

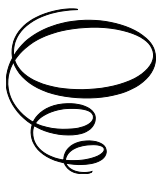
Community Ecology and Ecosystem Management

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By

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By Taiwo O. Ogunwale

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PREFACE

There is widespread paucity of instructional materials in the higher education establishments of Nigeria. The accessible materials concerning the course on the Community Ecology and Ecosystem Management are not adequate to our ecological and socio-economic setting.

This book is prepared mainly for EMT students, and is arranged on the basis of the lesson plan of Community Ecology and Ecosystem Management in the curriculum of EMT students. However, the lecture note is supposed to be beneficial for almost all degree and diploma Environmental Science students in the University and in another place in the nation. Taking into consideration the dearth of instructional materials for the course- Community Ecology and Ecosystem Management, this book is proposed to be utilized as a reference for students.

This material is presented in thirty-two units with five modules. Module one entails: ecosystems ecology, component of the ecosystem, ecosystem functioning part i, ecosystem functioning (trophic pyramids) part ii, productivity and energy flow in ecosystems, nutrient cycling in ecosystems, ecosystem interactions, and discusses the community structure patterns. Module two presents population ecology, population trends and measurements, population growth, population regulation, and growth in the human population. Module three is all about biotic communities such as ecological communities, community structure and functioning, niche ecology, resource shift and overlap competition coexistence, habitat i: the main terrestrial habitat that has an impact on humans, habitat ii: the main aquatic environment that has an impact on humans; human-caused habitat alteration, and including the environment and ecology in development planning. Module four covers man and environmental relationships, pollution: types, sources, and characteristics, pollution's impact on the environment, pollution: impacts, prevention, and management, and humans, environment, and health. Module five involves conservation of natural resources, ecological management, incorporated development and eco-Development, multidisciplinary, holistic, and all-encompassing principles of environmental planning, participatory coordinated, incorporated, and ongoing planning are the guiding principles

of environmental planning, and standard community sampling procedures in environmental studies in the Nigerian context are presented.

Each chapter starts with preamble, desired learning objectives, by signifying what is expected from students on end of the unit. In addition, at the end of each unit there are conclusion, recap, and short questions for revision related to the basic issues of the respective unit. Lastly, tutorial questions are set for exam preparation and glossary are presented and described to prevent any confusion.

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I am very indebted to the Managing Director of Cambridge Scholar Publishers Limited for his positive suggestion, encouragement, subsidy and moral support. I also acknowledge efforts of the Editorial crew and all staff of Cambridge Scholar Publishers for editing and publishing this textbook.

I express my deep appreciation to all my teachers who taught me at the various levels of my academic endeavors. They have all been so unique. I am specifically indebted to those who taught me at the tertiary level for granting to use their past questions.

Above all I thank Almighty God, the Author of knowledge, wisdom, and understanding with whom nothing is unattainable.

I value everybody that has added one way or the other to the successful culmination of this textbook. God will bless you all.

Thanks.

UNIQUENESS

This book is easy to comprehend. It is an all-encompassing textbook as it outlines the materials required to pass some levels of examinations. What makes this textbook very valuable and distinctive is the style of presentation of materials for easy recall and understanding. Each chapter starts with preamble, desired learning objectives, by signifying what is expected from students on end of the unit. In addition, at the end of each unit there are conclusion, recap, and short questions for revision related to the basic issues of the respective unit. The syllabus for Community Ecology and Ecosystem Management is fairly covered. The book is strongly recommended for all three tiers of education. It is also a useful tool for ecology and environmental science tutors. They will undoubtedly find this textbook essential to their studies towards attaining success in their various academic programmes

