies: Gantt chart, dedicated time blocks, regular communication with partners and instructor.
2. Report structure: IMRAD (Introduction: background, literature, hypothesis; Methods: site, design, procedures, analysis in replicable detail; Results: tables, figures, descriptive text; Discussion: interpretation, literature comparison, limitations; Conclusion: summary). Additional sections: abstract (200-250 words), references (Harvard alphabetical), appendices. Writing: precise, objective, passive voice in Methods, numbers match tables, scientific names

italicised. Assessment: continuous (field notebook, specimen quality, conduct), project report (IMRAD), practical exam (specimen ID, data interpretation, method demonstration). Reflection connects experience to learning and career.

Answers to Pilot Questions [Series 5]

Part 5.1

1. Planning, field data collection, specimen preparation, data analysis, and write-up.
2. The biological question and context, the null hypothesis or objectives, the study sites with justification, the methods and sampling design, and the analysis plan (or timeline).
3. Leaving data collection too late (avoided by Gantt chart with early field deadlines); failing to process specimens promptly (avoided by scheduling specimen processing sessions immediately after each collection trip).
4. A Gantt chart shows tasks as horizontal bars on a weekly timeline with milestones for key completion points; it helps project management by making all tasks and their deadlines visible, preventing procrastination and identifying scheduling conflicts.
5. Independence of judgement (making field decisions without immediate instructor guidance) and troubleshooting (adapting methods when planned approaches prove impractical).

Part 5.2

1. Introduction (background, rationale, hypothesis), Methods (site, design, procedures), Results (data presentation), Discussion (interpretation, limitations), Conclusion (summary and significance).
2. An abstract summarises the entire report in 200 to 250 words, covering the biological question, methods used, main results, and principal conclusions; it is written last but placed first.
3. Scientific writing requires precision (specific quantitative statements rather than vague qualitative ones) and objectivity (describing observations rather than interpretations or assumptions).

4. Citations appear in text as (Author, Year) in parentheses; a complete reference list in alphabetical order by first author surname appears at the end, with full publication details for each source.
5. Plagiarism is presenting another person work as one own without citation; it can occur through direct copying of text without quotation marks and citation, or through careless paraphrasing that reproduces the original wording or structure without acknowledgement.

Part 5.3

1. Continuous assessment, field project report, and practical examination.
2. Continuous assessment evaluates skills that can only be demonstrated through sustained practice over multiple sessions (notebook quality, specimen preparation standard, safety conduct); a single strong performance at the end cannot retroactively demonstrate consistent application of these skills.
3. Specimen identification stations, data interpretation stations, and method demonstration stations.
4. Students should know their own collected specimens to family or order level without a key, and to genus or species level with a key; they should review all identification keys used during the course and practice identifying specimens from the collection under time pressure.
5. Effective reflection is specific (refers to particular field experiences rather than generalities), analytical (explains why the experience was valuable rather than simply describing it), and forward-looking (identifies how it will influence future study, practice, or career choices).

References and Attributions

Textual References (Books and External Sources)

- Day, R. A., & Gastel, B. (2016). How to write and publish a scientific paper (8th ed.). Cambridge University Press.
- Sutherland, W. J. (Ed.). (2006). Ecological census techniques: A handbook (2nd ed.). Cambridge University Press.
- Fowler, J., Cohen, L., & Jarvis, P. (1998). Practical statistics for field biology (2nd ed.). Wiley.
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Figures, Plates, Tables, and Boxes

- Figure 5.1: Field project planning and management Attribution: AI generated. Suggested OER search string: "field project proposal Gantt chart time management scientific investigation planning field biology Nigeria OER".
- Figure 5.2: Scientific report structure and writing Attribution: AI generated. Suggested OER search string: "IMRAD structure scientific report writing Harvard citation referencing academic integrity field biology OER".
- Figure 5.3: Assessment and reflection in BIO 407 Attribution: AI generated. Suggested OER search string: "field biology assessment practical examination reflection learning cycle report writing BIO 407 Nigeria OER".