ABSTRACT

This book intrinsically addresses the basic community ecology and ecosystem management. The desire of my students to have a book on basic ecology prompted me to produce this book. A qualitative research methodology was used to obtain relevant information. The book is intended to discuss the ecosystems ecology, component of the ecosystem, ecosystem functioning part i, ecosystem functioning (trophic pyramids) part ii, productivity and energy flow in ecosystems, nutrient cycling in ecosystems, ecosystem interactions, and discusses the community structure patterns; population ecology, population trends and measurements, population growth, population regulation, and growth in the human population; biotic communities such as ecological communities, community structure and functioning, niche ecology, resource shift and overlap competition coexistence, habitat i: the main terrestrial habitat that has an impact on humans, habitat ii: the main aquatic environment that has an impact on humans; human-caused habitat alteration, and including the environment and ecology in development planning; man and environmental relationships, pollution: types, sources, and characteristics, pollution's impact on the environment, pollution: impacts, prevention, and management, and humans, environment, and health; conservation of natural resources, ecological management, incorporated development and eco-Development, multidisciplinary, holistic, and all-encompassing principles of environmental planning, participatory coordinated, incorporated, and ongoing planning are the guiding principles of environmental planning, and standard community sampling procedures in environmental studies in the Nigerian context, etc., are presented.

It will assist candidates preparing for the Master and PhD Certificate Examination in ecology aspects and those preparing for monotronics (colleges of forestry, wildlife, agriculture; horticulture, and education), polytechnics, universities, and professional examinations, e.g., health safety environment, etc.

It must be added that some worked examples with questions of a relevant standard for student preparation, are given at the end of each chapter. Also, all the names of individual flora and fauna used in this book are

purely fictional for illustrative purpose. Any errors or misprints will be corrected. Nevertheless, other additional corrections, suggestions or criticism that will improve the production are highly welcomed.

In conclusion, I want to remind students that, the real secret of success depends on full preparation together with exhaustive revision of these Self-Evaluation Tasks questions and answers will bring about success in both internal and external examinations.

MODULE ONE

CHAPTER ONE

ECOSYSTEMS ECOLOGY

1.1 Preamble

There are two main types of ecosystems under which any other sub-ecosystem falls. You will learn about the definition, scope, meaning, and functioning of ecosystems, which reflect the collective life activities of plants, animals, and microbes and the effects these activities—such as feeding, growing, moving, excreting waste, respiration, lifespan, competition, reproduction, and so on—have on the physical and chemical conditions of their environment.

1.2 Desired Learning Objectives (DLOs)

By the end of this chapter, the learner should be able to:

Define the term ecology;

Explain the scopes of ecology;

Understand the meaning of ecology and ecosystems functioning;

Appraise the different types of ecosystems; and

Describe the different categories of freshwater ecosystems.

1.3 Main Text

1.3.1 Ecology: Definition and Scope

Since the beginning of time, man has had a practical interest in ecology. Every person in a primitive culture must possess a thorough understanding of his surroundings, including the forces of nature and the nearby flora and fauna, in order to survive. One of the most popular branches of biology is ecology. Because it relies on a broad range of approaches and methodologies rather than a small number of concepts and techniques, it is a pluralistic science. Even though ecology is considered a division of biology, it varies from most other branches of biology in that it can only

be fully understood or studied through a multidisciplinary approach that involves close collaboration from experts in other fields.

1.3.2 Ecology Definition

The term "ecology," which refers to the study of organisms in their natural habitats, was derived from the Greek word "oikos," which means "house" or "a place to live." In particular, it refers to the study of how organisms interact with their physical and chemical surroundings as well as with one another. The word "logy" refers to the study.

Examining the degrees of biological organizations is another method of characterizing ecology. Life's molecules are structured in particular ways to form cells, which are then grouped into tissues, which are then arranged to create functional organs. An organism is made up of the whole variety of organ systems that are created by the integration of the body's organs. Organisms occur in groupings known as populations rather than as a single individual. A community is made up of different populations of organisms that interact with one another. An ecosystem is made up of interconnected communities of creatures that interact with the physical environment. Ultimately, the planet's ecosystems come together to form the biosphere or ecosphere, a degree of order. The layers of structure that go beyond the individual organism—population, community, ecosystem, and biosphere—are the focus of ecology.

1.3.3 Ecology's Scope

The growth and stability of populations over time are governed by specific rules, whether we are discussing humans or any other type of life. The pattern of interactions between organisms and their surroundings is influenced by these concepts. Ecology focuses on these patterns in all of their different manifestations. Ecology, as a science, aims to apply a single set of ideas and principles to the natural world, including its human component.

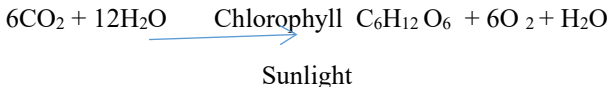
Ecology addresses issues like:

- How do different organisms interact with one another and the physical environment?
- Why do some organisms make up natural communities while others do not?
- How can we manage and preserve these natural communities?

1.4 What Ecosystem Ecology Means

The scientific field of ecology studies the interactions between living organisms and their natural environments. Ecology can be examined from the viewpoints of (1) the environment and the demands it places on the species that live there, or (2) organisms and how they adjust to their surroundings. A group of organisms that engage in a largely cyclic exchange of materials with one another and their environment make up an ecosystem. An ecosystem is made up of physical, chemical, and biological elements in addition to energy sources and channels for the flow of materials and energy. The environment in which a particular organism lives is known as its habitat. The word "niche" describes an organism's role in its environment. Ecosystem ecology is the study of ecosystem elements and interactions. In summary, ecosystem ecology is the study of how biotic (living) and abiotic (non-living) components interact within an ecological framework. We need to study the components, characteristics, and classification of ecosystems. Now, let's begin.

An ecosystem is a dynamic system where biotic and abiotic factors interact and operate continuously, changing the structure and operation of a community. Therefore, the term "ecosystem" was first used in 1935 by British ecologist A.G. Tansely. "A community and its abiotic surroundings form a complex, interacting system known as an ecosystem." Ecosystems are composed of discrete structural components, including living things and the natural environment, that interact with one another through material cycles and energy flow to maintain life. Ecosystems are not independent; they are all interconnected in some way. This eating and being eaten relationship between living things is mediated by two fundamental mechanisms. To begin with, only green plants and a few autotrophic bacteria are able to produce their own food by binding basic molecules of O_2 , H_2O , and other elements such as N, P, Ca, K, Mg, and S using the energy of solar radiation (Light).



Energy flow: the energy that plants use is transferred through different creatures before being released as heat. We refer to it as the energy flow.

Bio-geochemical cycling: The chemical and energy materials go through the body yet can be used again and again. Thus, biogeochemical cycling is

the term used to describe the process. Which two processes combine to form an interacting complex unit between organisms (feeding and being) and their surroundings?

1.4.1 An Ecosystem's General Characteristics

The following characteristics are shared by most ecosystems, according to Smith (1966): The ecosystem is a crucial structural and functional element of ecology. There is a relationship between species diversity and ecosystem structure. An ecosystem's capacity to fulfill its intended function is correlated with the movement of energy and the cycling of materials through and within it. The percentage of energy needed to maintain an ecosystem depends on its structure. Anything becomes more complex the less energy it needs to sustain itself. As ecosystems evolve from simpler to more complex states, they undergo development. Early stages of this succession are characterized by excess potential energy and a comparatively high energy flow per unit biomass. Later (mature) stages have a wider range of components they pass through and acquire less energy. There is a limited habitat and energy supply in every ecosystem that cannot be surpassed without causing serious harm. As conditions change, the population must adjust to the selection forces at play. Organisms that are unable to adapt to the changing environment must go.

Self-Evaluation Tasks No 1

1. What is ecosystem ecology?
2. Which perspectives underpin the study of ecology?

1.5 Ecosystem Classification

The only generic categories that can be utilized in ecological classification are those that include similar kinds of creatures. Two categories of ecosystems exist:

1. Natural Ecosystems: These are ecosystems that can thrive without human help and that emerge naturally. Ecosystems include things like rivers, mountains, and other aspects of the natural terrain. A natural ecosystem, as defined by the concept, is one that exists in nature and in which creatures is free to interact with other aspects of their surroundings. One of the main characteristics of this ecosystem is its self-sufficiency. For example, woodlands are home to both herbivores and carnivores.

Herbivores devour grass, seeds, and fruits. They are then consumed by the carnivores. Herbivores consume the grass and trees that are produced when carnivores die because their remains disintegrate into the soil and restore it with essential nutrients. Consequently, the biological cycle persists.

2. Ecosystems that are artificial or man-made: Humans create artificial ecosystems by either creating them themselves to mimic the natural world or by modifying an existing ecosystem to meet their requirements. The fundamental difference between natural and artificial ecosystems is that the former need constant upkeep because they are not self-sustaining. This type of habitat includes, for instance, gardens, dams, agricultural areas, and aquariums.

1.5.1 Types of Natural Ecosystems

Two categories of natural ecosystems exist:

A. Terrestrial Ecosystem: The term "terrestrial ecosystem" refers to ecosystems that are located on land. They can be categorized according to temperature and climate. Below is a detailed discussion of these:

i). **Forests:** They comprise around 31% of the land area on Earth. Depending on the climate and forest type, there are three distinct kinds of forest ecosystems throughout the world. These consist of rainforests, temperate forests, and coniferous forests. In areas with high rainfall, a tropical wet wood can be found. Coniferous forests are found in cold mountainous areas, in contrast to temperate forests, which grow in areas with cold winters and pleasant summers. As the world's most diverse terrestrial ecosystems, they serve as habitats for a wide variety of animals, birds, insects, and other species, and we rely on woods for many other purposes.

ii. **Deserts:** Deserts can be either hot or cold. These ecosystems experience extreme weather conditions, such as dry air, temperatures that are too hot during the day and too cold at night, and little to no rainfall. As a result, there is little vegetation and few animals in a desert, such as camels, cattle, desert snakes, lizards, and scorpions.

iii). **Grasslands:** Two types of this type of natural habitat are tropical savannahs and temperate grasslands. The vegetation is extensive, consisting of tall grass and a few trees and bushes. Numerous creatures,

including as wolves, zebras, gazelles, and rabbits, can be found on the grasslands. Which three categories of ecosystems do all other sub-ecosystems fall under?

B). Aquatic Ecosystem: These comprise the ecosystems that are located in bodies of water, as the name implies. Since water covers around 75% of the Earth's surface, these are the most prevalent ecological types there. It is separated into two categories:

i). Freshwater: Only over 3% of the 75% is made up of freshwater. This category includes natural ecosystems such as lakes, rivers, ponds, streams, marshes, among others. Essential nutrients are carried by rivers and streams that emerge from mountains and end up in lakes and ponds. Additionally, a wide range of flora, fauna, and microorganisms call freshwater home.

ii) Marine Environment: This type of environment is among the most varied. Coral reefs, kelp forests, salt marshes, mangroves, rocky coasts, the deep sea, the wide ocean, and so on are all part of it. Physical elements such as high salt content, light availability, temperature, tides, geology, and geography all affect marine habitats. Because of this, some places, like salt marshes and mangroves, are teeming with life, other places like the abyssal plain at the sea's bottom are devoid of it.

2. Man-made environment: Abiotic and biotic elements are designed to interact with one another in artificial ecosystems, which are man-made buildings. It can die without human assistance and is not self-sustaining. Artificial ecosystems fall into two main categories: i) Cropland ecosystems and ii) Fish farm ecosystems. Examples of artificial ecosystems include aquariums, zoos, and agricultural fields. Which local physical circumstances influence aquatic ecosystems?

Self-Evaluation Tasks No 2

1. Which three fundamental types of freshwater ecosystems are there?
2. How diverse are the creatures that inhabit maritime environments?

1.6 Divisions of Contemporary Ecology

Two main subfields of contemporary ecology are:

- **Ecosystem ecology-** which sees ecosystems as vast units, and

- **Population ecology:** which aims to explain ecosystem behavior from the characteristics of individual units in practice, the two approaches are often used together. Descriptive ecology describes the types and characteristics of animals and their environments, emphasizing population structures, dispersal patterns, ecosystem, and community architecture.

1. Functional Ecology: explains the movement of matter and energy throughout ecosystems as well as how populations respond to changes in their surroundings. Ecosystems can be broadly divided into two categories: natural and artificial. Natural ecosystems, or those found in nature, are divided into terrestrial and aquatic ecosystems. In contrast to terrestrial environments, which include hot deserts, grasslands, tropical and temperate rainforests, and so on, aquatic environments include ponds, rivers, streams, lakes, estuaries, oceans, mangroves, swamps, and bays. The open, self-regulating nature of these two ecosystems, on the other hand, permits unfettered inputs and outputs from other systems. Artificial ecosystems are simple, man-made, prone to human manipulation, and unstable. In order to make a crop field or other agricultural area, a piece of grassland or forest is usually removed.

1. Structure and Function of Ecosystems: The components of an ecosystem are biotic (made up of living creatures) and abiotic (made up of things that are not alive). Some sources classify the following as non-living constituents: inorganic and organic nutrients, temperature, moisture, gasses, sunlight, and habitat. Living organisms can be further classified as producers, consumers, and decomposers. Abiotic components are the fundamental biological and inorganic aspects of an organism's environment or habitat. The inorganic components of an ecosystem— CO_2 , H_2O , N , and $\text{Ca}_2\text{PO}_4^{3-}$ (calcium phosphate)—all participate in the matter cycle, also known as the biogeochemical cycle. The organic elements of an ecosystem are amino acids, proteins, carbohydrates, and lipids. They all come into an ecosystem as waste products, decaying bodies, etc., and are created by the biota (flora and fauna). Abiotic components of ecosystems include soil lightness, temperature, and other climate-related factors, or "microclimate."

1.7 Ecosystem Functions

The ability of natural components and processes to either directly or indirectly satisfy human needs for goods and services is known as

ecosystem function. Ecosystem functions are subsets of ecological processes and ecosystem structures. Each function is produced by the natural processes that comprise the complete ecological sub-system, of which it is a component. In contrast, natural processes are driven by the universal forces of matter and energy and result from complex interactions between biotic (living things) and abiotic (chemical and physical) components of ecosystems. Ecosystem functions fall into four main categories:

- (1) Regulatory functions,
- (2) Habitat functions,
- (3) Production functions and
- (4) Information functions.

This category applies to all habitats, not only forests. The general characteristics of ecological functions are as follows:

(1) Regulatory Functions: This group of functions refers to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes. Clean air, water, and soil, as well as biological control services, are just a few of the many benefits that these regulatory activities provide to people directly and indirectly, in addition to maintaining the health of the ecosystem (and the biosphere).

(2) Habitat Functions: By giving wild plants and animals a place to live and reproduce, natural ecosystems support the evolutionary process and the (*in situ*) preservation of biological and genetic diversity.

(3) Production Functions: Through photosynthesis and nutrient intake, autotrophs convert energy, CO₂, H₂O, and nutrients into a variety of carbohydrate structures. Secondary producers then use these structures to create an even greater variety of living biomass. The diverse range of carbohydrate structures produces many ecosystem products for human use, such as food and raw materials, energy sources, and genetic material.

(4) Informational Purposes: By providing chances for reflection, spiritual enlightenment, cognitive growth, leisure, and aesthetic appreciation, natural ecosystems promote human health. Natural ecosystems help to maintain human health because much of human evolution took place in an undomesticated environment. Producers, consumers, decomposers, and abiotic components like ponds are the four

fundamental components of an ecosystem. An ecosystem is deemed incomplete if any one of these four components is absent, such as the depth of the ocean or a cave.

Environmental Productivity: Primary productivity, secondary productivity, and net productivity are the three categories of productivity. The pace at which the vegetation in an ecosystem fixes solar energy is known as ecological productivity. Primary productivity is the rate at which producers' photosynthetic and chemosynthetic activity (NPP) stores radiant energy. It is sometimes referred to as gross primary productivity (GPP) and net primary productivity. Energy (kcal/m²) or weight (g/m²/yr) is the units of measurement. Secondary productivity is the term used to describe consumer-level energy storage rates. An understanding of ecology is essential for managing modern industrialized societies in ways that are compatible with environmental improvement and preservation.

The field of ecology known as "**Applied Ecology**" is concerned with predicting the effects of development and technology on ecosystems and making suggestions to minimize any adverse effects—or even positive ones—that these actions may have. It is an interdisciplinary approach.

1.8 Concepts of Ecology

A few key concepts that are frequently employed in ecology research help people comprehend the topic. These ecological concepts include, among others:

(1) Environment: The environment encompasses all elements that have an impact on an organism, both internal and external, living and non-living.

(2) The Biosphere or Ecosphere: The area of the earth that is home to living things is known as the biosphere or ecosphere. It is a layer of life that covers the surface of the earth. Complex biological and chemical processes take place in a small area known as the biosphere. It is present in the air, water, and soil on land. It gives creatures like plants, animals, and microbes a place to live.

(3) Lithosphere: The lithosphere is the solid core of the earth. It is the outermost layer or zone of the earth's crust. It is made up of rocks and minerals and accounts for 30% of the earth's surface. Loose rock components, such as gravel, sand, and soils, make up the lithosphere, the

topmost layer of the landmass that forms the basis for all human settlement.

(4) Hydrosphere: The hydrosphere is the liquid or aquatic part of the globe or biosphere. It covers over 70 percent of the earth's crust. It has the ability to store water in three different states: solid (ice), liquid (water), and gaseous (water vapor). Hydrospheres include things like lakes, pools, springs, the sea or ocean, ponds, oases, rivers, and streams.

(5) Atmosphere: The earth's gaseous layer is known as the atmosphere. The earth is surrounded by this layer of gasses. Within 30 kilometers of the earth's surface, more than 99 percent of the atmosphere is located. It has 0.97 rare or inert gases, 21% oxygen, 0.03% CO₂, and 78% nitrogen.

(6) Habitat: A habitat is an area or residence inside an ecosystem where an organism resides by nature. A habitat is another name for the home of a biotic community. In other words, a habitat is any setting that a thing lives in. For example, fish inhabit water as their habitat. Terrestrial habitats, such as deserts and savanna woodlands, and aquatic habitats, such as rivers, lakes, ponds, streams, lagoons, seas, and oceans, are among the various types of habitats. Groups of similar species often interact and cohabit. Environmental factors, both biotic and abiotic, affect every ecosystem. Habitats can be aquatic, such as the ocean, lake, pond, tree trunks, leaf surface, or any other appropriate example, or terrestrial, such as tropical wet wood, grassland, savanna, or desert

(7). Biome or Biotic Community: A biotic community is any naturally occurring collection of diverse organisms that coexist and are interesting in the same habitat. A biome is the largest group of living organisms; rainforests and Guinea savanna are two examples.

(8) An Ecological Niche: is a specific section of a habitat that is occupied by a specific species or organism. Every creature has a specific role within its community and is adapted to that environment. Examples of these roles include being a producer or a consumer, acquiring nutrients from its habitat or returning those nutrients to it, or feeding on or serving as a food source for other species. The sum of all these roles for a particular organism is called its ecological niche. Aphids and caterpillars, for example, have distinct ecological niches on the same plant. The caterpillar mostly resides on the leaves and feeds on them, whereas the aphid feeds on the sap of the young stem. Even though they share a habitat, each organism has its own food source and living area.

(9). Population: The total number of organisms of the same species that exist in a given area and time period is known as the population. The quantity of tilapia fish in a pond, for example, is equivalent to the total number of tilapia fish in that habitat.

(10). An Ecosystem: is a naturally occurring system composed of both living and non-living elements that cooperate to form a stable whole. A group of living organisms coexisting with their inorganic surroundings is called an ecosystem. In other words, the ecosystem of a habitat consists of both living and non-living elements.

(11). Community: This refers to a group of living things that can adapt to the environment of a particular place. Because they are interdependent—that is, they rely on one another—they may live long and produce new children.

(12). Climax Community: The peak community is established when an ecological succession has achieved a stable or unchanging community. The environment and the community are in harmony. Vegetative development reaches its apex. The same organisms, plants, or animals return year after year.

Self-Evaluation Task No 3

1. An ecological niche: what is it?
2. What is a community of biotic organisms?

1.9 Recap

The definition and scope of ecology, ecosystems, and their functioning—the integrated study of ecosystem components and their interactions—have all been covered. In order to achieve the objective of sustaining life, ecosystems consist of particular structural elements (the living things and the physical surroundings) that interact with one another through energy flow and material cycle. Additionally, you have explored the distinctions between manufactured and natural ecosystems. The diverse ecosystem types—terrestrial and freshwater—as well as their constituent parts have been emphasized.